POWER THEFT IDENTIFICATION SYSTEM IN DISTRIBUTION LINES USING DIFFERENTIAL POWER MEASUREMENT

A Main project report submitted in partial fulfilment of the requirements for the award of the degree of

BACHELOR OF TECHNOLOGY
IN
ELECTRICAL AND ELECTRONICS ENGINEERING

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R G M C E T

(ESTD-1995)

DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

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BONAFIDE CERTIFICATE

This is to certify that the thesis entitled "POWER THEFT IDENTIFICATION SYSTEM IN DISTRIBUTION LINES USING DIFFERENTIAL POWER MEASUREMENT" that is being submitted by K. JOHN GILMOUR (18095A0214), G. ANJUM (17091A0203), T. CHANDRAVADHAN REDDY (17091A0212), CH. PRAKASH (18095A0226), M. SAI CHARAN REDDY (17091A0254),P. VENKATA VASANTH SAI (17091A0279) have carried out the main project for the fulfilment of the award of Bachelor of Technology in Electrical and Electronics Engineering in Rajeev Gandhi Memorial college of Engineering & technology(Autonomous) and this is a record of bonafide record of the work done by them during the year 2020-21.

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ABSTRACT

Science and technology with all its miraculous advancements has fascinated human life to a great extent that imagining a world without these innovations is hardly possible. While technology is on the raising slope, we should also note the increasing immoral activities. With a technical view, “Power Theft” is a non-ignorable crime that is highly prevalent, and at the same time it directly affects the economy of a nation..

This project is designed to find out such power theft in the normal distribution lines. This project is using the principle of the differential protection scheme for the identification of the power theft. The differential protection scheme consists of two CTs (current transformers) connected at both the terminals of the load. If there is no fault in the load then the secondary currents of both the CTs will be same. Using the same principle one CT is connected at the starting end of the distributor and the remaining other CT is connected to the different loads which are legal. If there is no power theft in the line then the vector sum of all the CT’s which are connected to the load will be equal to the current in the main CT. if there is a difference then we can make out that it should either be the power theft or a fault in the line.

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INTRODUCTION

CHAPTER-1

INTRODUCTION

1.1 INTRODUCTION

According to the survey, INDIAN POWER SYSTEM faces loss of about 30% of its total production of electricity. This loss is very high which takes place because of transmission losses, electricity theft, etc. Major portion of its losses is due to power theft. Power theft is done by taking tapping or hooking from transmission line or by from the meters. Generally this type of power theft is seen in residential area which can't be easily detected as this type of theft is done during night hours. Moreover, this kind of power theft causes unbalance/overloading of three phases of distribution transformer. Due to unbalance/overloading condition, the transformer is damaged due to heating of the overloaded phase. This project based on protection of transformer from overloading due to theft of power. Basically, it consists of power board where three phases enters through which the load is supplied instead of taking tapping from nearby line passing. The power board also contains meter or the current detector which will compare the outgoing current and the consumed current by the customer (power delivered and power consumed). If the both the power is different (which ultimately tells about the power theft) then, the meter will send information about the area and pole immediately from where losses/theft is being carried out. Also, it will secure the distribution transformer from unbalance condition. When any of the three phases of distribution is unbalance or overloaded, this system will try to balance the three phases which ultimately save the transformer from tripping. As the transformer is tripped it takes about an hour to get restarted which will affect the consumers if they are doing some important work or they are in the lift. This system tries to balance the three phases and prevent from overloading by shifting the load of loaded phase to the least loaded phase. If all the phases are loaded then this system will send signal to the transformer for tap changing which will try to compensate the load.

1.2 METHODOLOGY

1.2.1 FACTORS THAT INFLUENCE ILLEGAL CONSUMERS:

There are many factors that encourage people to steal electricity. Of which socio- economic factors influences people to a great extent in stealing electricity. A common notion in many people is that, it is dishonest to steal something from their neighbour but not from the state or public owned utility company. In addition, other factors that influence illegal consumers are:

• Higher energy prices deject consumers from buying electricity.

. In light of this, rich and highly educated communities also steal electricity to escape from huge utility bills.

• Growing unemployment rate show severe

1.2.2 METHODS OF THEFT:

Methods used to commit theft fall into the Following broad categories: a. Connection of supply without a meter Connection of supply without a meter following disconnection for non-payment or by “squatters” occupying empty properties. b. By passing the meter with a cable. It coveted into the supply side of the metering installation (i.e. the meter terminals, the metering cables, the cut-out or the service cable). c. Interfering with the meter to slow or stop The disc, including use of electrical devices which stop the meter or cause it to reverse (so-called 'black boxes). d. Interfering with the timing control Equipment used for two rate tariffs to obtain a cheaper rate. Methods (c) and (d) usually involve removal of official (certification) seals and/or company seals. there effect on the customer’s economic situation.

1.2.3 EFFECTS OF ELECTRICITY THEFT:

Negative effects of electricity theft are severe and dangerous. Primarily, electricity theft affects the utility company and then its customers. In addition, electricity theft overloads the generation unit. In energy market, utility companies expect their money back from the customers for the electricity supplied, most of which is lost by them due to the NTL (Non technical losses).Electricity theft is a serious concern for utility companies as they are under threat of survival because of these incurring economic losses. It is evident that some utility companies in developing countries are losing about 10 to 30 percent of their total revenue, which shows that they could not

invest on measures to reduce the electricity theft. These economic losses affect the utility company's interest in development of the devices in view of improving paint he quality of supply or for electrification process.

1.3 LITERATURE SURVEY

Following is the brief description of work done on theft detection models by various researchers:-

[1] The paper uses the approach based on power line communication principle which is use for detecting theft in electricity. A high frequency signal is introduced in the distribution network which changes its amplitude and frequency as the load in the lines increases or decreases. The changes will be detected through the gain detectors if any illegal connection is made between the poles then there will be modification in the values of gain and through which the illegal connection in the electricity will be discovered and proper action will be taken by the authorities to neutralize such connection but this approach is not tried for the theft detection for the customers illegal use and it is infrastructure based.

[2] Uses the concept of customer's historic usage pattern of electricity to create the user load profiling information which is used to detect the unusual flow of electricity and thus provides the class of customers which could be further synthesized to detect possible fraud customers. The paper uses many concepts like Extreme Learning Machine, Support Vector Machine. There are various process carried out in these process of detection. Firstly the usage data of customers is pre-processed. The processing is done in three steps Data Selection, Data Separation and Data Normalization. Then there is the process of feature selection which automatically takes the important features of the data. Then the data is categorized by the abnormal usage patterns by using ELM. Then the categorized data is further classified by SVM to detect the possible fraud in electricity. But as we are using SVM. The accuracy of detection decreases as SVM is not accurate in classifying data to the extent so there is possibility of getting failure in detection of fraud.

CHAPTER-2

DESCRIPTION OF THE COMPONENTS

DESCRIPTION OF THE COMPONENTS

2.1 Arduino Nano:

Arduino is an open-source prototyping platform based on easy-to-use hardware and software. Arduino boards are able to read inputs - light on a sensor, a finger on a button, or a Twitter message - and turn it into an output - activating a motor, turning on an LED, publishing something online. You can tell your board what to do by sending a set of instructions to the microcontroller on the board. It is like the brain of a project.

Because it is so flexible and open source, Arduino is the best solution if you are interested in creating interactive objects or environments no matter you are artists, designers or hobbyists.

One of Seeed Studio's motto is "Grow the Difference", which has now become part of the culture of the company. This is not just reflected from what we are doing in popularizing open source culture, but also from our products. Ever since the company funded, we are continuously creating our own open platform to differentiate from the existing one.

Here at Seeed, you can find not only Arduino boards, such as Arduino Nano and Arduino Mega, but also many boards that derived from Arduino such as Seeeduino, a joint effort by Seeed Studio and Arduino. Seeeduino is compatible with Arduino while has more powerful functions and lower price. To start with, you can try the latest version Seeeduino V4.2 or Seeeduino Mega that corresponding to Arduino Mega.

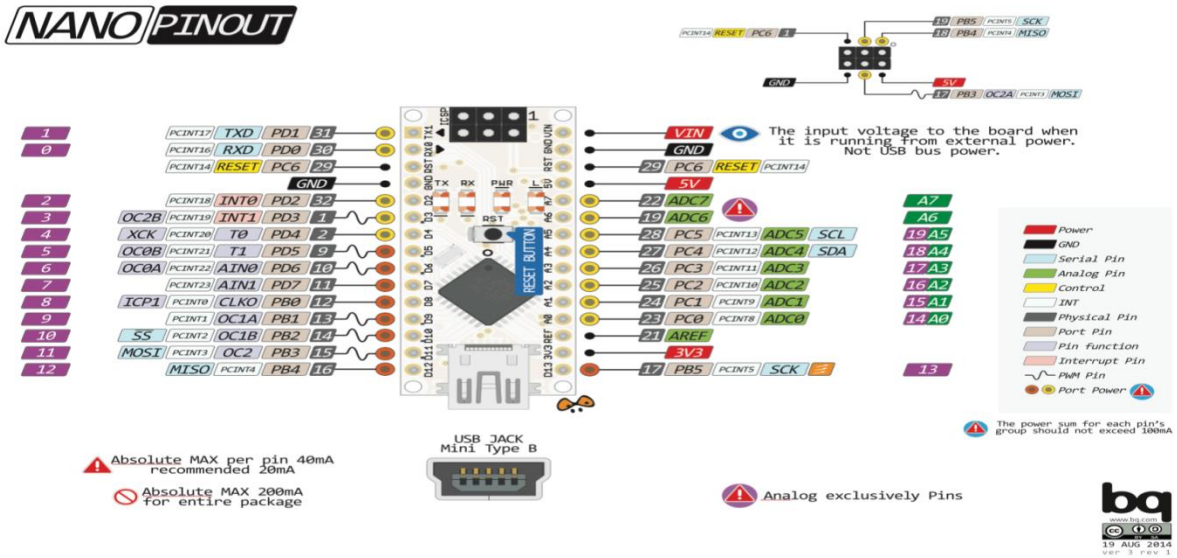


Fig.2.1 Arduino nano pinout

Arduino is an open-source platform used for building electronics projects. Arduino consists of both a physical programmable circuit board (often referred to as a microcontroller) and a piece of software, or IDE (Integrated Development Environment) that runs on your computer, used to write and upload computer code to the physical board.

The Arduino platform has become quite popular with people just starting out with electronics,and for good reason. Unlike most previous programmable circuit boards, the Arduino does not need a separate piece of hardware (called a programmer) in order to load new code onto the board – you can simply use a USB cable. Additionally, the Arduino IDE uses a simplified version of C++, making it easier to learn to program. Finally, Arduino provides a standard form factor that breaks out the functions of the micro-controller into a more accessible package.

Fig. 2.2. Arduino Nano Chip

- The micro-USB connector is not soldered to the board very well and is easily broken.

There are multiple versions of this board with different connectors. Refer to the pictures for examples. You can increase the strength by re-soldering the connector and possibly covering the connector in epoxy glue or hot-melt glue.

- The 3.3V voltage regulator is a very small, knock-off device. It overheats quickly and often has no thermal protection, feeding through its input voltage when it fails.

It's recommended to power external components with another regulator so that the power draw on the Blue Pill does not exceed 100 mA.

- Analogue power and ground is connected directly to digital power and ground, which can cause additional noise on the ADC input.
- The reset button on some of these boards is very hard to press.
- There is no dedicated USB reset circuitry on this board.
- There is no Schottky diode between USB +5V and system VIN power. So you cannot power the board directly from a 5 Volt supply, and use USB at the same time.
- Most bluepill boards have the wrong pullup resistor value which prevents native USB from working properly. The R10 resistor should have a value of 1k5 and be pulled up to 3v3. In spite of this flaw, native USB will work on some PCs. Try the board on your PC before you bother changing the resistor.

- **Microcontroller:-** most of the arduino board makes use of Atmel AVR. Microcontroller is the place where all your codes stored and executed. Microcontroller used in most commonly used arduino UNO is the ATmega328p.

- **Pins:-** these pins are used to make connections with sensors and module. Common pins on arduino boards are 5V, 3.3V, GND, Digital, PWM, Analog, AREF.

- **Power supply and USB:-** USB is used to upload the code onto your arduino board along with it you can power your arduino board via USB but it might not be always handy to power your arduino with USB in that case you can use barrel jack which is provided for power supply. A power supply anywhere between 6-12 volt will be good to power your arduino.

- (Note:-Do Not use a power supply greater than 20 volt which might overpower your arduino and destroy it.)

- **Reset button:-** this button is used to restart your arduino and make it to run the code from the beginning.

- **Power LED indicator**:- on the arduino board you will find a LED just next to 'ON' this LED glows when you connect your arduino to a power supply. If this LED does not glow either there is problem in the board or you have not connected the arduino board with power supply properly.

- **RX and TX LED:-** first of all RX and TX is short term for receive and transmit respectively. When ever there is data transfer while uploading code or communicating with bluetooth module etc these LED glow.

- **Voltage regulator:-** this controls the amount of voltage which is let into arduino by turning away extra voltage which may dame our board. This regulator also has a limit so Do Not burn up arduino by supplying power more than 20 volts.

- **Arduino NANO:-** the main feature of this board is its size ,it is very small when compared to an arduino UNO but it is capable of doing most of the thing which any other Arduino board can do.

- **Arduino Mega 2560 Rev3:-** This board is used for more complex projects as it has 54 digital pins and 16 analog pins.
  Arduino clones
- There are many clone version of arduino which are way cheaper than the original board. I would recommend a clone arduino for beginners as it serves the same purpose but at lower cost. Once you are familiar with it you can go for original made in Italy arduino boards.

`The Arduino Nano is a small, complete, and breadboard-friendly board based on the ATmega328 (Arduino Nano 3.0) or ATmega168 (Arduino Nano 2.x). It has more or less the same functionality of the Arduino Duemilanove, but in a different package. It lacks only a DC power jack, and works with a Mini-B USB cable instead of a standard one. The Nano was designed and is being produced by Gravitech. The Nano 328 is a small, complete, and breadboard-friendly board based on the ATmega328 (Arduino Nano 3.0) or ATmega168 (Arduino Nano 2.x).It have an integrated on-board USB. As the function, It has almost all the analog and digital pins that the UNO or Duemilanove has and the same function as Duemilanove or UNO. This Nano 328(Arduino compatible) can go with the IO Shield for Arduino Nano, it would be more friendly and convenient for users to enter the Arduino world and make use of Arduino to make their dream into reality. As an upgrade version of Arduino Nano, This Nano 328 is 100% compatible to Arduino Nano and its shield and IDEs. On the hardware part, remarkable changes are taken to improve the flexibility and user experience. The Arduino Nano is a small, complete, and breadboard-friendly board based on the ATmega328P (Arduino Nano 3.x). It has more or less the same functionality of the Arduino Duemilanove, but in a different package. It lacks only a DC power jack, and works with a Mini-B USB cable instead of a standard one.

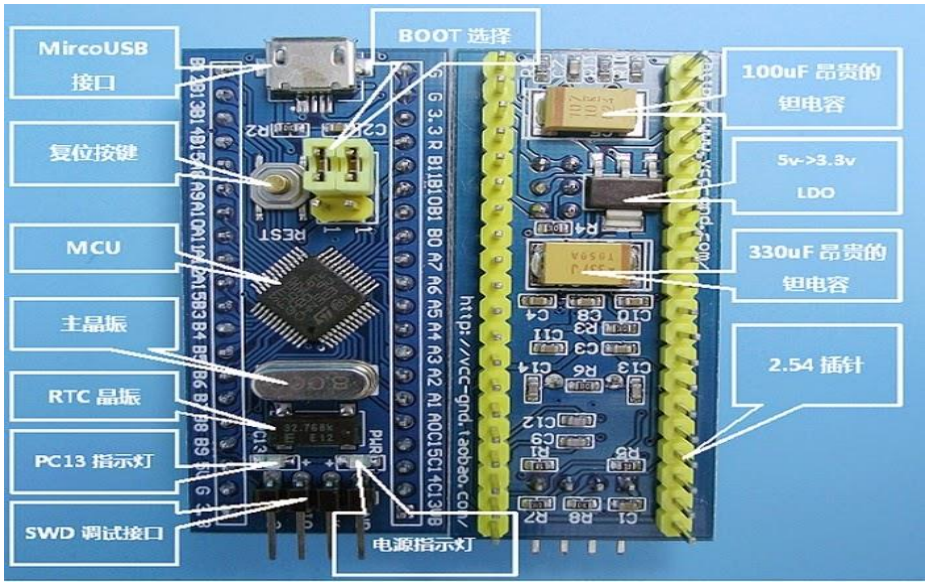


Fig 2.3.Arduino chip description

Arduino board designs use a variety of microprocessors and controllers. The boards are equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards or breadboards (*shields*) and other circuits. The boards feature

serial communications interfaces, including Universal Serial Bus (USB) on some models, which are also used for loading programs from personal computers. The microcontrollers are typically programmed using a dialect of features from the programming languages C and C++. In addition to using traditional compiler tool chains, the Arduino project provides an integrated development environment (IDE) based on the Processing language project.

The Arduino project started in 2003 as a program for students at the Interaction Design Institute Ivrea in Ivrea, Italy, aiming to provide a low-cost and easy way for novices and professionals to create devices that interact with their environment using sensors and actuators. Common examples of such devices intended for beginner hobbyists include simple robots, thermostats and motion detectors.

The name Arduino comes from a bar in Ivrea, Italy, where some of the founders of the project used to meet. The bar was named after Arduino of Ivrea, who was the margrave of the March of Ivrea and King of Italy from 1002 to 1014

2.1.1 Features

1. Power OK blue LED, RST red LED for reset the Nano.
2. Green (TX), red (RX) and orange (L) LED
3. Upgraded 5V voltage sourcing, more powerful drive capability.
4. Mini-B USB for programming and serial monitor, TX&RX breakout for application as USB-UART convertor.
5. Surface-Mount ICSP header
6. Standard 0.1” spacing DIP (Breadboard Friendly)
7. Power OK red LED, Green (TX), green (RX) and green (L) LED
8. Upgraded 5V voltage sourcing, more powerful drive capability
9. Mini-B USB for programming and serial monitor, TX&RX breakout for application as USB-UART convertor
10. Surface-Mount ICSP header

    Standard 2.54mm spacing DIP (breadboard friendly)

Microcontroller	ATmega328P – 8 bit AVR family microcontroller
Operating Voltage	5V
Recommended Input Voltage for Vin pin	7-12V
Analog Input Pins	6(A0-A5)
Digital I/O Pins	14(Out of which 6 provide PWM output)
DC Current on I/O Pins	40mA
DC Current on 3.3V Pin	50mA
Flash Memory	32KB(2 KB is used for Bootloader)
SRAM	2KB
Frequency(Clock Speed)	16 MHz
EEPROM	1KB
Communication	IIC, SPI< USART
Dimensions	0.73" x 1.70"

Table.2.1 Specifications of Arduino nano

2.2. LED Indicators:

A “Light Emitting Diode” or LED as it is more commonly called, is basically a specialised type of PN junction diode, made from a very thin layer of fairly heavily doped semiconductor material. When the diode is forward biased, electrons from the semiconductors conduction band recombine with holes from the valence band releasing sufficient energy to produce photons which emit a monochromatic (single colour) of light. Three LED’S are visible in the design as indicators.

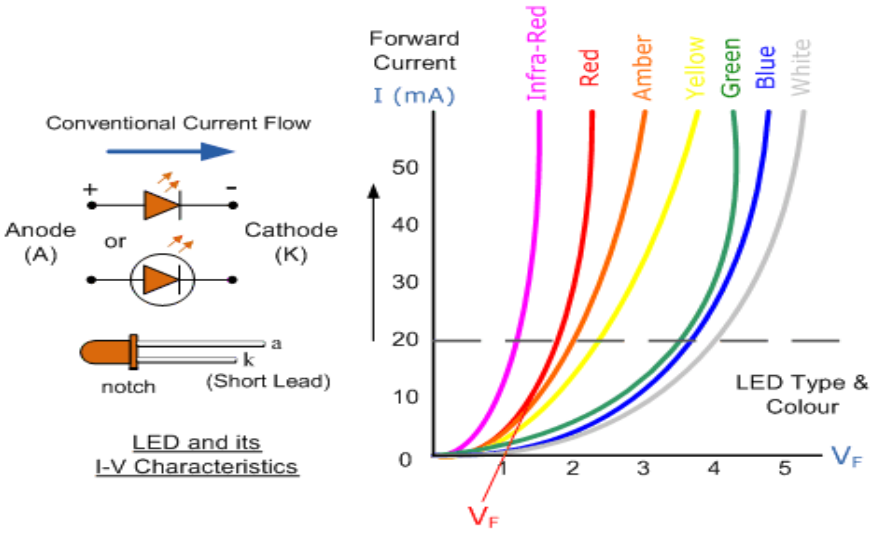


Fig.2.4 Led schematic symbol and I-V characteristics curves showing the different colours available

A light-emitting diode (LED) is a semiconductor light source. LEDs are used as indicator lamps in many devices and are increasingly used for other lighting. Appearing as practical electronic components in 1962, early LEDs emitted low intensity red light, but modern versions are available across the visible, ultraviolet, and infrared wavelengths, with very high brightness.

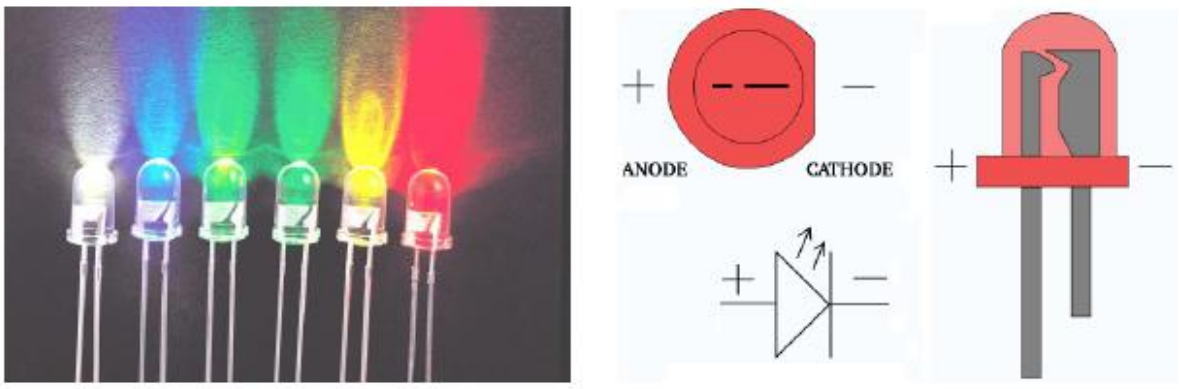


Fig.2.5. Light Emitting Diode

When a light-emitting diode is switched on, electrons are able to recombine with holes within the device, releasing energy in the form of photons. This effect is called electroluminescence and the color of the light (corresponding to the energy of the photon) is determined by the energy band gap of the semiconductor. An LED is often small in area (less than 1 mm2), and integrated optical components may be used to shape its radiation pattern. LEDs present many advantages over incandescent light sources including lower energy consumption, longer lifetime, improved physical robustness, smaller size, and faster switching. However, LEDs

powerful enough for room lighting are relatively expensive and require more precise current and heat management than compact fluorescent lamp sources of comparable output.

2.3. Wires:

A jump wire (also known as jumper, jumper wire, jumper cable, DuPont wire, or DuPont cable – named for one manufacturer of them) is an electrical wire or group of them in a cable with a connector or pin at each end (or sometimes without them – simply "tinned"), which is normally used to interconnect the components of a breadboard or other prototype or test circuit, internally or with other equipment or components, without soldering.

Fig:2.6 Wires

2.4. PCB:

A printed circuit board (PCB) mechanically supports and electrically connects electrical or electronic components using conductive tracks, pads and other features etched from one or more sheet layers of copper laminated onto and/or between sheet layers of a non-conductive substrate. Components are generally soldered onto the PCB to both electrically connect and mechanically fasten them to it.

Printed circuit boards are used in all but the simplest electronic products. They are also used in some electrical products, such as passive switch boxes.

Alternatives to PCBs include wire wrap and point-to-point construction, both once popular but now rarely used. PCBs require additional design effort to lay out the circuit, but manufacturing and assembly can be automated. Electronic computer-aided design software is available to do much of the work of layout. Mass-producing circuits with PCBs is cheaper and faster than with other wiring methods, as components are mounted and wired in one operation. Large numbers of PCBs can be fabricated at the same time, and the layout only has to be done once. PCBs can also be made manually in small quantities, with reduced benefits.

PCBs can be single-sided (one copper layer), double-sided (two copper layers on both sides of one substrate layer), or multi-layer (outer and inner layers of copper, alternating with layers of substrate). Multi-layer PCBs allow for much higher component density, because circuit traces on the inner layers would otherwise take up surface space between components. The rise in popularity of multilayer PCBs with more than two, and especially with more than four, copper planes was concurrent with the adoption of surface mount technology. However, multilayer PCBs make repair, analysis, and field modification of circuits much more difficult and usually impractical.

A basic PCB consists of a flat sheet of insulating material and a layer of copper foil, laminated to the substrate. Chemical etching divides the copper into separate conducting lines called tracks or circuit traces, pads for connections, vias to pass connections between layers of copper, and features such as solid conductive areas for electromagnetic shielding or other purposes. The tracks function as wires fixed in place, and are insulated from each other by air and the board substrate material. The surface of a PCB may have a coating that protects the copper from corrosion and reduces the chances of solder shorts between traces or undesired electrical contact with stray bare wires. For its function in helping to prevent solder shorts, the coating is called solder resist or solder mask.

A printed circuit board can have multiple copper layers. A two-layer board has copper on both sides; multi layer boards sandwich additional copper layers between layers of insulating material. Conductors on different layers are connected with vias, which are copper-plated holes that function as electrical tunnels through the insulating substrate. Through-hole component leads sometimes also effectively function as vias. After two-layer PCBs, the next step up is usually four-layer. Often two layers are dedicated as power supply and ground planes, and the other two are used for signal wiring between components.

"Through hole" components are mounted by their wire leads passing through the board and soldered to traces on the other side. "Surface mount" components are attached by their leads to copper traces on the same side of the board. A board may use both methods for mounting components. PCBs with only through-hole mounted components are now uncommon. Surface mounting is used for transistors, diodes, IC chips, resistors and capacitors. Through-hole mounting may be used for some large components such as electrolytic capacitors and connectors.

The pattern to be etched into each copper layer of a PCB is called the "artwork". The etching is usually done using photo resist which is coated onto the PCB, then exposed to light projected in the pattern of the artwork. The resist material protects the copper from dissolution into the etching solution. The etched board is then cleaned. A PCB design can be mass-reproduced in a way similar to the way photographs can be mass-duplicated from film negatives using a photographic printer.

In multi-layer boards, the layers of material are laminated together in an alternating sandwich: copper, substrate, copper, substrate, copper, etc.; each plane of copper is etched, and any internal vias (that will not extend to both outer surfaces of the finished multilayer board) are plated-through, before the layers are laminated together. Only the outer layers need be coated; the inner copper layers are protected by the adjacent substrate layers.

FR-4 glass epoxy is the most common insulating substrate. Another substrate material is cotton paper impregnated with phenolic resin, often tan or brown.

When a PCB has no components installed, it is less ambiguously called a printed wiring board (PWB) or etched wiring board. However, the term "printed wiring board" has fallen into disuse. A PCB populated with electronic components is called a printed circuit assembly (PCA), printed circuit board assembly or PCB assembly (PCBA). In informal usage, the term "printed circuit board" most commonly means "printed circuit assembly" (with components). The IPC preferred term for assembled boards is circuit card assembly (CCA),[4] and for assembled backplanes it is backplane assemblies. "Card" is another widely used informal term for a "printed circuit assembly". For example, expansion card.

A PCB may be "silkscreen" printed with a legend identifying the components, test points, or identifying text. Originally, an actual silkscreen printing process was used for this purpose, but today other, finer quality printing methods are usually used instead. Normally the screen printing is not significant to the function of the PCBA.

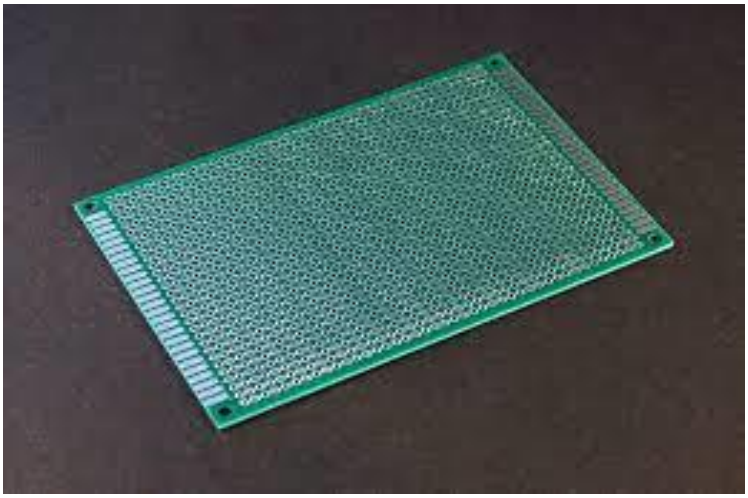


Fig.2.7.PCB

A minimal PCB for a single component, used for prototyping, is called a breakout board. The purpose of a breakout board is to "break out" the leads of a component on separate terminals so that manual connections to them can be made easily. Breakout boards are especially used for surface-mount components or any components with fine lead pitch.

Advanced PCBs may contain components embedded in the substrate.

2.4.1 Characteristics:

The first PCBs used through-hole technology, mounting electronic components by leads inserted through holes on one side of the board and soldered onto copper traces on the other side. Boards may be single-sided, with an unplated component side, or more compact double-sided boards, with components soldered on both sides. Horizontal installation of through-hole parts with two axial leads (such as resistors, capacitors, and diodes) is done by bending the leads 90 degrees in the same direction, inserting the part in the board (often bending leads located on the back of the board in opposite directions to improve the part's mechanical strength), soldering the leads, and trimming off the ends. Leads may be soldered either manually or by a wave soldering machine.

Through-hole manufacture adds to board cost by requiring many holes to be drilled accurately, and it limits the available routing area for signal traces on layers immediately below the top layer on multi-layer boards, since the holes must pass through all layers to the opposite side. Once surface-mounting came into use, small-sized SMD components were used where possible, with through-hole mounting only of components unsuitably large for surface-mounting due to power requirements or mechanical limitations, or subject to

mechanical stress which might damage the PCB (e.g. by lifting the copper off the board surface).

2.5. RESISTOR

A resistor is a passive two-terminal electrical component that implements electrical resistance as a circuit element.

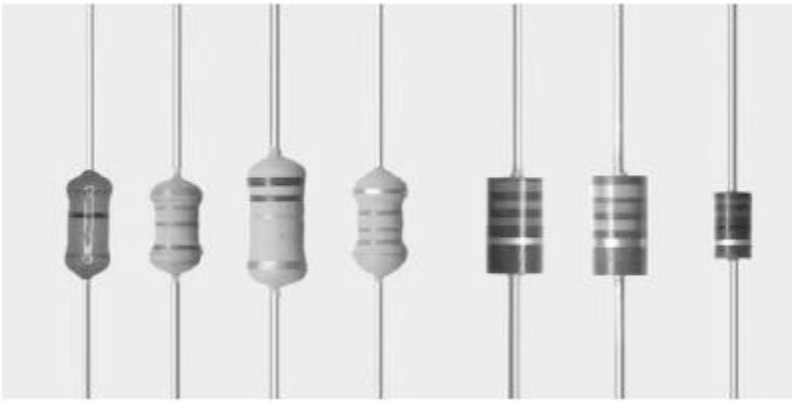


Fig.2.8 Resistor

The current through a resistor is in direct proportion to the voltage across the resistor's terminals. This relationship is represented by Ohm's law:

V=IR (4.1)

Where I is the current through the conductor in units of amperes, V is the potential difference measured across the conductor in units of volts, and R is the resistance of the conductor in units of ohms. The ratio of the voltage applied across a resistor's terminals to the intensity of current in the circuit is called its resistance, and this can be assumed to be a constant (independent of the voltage) for ordinary resistors working within their ratings. Resistors are common elements of electrical networks and electronic circuits and are ubiquitous in electronic equipment. Practical resistors can be made of various compounds and films, as well as resistance wire (wire made of a high- resistivity alloy, such as nickel-chrome). Resistors are also implemented within integrated circuits, particularly analog devices, and can also be integrated into hybrid and printed circuits.

2.5.1 Types of Resistors:

There are many thousands of different Types of Resistors and are produced in a variety of forms because their particular characteristics and accuracy suit certain areas of application, such as High Stability, High Voltage, High Current etc., or are used as general purpose resistors where their characteristics are less of a problem. All modern fixed value resistors can be classified into four broad groups, Carbon Composition Resistor - Made of carbon dust

or graphite paste, low wattage values. Film or Cermet Resistor - Made from conductive metal oxide paste, very low wattage values. Wire-wound Resistor - Metallic bodies for heat sink mounting, very high wattage ratings.

Semiconductor Resistor - High frequency/precision surface mount thin film technology.

Resistance Color Code: In order to identify the nominal resistance and the tolerance of a resistor, manufacturers typically use a color band system known as the resistor color code. The electronic color code is used to indicate the values or ratings of electronic components, usually for resistors. The power rating is not indicated in the resistor color code and must be determined by experience using the physical size of the resistor as a guide. For resistors with □5% or □10% tolerance, the color code consists of 4 color bands. For resistors with □1% or □2% tolerance, the color code consists of 5 bands. Tight tolerance resistors may have three bands for significant figures rather than two, or an additional band indicating temperature coefficient, in units of ppm/K.

2.5.2 Application:

Resistors are used with transducers to make sensor subsystems. Transducers are electronic components which convert energy from one form into another, where one of the forms of energy is electrical. Microphones and switches are input transducers. Output transducers include loudspeakers, filament lamps and LEDs.

In other circuits, resistors are used to direct current flow to particular parts of the circuit, or may be used to determine the voltage gain of an amplifier. Resistors are used with capacitors to introduce time delays.

Most electronic circuits require resistors to make them work properly and it is obviously important to find out something about the different types of resistor available, and to be able to choose the correct resistor value, in Ω,KΩ or MΩ for a particular application.

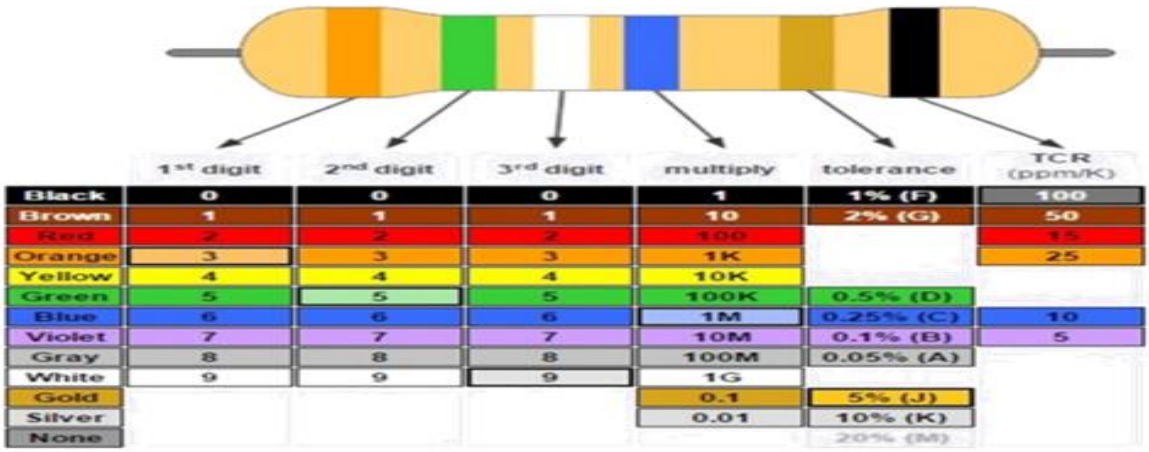


Fig:2.9. Color Coding of Resistor

1. On most resistors, you'll see there are three rainbow-colored bands, then a space, then a fourth band colored brown, red, gold, or silver.
2. Turn the resistor so the three rainbow bands are on the left.
3. The first two of the rainbow bands tell you the first two digits of the resistance. Suppose you have a resistor like the one shown here, with colored bands that are brown, black, and red and a fourth golden band. You can see from the color chart below that brown means 1 and black means 0, so the resistance is going to start with "10". The third band is a decimal multiplier: it tells you how many powers of ten to multiply the first two numbers by (or how many zeros to add on the end, if you prefer to think of it that way). Red means 2, so we multiply the 10 we've got already by 10 × 10 = 100 and get 1000. Our resistor is 1000 ohms.
4. The final band is called the tolerance and it tells you how accurate the resistance value you've just figured out is likely to be. If you have a final band colored gold, it means the resistance is accurate to within plus or minus 5 percent. So while the officially stated resistance is 1000 ohms, in practice, the real resistance is likely to be anywhere between 950 and 1050 ohms.
5. If there are five bands instead of four, the first three bands give the value of the resistance, the fourth band is the decimal multiplier, and the final band is the tolerance. Five-band resistors quoted with three digits and a multiplier, like this, are necessarily more accurate than four-band resistors, so they have a lower tolerance value.

2.6. SWITCHES

In electrical engineering, a switch is an electrical component that can disconnect or connect the conducting path in an electrical circuit, interrupting the electric current or diverting it from one conductor to another. The most common type of switch is an electromechanical device consisting of one or more sets of movable electrical contacts connected to external circuits. When a pair of contacts is touching current can pass between them, while when the contacts are separated no current can flow.

Switches are made in many different configurations; they may have multiple sets of contacts controlled by the same knob or actuator, and the contacts may operate simultaneously, sequentially, or alternately. A switch may be operated manually, for example, a light switch or a keyboard button, or may function as a sensing element to sense the position of a machine part, liquid level, pressure, or temperature, such as a thermostat. Many specialized forms exist, such as the toggle switch, rotary switch, mercury switch, pushbutton switch, reversing switch, relay, and circuit breaker. A common use is control of lighting, where multiple switches may be wired into one circuit to allow convenient control of light fixtures. Switches in high-powered circuits must have special construction to prevent destructive arcing when they are opened.

The most familiar form of switch is a manually operated electromechanical device with one or more sets of electrical contacts, which are connected to external circuits. Each set of contacts can be in one of two states: either "closed" meaning the contacts are touching and electricity can flow between them, or "open", meaning the contacts are separated and the switch is non-conducting. The mechanism actuating the transition between these two states (open or closed) are usually (there are other types of actions) either an "alternate action" (flip the switch for continuous "on" or "off") or "momentary" (push for "on" and release for "off") type.

A switch may be directly manipulated by a human as a control signal to a system, such as a computer keyboard button, or to control power flow in a circuit, such as a light switch. Automatically operated switches can be used to control the motions of machines, for example, to indicate that a garage door has reached its full open position or that a machine tool is in a position to accept another workpiece. Switches may be operated by process variables such as pressure, temperature, flow, current, voltage, and force, acting as sensors in a process and used to automatically control a system. For example, a thermostat is a temperature-operated switch used to control a heating process. A switch that is operated by another electrical circuit is called a relay. Large switches may be remotely operated by a

motor drive mechanism. Some switches are used to isolate electric power from a system, providing a visible point of isolation that can be padlocked if necessary to prevent accidental operation of a machine during maintenance, or to prevent electric shock.

Fig.2.10 Types of Switches

An ideal switch would have no voltage drop when closed, and would have no limits on voltage or current rating. It would have zero rise time and fall time during state changes, and would change state without "bouncing" between on and off positions.

Practical switches fall short of this ideal; as the result of roughness and oxide films, they exhibit contact resistance, limits on the current and voltage they can handle, finite switching time, etc. The ideal switch is often used in circuit analysis as it greatly simplifies the system of equations to be solved, but this can lead to a less accurate solution. Theoretical treatment of the effects of non-ideal properties is required in the design of large networks of switches, as for example used in telephone exchanges.

2.7. POTENTIOMETER

The Potentiometer is an electric instrument that used to measure the EMF (electro motive force) of a given cell, the internal resistance of a cell. And also it is used to compare EMFs of different cells. It can also use as a variable resistor in most of the applications. These potentiometers are used in huge quantities in the manufacture of electronics equipment that provides a way of adjusting electronic circuits so that the correct outputs are obtained. Although their most obvious use must be for volume controls on radios and other electronic equipment used for audio.

Fig.2.11 Potentiometer

Why is Potentiometer chosen over Voltmeter to measure the potential (EMF) of a cell? When we use Voltmeter, current flows through the circuit and because of the internal resistance of the cell, always terminal potential will be less than the actual cell potential. In this circuit, when the potential difference is balanced (using a Galvanometer null detection), no current flows in the circuit, so the terminal potential will be equal to the actual cell potential. So we can understand that the Voltmeter measures the terminal potential of a cell, but this measures actual cell potential. The schematic symbols of this is shown below.

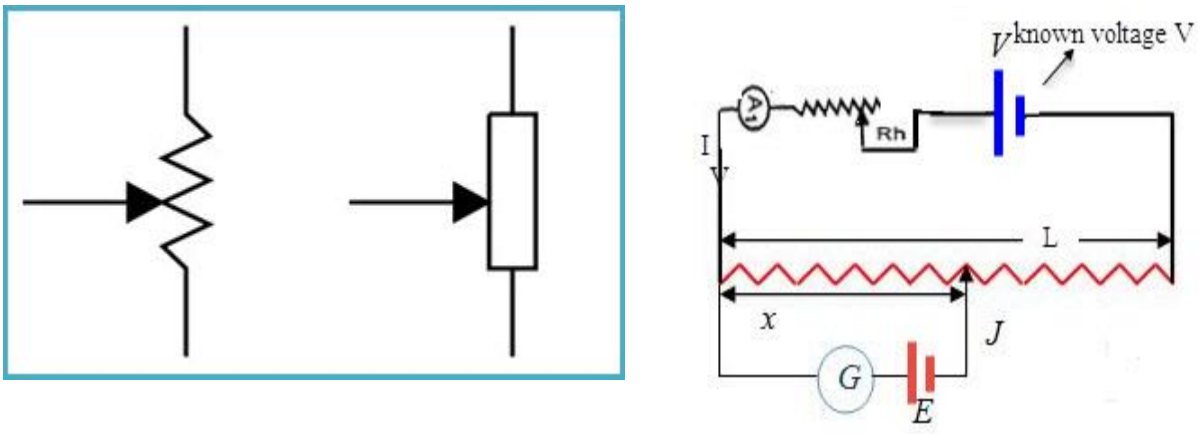


Fig. 2.12.Symbol and Construction of Potentiometer

The basic working principle of this is based on the fact that the fall of the potential across any portion of the wire is directly proportional to the length of the wire, provided wire has uniform cross-sectional area and the constant current flowing through it.“When there is no potential difference between any two nodes there is electric current will flow”. Now the potentiometer wire is actually a wire with high resistivity (ṕ) with uniform cross-sectional area A. Thus, throughout the wire, it has uniform resistance. Now this potentiometer terminal connected to the cell of high EMF V (neglecting its internal resistance) called driver cell or

the voltage source. Let the current through the potentiometer is I and R is the total resistance of the potentiometer.

Then by Ohms law V=IR

2.7.1 Types of Potentiometers

A potentiometer is also commonly known as pot. These potentiometers have three terminal connections. One terminal connected to a sliding contact called wiper and the other two terminals are connected to a fixed resistance track. The wiper can be moved along the resistive track either by use of a linear sliding control or a rotary "wiper" contact. Both rotary and linear controls have the same basic operation. The most common form of the potentiometer is the single turn rotary potentiometer. This type of potentiometer is often used in audio volume control (logarithmic taper) as well as many other applications. Different materials are used to construct potentiometers, including carbon composition, cermet, conductive plastic, and the metal film.

2.7.1.1 Rotary Potentiometers

These are the most common type of potentiometers, where the wiper moves along a circular path.

Fig.2.13 Rotatory Potentiometers

Type	Description	Application
Single-turn pot	Single rotation of approximately 270 degrees or ¾ of a full turn	Most common pot, used in applications where a single turn provides enough control resolution.
Multi-turn pot	Multiple rotation(mostly 5, 10 or 20), for increased prescision. They are constructed either with a wiper thwt follows a spiral or helix form, or by using a worm-gear	Used where high precision and resolution required. The worm-gear multi turn pots are often used as trimpots on PCB
Dual-gang pot	Two potentiometer combined on the same shaft, enabiling the parallel setting of two channels, most common are single turn potentiometers with equal resistance and taper. More than two gangs are possible but not very common	Used in for example stereo audio volume control or other applications where 2 channels have to be adjusted in parallel.
Concentric pot	Dual pot meter, where the two potentiometers are individually adjusted by means of concentric shafts. Enables the use of two controls on one unit.	Often encountered in car radios, where the volume and tone controls are combined.
Servo pot	A motorized pot meter which can also be automatically adjusted by a servo motor	Used where manual and automatic adjustments is required. Often seen in audio equipment, where the remote-control can turn volume control knob.

Table.2.2.Rotary Potentiometer types and applications

2.7.1.2 Linear Potentiometers

In these types of Potentiometers the wiper moves along a linear path. Also known as slide pot, slider, or fader.

Fig.2.14 Linear potentiometers

Type	Description	Applications
Slide pot	Single linear slider potentiometer, for audio applications also known as a fader. High quality faders are often constructed from conductive plastic	For single channel control or measurement of distance.
Dual-slide pot	Dual slide potentiometer, Single slider controlling two potentiometers in parallel.	Often used for stereo control in professional audio or other applications where dual parallel channels are controlled.
Multi-turn slide	Constructed from a spindle which actuates a linear potentiometer wiper. Miltiple rotations, for increased prescision	Used where high precision and resolution is required. The multi turn linear pots are used as trimpots on PCB, but not as common as the worm-gear trimmer potentiometer.
Motorized fader	Fader which can be automatically adjusted by a servo motor	Used where manual and automatic adjustment is required. Common in studio audio mixers, where the servo faders can be automatically moved to a saved configuration.

Table.2.3.Linear Potentiometers types and Applications

2.7.2 Applications of Potentiometers

Potentiometer as a Voltage Divider

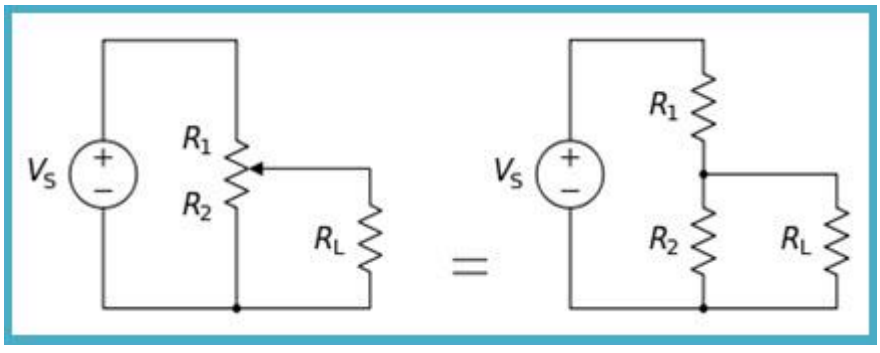


Fig .2.15.Circuit diagram of Potentiometer as a Voltage Divider

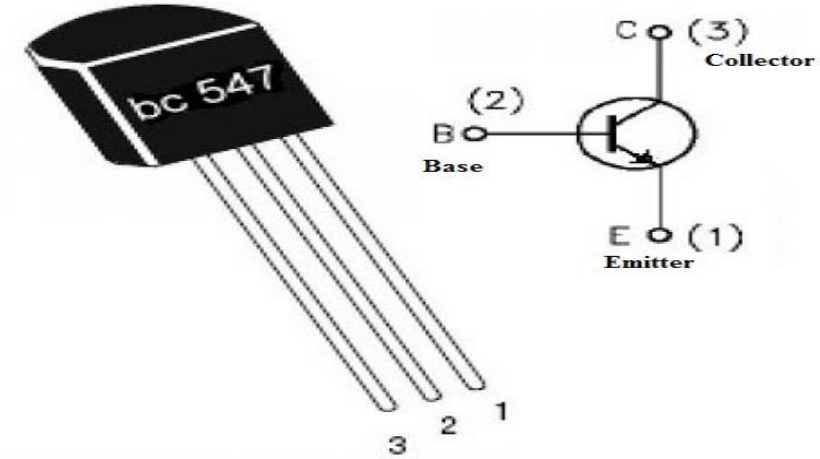
The potentiometer can be worked as a voltage divider to obtain a manual adjustable output voltage at the slider from a fixed input voltage applied across the two ends of the potentiometer. Now the load voltage across RL can be measured as

VL= R2RL. VS/(R1RL+R2RL+R1R2)

2.8. BC547 TRANSISTOR:

The semiconductor device like a transistor is one kind of switch which controls electrically. It consists of three terminals like an i/p, o/p & a control line. These are named as the emitter (E), collector(C) and base (B). A transistor works like a switch as well as an amplifier to convert the waves from audio to electronic. Transistors are smaller in size, long life and can operate with low voltage supplies. The first transistor was designed with Ge (germanium). In modern electronics, it is the basic building block and used in various electrical and electronic systems. This article discusses an overview of BC547 transistor working and its applications.

The BC547 transistor is an NPN transistor. A transistor is nothing but the transfer of resistance which is used for amplifying the current. A small current of the base terminal of this transistor will control the large current of emitter and base terminals. The main function of this transistor is to amplify as well as switching purposes. The maximum gain current of this transistor is 800A.



Fig,2.16. BC 547-transistor

The similar transistors are like BC548 & BC549. This transistor works in a fixed DC voltage in the preferred region of its characteristics which is called the biasing. Further, the series of this transistor can be divided into three groups based on the current gain like BC547A, BC547B & BC547C.

2.8.1 BC547 Transistor Pin Configuration

The BC547 transistor includes three pins which include the following.

bc547-transistor-pin-configuration

- Pin1 (Collector): This pin is denoted with symbol 'C' and the flow of current will be through the collector terminal.
- Pin2 (Base): This pin controls the transistor biasing.
- Pin3 (Emitter): The current supplies out through emitter terminal

A Transistor works as an amplifier while functions in the active region to amplify voltage, current, and power at various configurations. The amplifier circuit uses three configurations which include the following.

- Common emitter (CE) amplifier
- Common collector (CC) amplifier
- Common base (CB) amplifier

From the above three configurations, CE is the most widely used configuration.

Working States of Transistor

The working states of BC547 transistor include the following.

- Forward Bias.
- Reverse Bias.

In a forward bias mode, the two terminals like emitter & collector are connected to allow the flow of current through it. Whereas in a reverse bias mode, it doesn't allow the flow of current through it because it works as an open switch.

2.8.2 Features

The features of the BC547 transistor include the following.

- The gain of DC current (hFE) = 800 A
- Continuous Ic (collector current) = 100mA
- VBE (emitter-base voltage) = 6V
- IB (base current) = 5mA
- The polarity of the transistor is NPN
- The transition frequency is 300MHz
- It is obtainable in semiconductor package like-92
- Power dissipation is 625mW

2.8.3 Precautions of this Transistor

The precautions of this transistor include the following.

- To run the transistor for a long time in a circuit, it is very important that it doesn't increase the load more than 100mA.
- The voltage should not exceed to 45V DC across the transistor.
- The base resistor should be used for providing the necessary current intended for saturation.
- Maintain the temperature from the above +150oC to -65 oC.
- Always verify the three terminals of the transistor while connecting in-circuit otherwise the performance can be reduced and the circuit can be damaged.

2.8.4 Applications

Applications of BC547 transistor include the following.

- This BC547 transistor is used general-purpose, widely used and it is used as an alternative as well as a substitute to different kinds of transistors. Thus, it can use in different electronic circuits
- The utmost transition frequency of BC547 is 300MHz so that it will perform well within RF circuits.
- Amplification of current
- Audio Amplifiers
- Switching Loads < 100mA
- Transistor Darlington Pairs
- Drivers like an LED driver, Relay Driver, etc.
- Amplifiers like Audio, signal, etc..
- Darlington pair
- Quick switching
- PWM (Pulse Width Modulation)

These transistors are used to build various electrical and electronic circuits which include the following.

- Alarm circuits
- LED flasher circuit
- Water level indicator

- Sensor-based circuits
- Audio Preamp circuits
- RF Circuits
- Touch-sensitive switch circuit
- Heat sensor circuit
- Moisture sensitive alarm
- Latch circuit
- Street light circuit
- Relay driver based on one channel
- Indication of volume level

2.9.LCD (Liquid Crystal Display):

This LCD screen is an electronic display module and find a wide range of applications. A 16x2 LCD display is very basic module and is very commonly used in various devices and circuits. These modules are preferred over seven segments and other multi segment LEDs. The reasons being: LCDs are economical; easily programmable; have no limitation of displaying special & even custom characters (unlike in seven segments), animations and so on.

A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, Command and Data.

The command register stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc. The data register stores the data to be displayed on the LCD. The data is the ASCII value of the character to be displayed on the LCD. Click to learn more about internal structure of a LCD.

Pin Diagram:

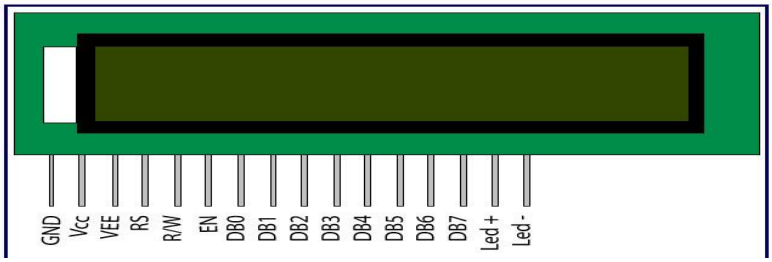


Fig. 2.17 Pin Description of LCD

Pin No	Function	Name
1	Ground (0V)	Ground
2	Supply voltage; 5V (4.7V – 5.3V)	Vcc
3	Contrast adjustment; through a variable resistor	VEE
4	Selects command register when low; and data register when high	Register Select
5	Low to write to the register; High to read from the register	Read/write
6	Sends data to data pins when a high to low pulse is given	Enable
7	8-bit data pins	DB0
8		DB1
9		DB2
10		DB3
11		DB4
12		DB5
13		DB6
14		DB7
15	Backlight VCC (5V)	Led+
16	Backlight Ground (0V)	Led-

Table.2.4 Pin Description of LCD

2.10. RELAY:

The relay is the device that open or close the contacts to cause the operation of the other electric control. It detects the intolerable or undesirable condition with an assigned area and gives the commands to the circuit breaker to disconnect the circuit. It works on the principle of electromagnetic attraction. It is a electromagnetic switch operated by a relatively small current that can control much larger current.

2.10.1 Features

Works on 5V 240V Appliances can be controlled from a ARM Processor with a 5V signal

High power loads which cannot be directly controlled from ARM Processors can be switched on/off with this relay module. Loads like 12V DC Motors, Solenoids, LEDs, etc can be controlled with this module. Relay board uses high quality relays with a maximum load of 7A/240 V AC or 7A/24V DC Board comes with connectors for easy connections to both the

ARM processor and the load. The board uses high quality relays, which can handle a maximum of 7A/240 V AC or 7A/24V DC. Each relay has all three connections - Common, Normally Open, Normally Closed brought out to 3 pin screw terminals which makes it easy to make and remove connections. The board has a power indication and a relay status LED to ease debugging. The board requires a 5V to power supply to power the relay. The relay can then be turned on and off with 5V HIGH Signal from a ARM Processor. Power input and relay control signals are brought to header pins on the board. Hence, the board can be easily interface with our Arduino and development boards using our female to female jumper wires.

The relay takes advantage of the fact that when electricity flows through a coil, it becomes an electromagnet. The electromagnetic coil attracts a steel plate, which is attached to a switch. So the switch's motion (ON and OFF) is controlled by the current flowing to the coil, or not, respectively.

A very useful feature of a relay is that it can be used to electrically isolate different parts of a circuit. It will allow a low voltage circuit (e.g. 5VDC) to switch the power in a high voltage circuit (e.g. 100 VAC or more).

The relay operates mechanically, so it can not operate at high speed.

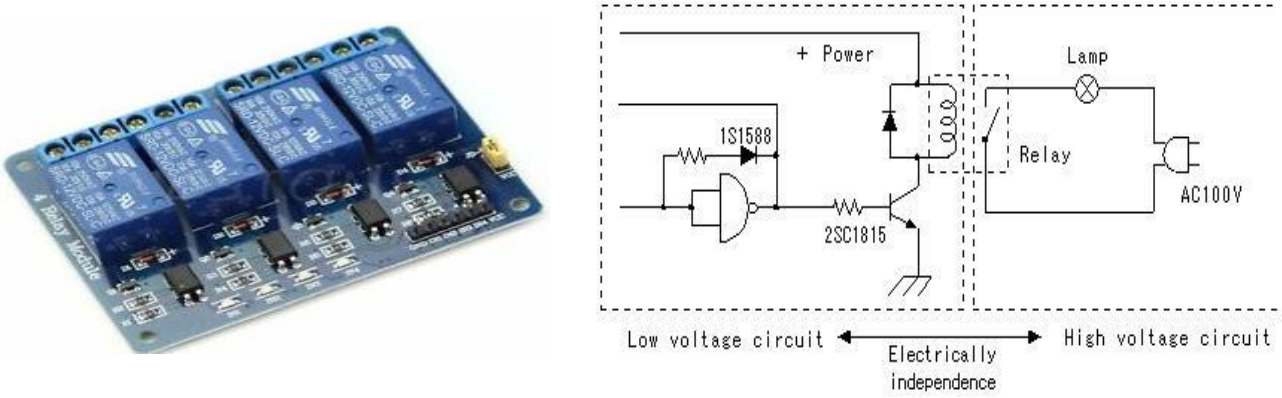


Fig. 2.18. Relay and Internal circuit of Relay

There are many kind of relays. You can select one according to your needs. The various things to consider when selecting a relay are its size, voltage and current capacity of the contact points, drive voltage, impedance, number of contacts, resistance of the contacts, etc. The resistance voltage of the contacts is the maximum voltage that can be conducted at the

point of contact in the switch. When the maximum is exceeded, the contacts will spark and melt, sometimes fusing together. The relay will fail. The value is printed on the relay.

2.11.STEP DOWN TRANSFORMER:

A transformer is a static electrical device that transfers energy by inductive coupling between its winding circuits. A varying current in the primary winding creates a varying magnetic flux in the transformer's core and thus a varying magnetic flux through the secondary winding. This varying magnetic flux induces a varying electromotive force (emf) or voltage in the secondary winding. A transformer whose output voltage is lower than it’s input voltage. A secondary winding of such a transformer has fewer turns than the primary. Such a transformer may have multiple secondary windings. It used, for instance, to decrease the voltage of electricity as it leaves the transmission system and enters the distribution system. The output voltage of a step-up transformer is higher than its input voltage. Also spelled step down transformer.

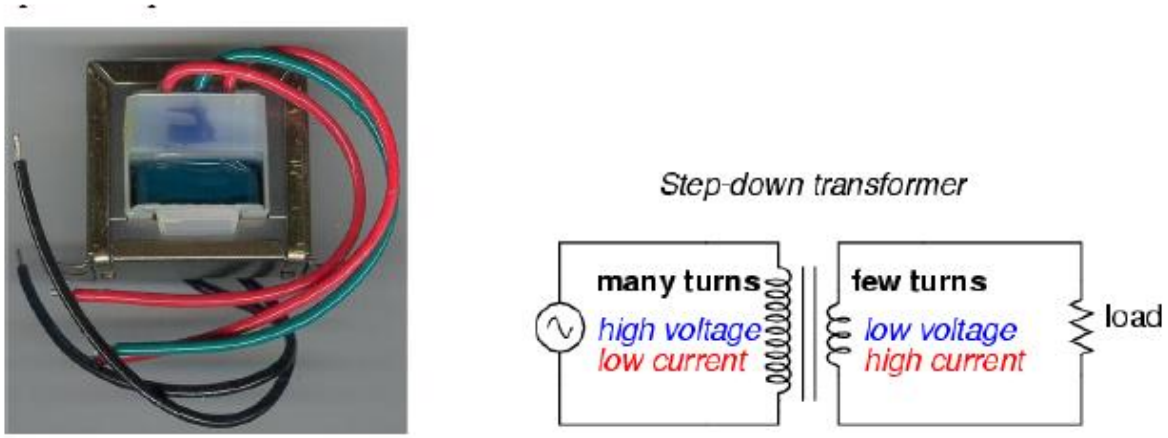


Fig:2.19. Step-down transformer

This is a step-down transformer, as evidenced by the high turn count of the primary winding and the low turn count of the secondary. As a step-down unit, this transformer converts high-voltage, low-current power into low-voltage, high-current power.12-0-12,1A Centre-Tapped Step Down Transformer is a general-purpose. Transformer has 230V primary winding and centre-tapped secondary winding. The Transformer act as a step-down transformer reducing 230VAC RMS to 12VAC RMS. It can be used in small rectifier circuits to charge a 12V battery, Power small devices with low voltage ratings like Arduino, PIC, AVR, and Raspberry Pi and other controllers. To connect the Transformer, you need to connect the input primary wires to the 230VAC RMS Voltage supply which is the standard wall socket

voltage in India. The voltage across blue and white wires is 12V and voltage across the two blue wires is 24V.

2.11.1 Working principle of a transformer:

- A transformer is static (or stationary) piece of apparatus which:

1.Transfers electric power from one circuit to another.

2.It does so without a change in frequency.

3.The principle is based on mutual induction between two circuits linked by a common magnetic flux.

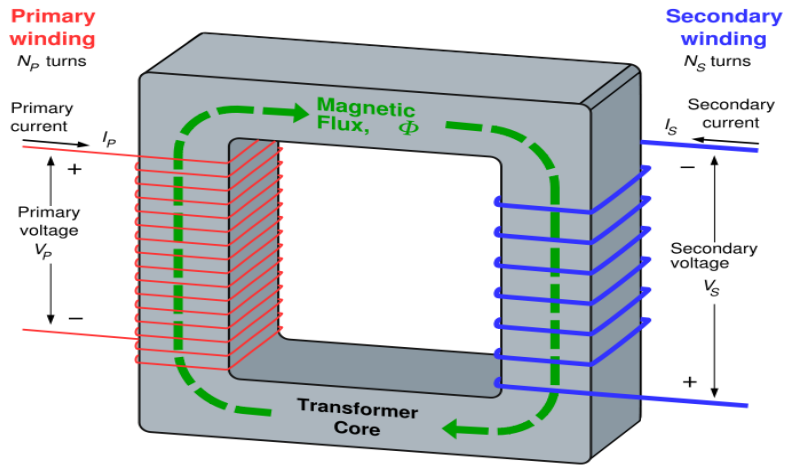


Fig.2.20. Step Down Transformer

- Basically a transformer consists o f a :

1.A primary coil or winding.

2.A secondary coil or winding.

3.A core that supports the coils or the windings

A Step Down transformer is a device which converts high primary voltage to a low secondary voltage. In a step down Transformer, the primary winding of a coil has more turns than the secondary winding. The above fig shows the step down transformer.

Transformer works on the principle of "Faraday's law of electromagnetic Induction". Mutual induction between the windings is responsible for transmission action in a transformer. Faraday's law states that "when the magnetic flux linking a circuit changes, an electromotive force is induced in the circuit proportional to the rate of change of the flux linkages. The emf(Electro Motive Force) induced between the two windings is determined by the number of turns in primary and secondary winding respectively. This ratio is called as Turns Ratio. The voltage reduction capability of step down transformer depends on the turn ratio of the

primary and secondary coil. As the number of windings in secondary coil is less as compared to the number of windings in primary coil, So the amount of flux linkages to the secondary coil of the transformer will also be less compared to the primary coil.

Accordingly, the emf induced will be less in the secondary coil. Due to this, the voltage reduces at the secondary winding compared to primary winding.

2.11.2 Specifications:

1. Input Voltage: 220V AC at 50Hz
2. Output Voltage: 24V, 12V or 0V
3. Output Current: 1A

Other center tapped transformers are (12-0-12),(18-0-18),(24-0-24),(2A,3A,5A) etc.

2.11.3 Applications:

1. Rectifier circuits
2. AC-AC step down
3. Full wave rectifiers

2.12. RECTIFIER

A rectifier is an electrical device that converts alternating current (AC), which periodically reverses direction, to direct current (DC), which flows in only one direction. The process is known as rectification. Physically, rectifiers take a number of forms, including vacuum tube diodes, mercury-arc valves, copper and selenium oxide rectifiers, semiconductor diodes, silicon-controlled rectifiers and other silicon based semiconductor switches. Based upon contolling the rectifiers divided into two types they are ‘Controlled’ and ‘Uncontrolled’ rectifiers. In this uncontrolled rectifiers are divided into two types they are ‘Half wave Rectifier’ and ‘Full wave Rectifier’. Again the Full wave rectifier is divided into two types they are ‘Bridge Rectifier’ and ‘Center-Tap Rectifier’. In our project we use ‘Uncontrolled Full wave Bridge Rectifier’.

2.12.1 Diode:

- A **diode** is a semiconductor device that essentially acts as a one-way switch for current. It allows current to flow easily in one direction, but severely restricts current from flowing in the opposite direction.
- Diodes are also known as **rectifiers** because they change alternating current (ac) into pulsating direct current (dc). Diodes are rated according to their type, voltage, and current capacity.

- Diodes have polarity, determined by an **anode** (positive lead) and **cathode** (negative lead). Most diodes allow current to flow only when positive voltage is applied to the anode.
- When a diode allows current flow, it is **forward-biased**. When a diode is **reverse-biased**, it acts as an insulator and does not permit current to flow.
- The diode symbol's arrow points against the direction of electron flow. Reason: Engineers conceived the symbol, and their schematics show current flowing from the positive (+) side of the voltage source to the negative (-). It's the same convention used for semiconductor symbols that include arrows—the arrow points in the permitted direction of "conventional" flow, and against the permitted direction of electron flow.

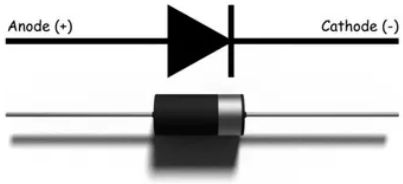


Fig.2.21.Diode

2.12.2 Capacitor:

A capacitor (originally known as a condenser) is a passive two-terminal electrical component used to store energy electrostatically in an electric field. Unlike a resistor, a capacitor does not dissipate energy. Instead, a capacitor stores energy in the form of an electrostatic field between its plates.

Capacitor, device for storing electrical energy, consisting of two conductors in close proximity and insulated from each other. A simple example of such a storage device is the parallel-plate capacitor. If positive charges with total charge +Q are deposited on one of the conductors and an equal amount of negative charge −Q is deposited on the second conductor, the capacitor is said to have a charge Q.

Fig.2.22.Capacitors

2.12.3 Bridge Rectifier

A bridge rectifier uses four diodes to convert both half cycle of the input AC and DC output

In this type of rectifier, the diodes are connected in a specific form as given below.

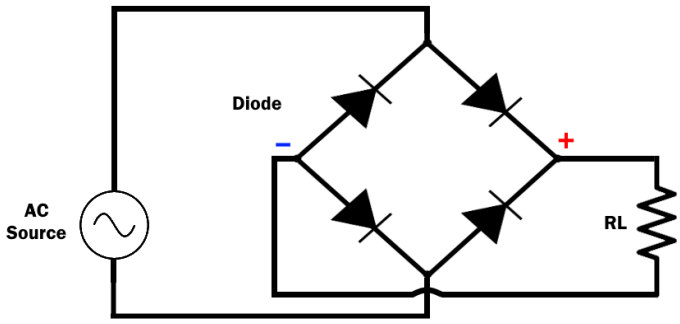


Fig.2.23. Bridge Rectifier

Positive Half Cycle:

During input positive half cycle, the diode D1 & D2 becomes forward bias while D3 & D4 becomes reverse bias. The diode D1 & D2 form a closed loop that provides a positive output voltage across the load resistor RL

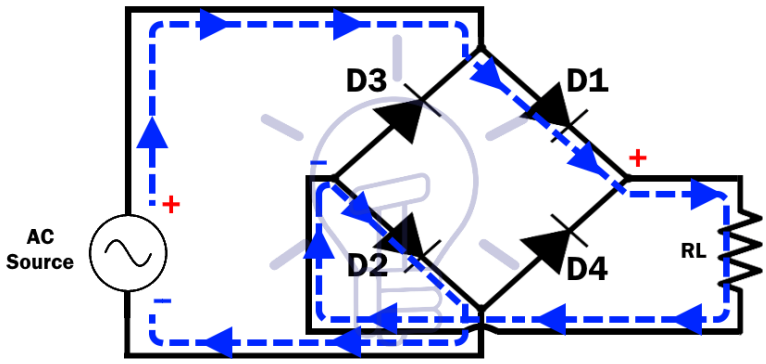


Fig.2.24.Bridge Rectifier During Positive Cycle

Negative Half Cycle:

During the negative half cycle, the diode D3 & D4 becomes forward bais while D1 & D2 becomes reverse bias. But the polarity across the load resistor RL remains the same and provides a positive output across the load.

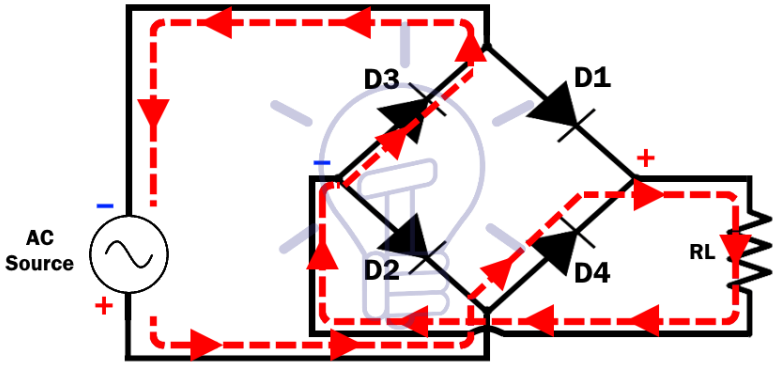


Fig.2.25.Bridge Rectifier During Negative Cycle

The output of full wave rectifier has low ripples compared to half wave rectifier but still, it's not smooth and steady.

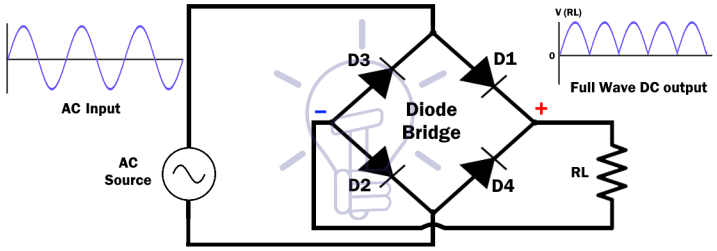


Fig.2.26.Bridge Rectifier Output

In order to make the output voltage smooth & steady, a capacitor is placed at the output as shown in the figure below.

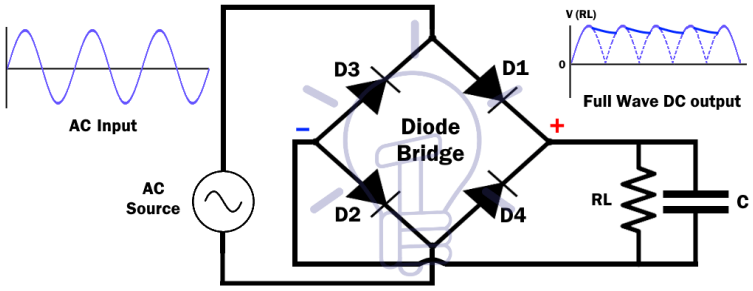


Fig.2.27.Bridge Rectifier Output With Capacitor

The capacitor charge & discharges which make smooth transitions between the half cycles.

2.12.4 Advantages of a Bridge Rectifier:

1. Low ripple in the output DC signal
2. High rectifier efficiency
3. Low Power Loss

2.13. Voltage Sensor Module:

2.13.1 Description:-

Voltage Sensor is a precise low cost sensor for measuring voltage. It is based on principle of resistive voltage divider design. It can make the red terminal connector input voltage to 5 times smaller. Arduino analog input voltages up to 5V, the voltage detection module input voltage not greater than 5Vx5=25V (if using 3.3V systems, input voltage not greater than 3.3Vx5=16.5V).

Arduino AVR chips have 10-bit AD, so this module simulates a resolution of 0.00489V (5V/1023), so the minimum voltage of input voltage detection module is 0.00489Vx5=0.02445V.

2.13.2 Features & Specifications:-

- Voltage input range: DC 0-25V
- Voltage detection range: DC 0.02445V-25V
- Voltage Analog Resolution: 0.00489V
- DC input connector: Terminal cathode connected to VCC, GND negative pole
- Output interface: "+" connect 5/3.3V, "-" connect GND, "s" connect the Arduino AD pins

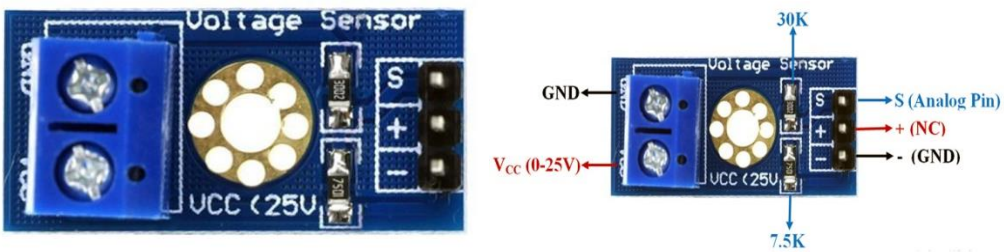


Fig.2.28.Voltage Sensor Module and Voltage Sensor Module Pinout

Voltage Sensor is a precise low-cost sensor for measuring voltage. It is based on the principle of resistive voltage divider design. It can make the red terminal connector input voltage to 5 times smaller.

Pin Name	Description
VCC	Positive terminal of the External voltage source (0-25V)
GND	Negative terminal of the External voltage source
S	Analog pin connected to Analog pin of Arduino
+	Not Connected
-	Ground Pin connected to GND of Arduino

Table2.5. Voltage Sensor Module Pinout Configuration

Input Voltage: 0 to 25V

Voltage Detection Range: 0.02445 to 25

Analog Voltage Resolution: 0.00489V

Needs no external components

Easy to use with Microcontrollers

Small, cheap and easily available

Dimensions: 4 × 3 × 2 cm

Brief about Voltage Sensor Module

Voltage Detection Sensor Module is a simple and very useful module that uses a potential divider to reduce any input voltage by a factor of 5. This allows us to use the Analog input pin of a microcontroller to monitor voltages higher than it capable of sensing. For example, with a 0V - 5V Analog input range, you are able to measure a voltage up to 25V. This module also includes convenient screw terminals for easy and secure connections of a wire.

The internal **circuit diagram of the Voltage Sensor Module** is given below.

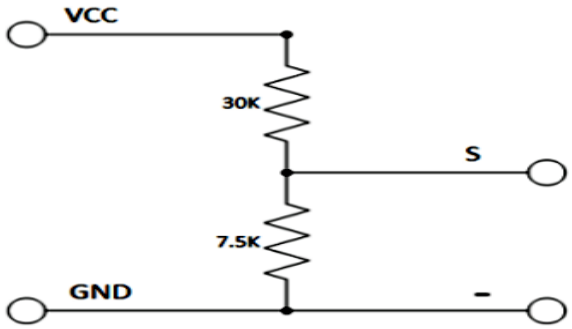


Fig.2.29.Circuit Diagram of the Voltage Sensor Module

The voltage circuit consists of a voltage divider circuit of two resistors in which R1 is 30K and R2 is 7.5K.

This is a simple but very useful module which uses a potential divider to reduce an input voltage by a factor of 5. The Voltage Sensor Module 25V allows you to use the analog input of a microcontroller to monitor voltages much higher than it capable of sensing.

For example with a 0-5V analog input range, you are able to measure a voltage up to 25V. This voltage sensor module also includes convenient screw terminals for easy and secure connection of a wire.

This module is based on the principle of resistive voltage divider design, can make the red terminal connector input voltage to 5 times smaller. Arduino analog input voltages up to 5 v, the voltage detection module input voltage not greater than 5Vx5=25V (if using 3.3V systems, input voltage not greater than 3.3Vx5=16.5V).

Arduino AVR chips have 10-bit AD, so this module simulates a resolution of 0.00489V (5V/1023), so the minimum voltage of input voltage detection module is 0.00489Vx5=0.02445V.

Note:

Keep in mind, you are restricted to voltages that are less than 25 volts. More than that and you will exceed the voltage limit of your Arduino input.

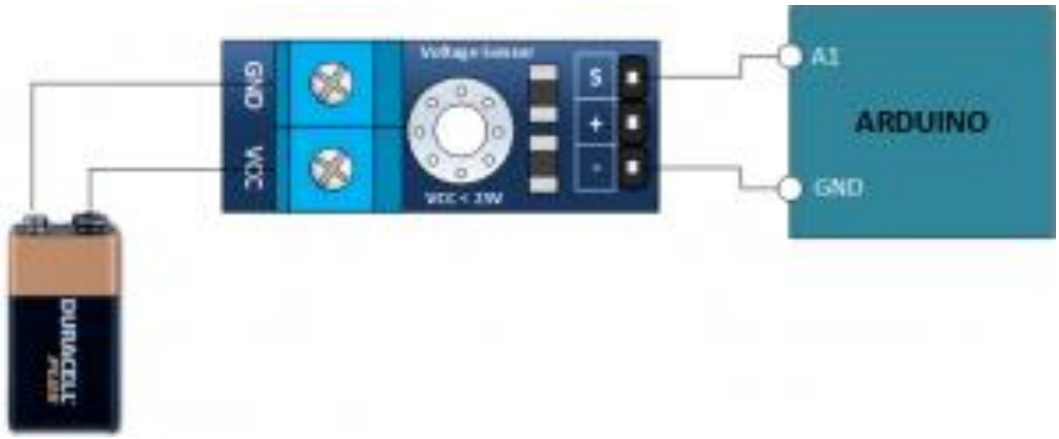


Fig.2.30.Connection Diagram

1. Output Interface: "+ " connected 5/3.3V, "-" connected GND, "s" connected Arduino AD pins
2. DC input interface: red terminal positive with VCC, negative with GND
3. You can also use the IICLCD1602 LCD to display voltage.

4. By 3P connector, connect this module with the expansion of board Arduino, not only makes it easier for you to detect voltage battery. Package Includes :1×Voltage Detection Sensor Module

2.14:BUZZER:

A buzzer or beeper is an audio signalling device, which may be mechanical, electromechanical, or piezoelectric (piezo for short). Typical uses of buzzers and beepers include alarm devices, timers, and confirmation of user input such as a mouse click or keystroke.

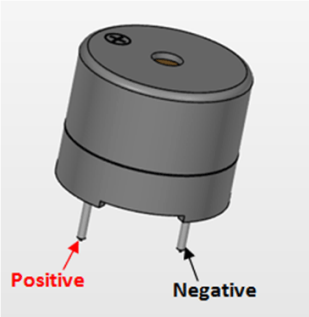


Fig.2.31 Buzzer

1 : one that buzzes specifically : an electric signaling device that makes a buzzing sound. 2 : the sound of a buzzer.

2.14.1 Features and Specifications

- Rated Voltage: 6V DC
- Operating Voltage: 4-8V DC
- Rated current: <30mA
- Sound Type: Continuous Beep
- Resonant Frequency: ~2300 Hz
- Small and neat sealed package
- Breadboard and Perf board friendly

2.14.2 Applications:

- Alarming Circuits, where the user has to be alarmed about something
- Communication equipments
- Automobile electronics
- Portable equipments, due to its compact size

2.15 7805 VOLTAGE REGULATOR

7805 is a three terminal linear voltage regulator IC with a fixed output voltage of 5V which is useful in a wide range of applications. Currently, the 7805 Voltage Regulator IC is manufactured by Texas Instruments, ON Semiconductor, STMicroelectronics, Diodes incorporated, Infineon Technologies, etc.

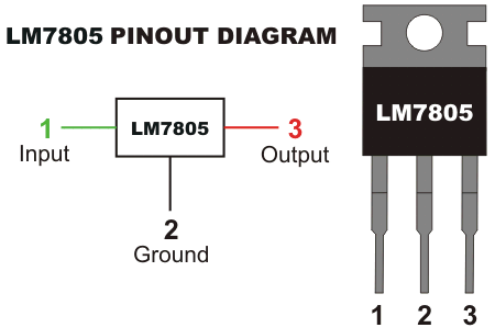


Fig2.32 LM7805 Pin Diagram

Pin1-Input

The function of this pin is to give the input voltage. It should be in the range of 7V to 35V. We apply an unregulated voltage to this pin for regulation. For 7.2V input, the PIN achieves its maximum efficiency.

Pin 2- Ground

We connect the ground to this pin. For output and input, this pin is equally neutral (0V).

Pin 3-Output

This pin is used to take the regulated output. It will be 5V

2.15.1 Features

- It can deliver up to 1.5 A of current (with heat sink).
- Has both internal current limiting and thermal shutdown features.

- Requires very minimum external components to fully function.

In this 7805 voltage regulator lots of energy is dissipated or exhausted in the form of ‘heat’. So to reduce that heat or to cool down the voltage regulator quickly we use ‘Heat sink’ which is fitted to it by means of screw.

CHAPTER-3

WORKING PROCEDURE

3.1 WORKING:

The working procedure of the 'Power Theft Identification System of Distribution Lines Using Differential Power Measurement is explained below.

This project is designed to find out such power theft in the normal distribution lines. In this project we use differential protection scheme. The Differential protection scheme consist of two CT's (Current Transformer) connected at both the terminals of the load. If there is no fault in the load then the secondary currents of both the CT's will be same.

So, by using same principle one CT is connected at the starting of the distribution line and the remaining other CT's are connected to the different legal loads. If there is no power theft in the line then the vector sum of the all CT's which are connected to the loads will be equal to the current in the main CT. If there is a difference then there is a power theft or any fault in the line.

This can be simply understand by its Block Diagram

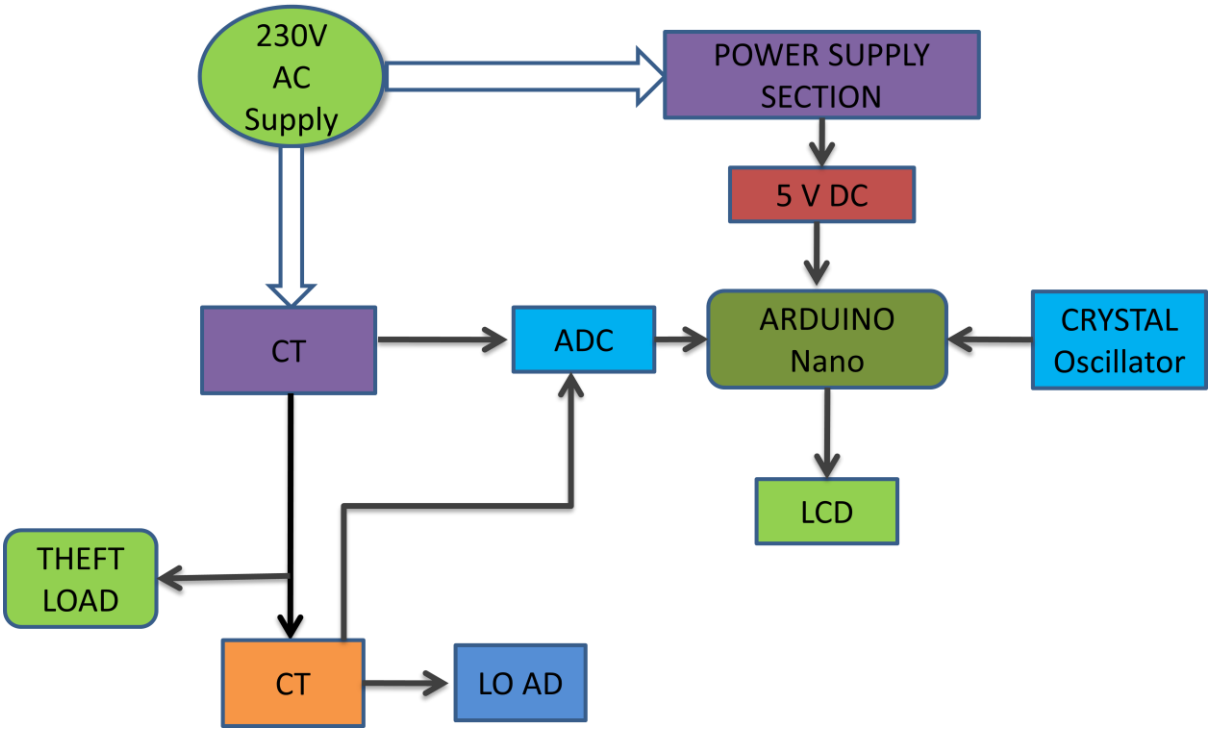


Fig.3.1 Block Diagram

3.2 BLOCK DIAGRAM EXPLANATION:

The Fig.3.1. is the block diagram of the power theft identification system of distribution lines using differential power measurement. It works on the principle of differential protection scheme .

In the Block Diagram it consists :

- Current transformer (CT's)
- Loads
- Arduino Nano
- LCD

The current transformers is used for the measurements of high current values .It is a stepdown current transformer. Primary is connected to the where the current is to be measured. At the secondary terminals stepdown current is obtained and the current is obtained in analog form it is converted to digital by ADC block

There are two types of loads in block diagram that is Legal load and Illegal load . legal loads are the loads which is connected by the meter and Ct's are connected at each legal loads. Illegal loads are the loads which are not connected by the meter and theft the power illegally and CT's are not present at this loads.

Arduino nano is a small, complete, and breadboard-friendly board based on ATmega328P. its operating voltage is 5V and it has both Analog and Digital pins . it has SRAM of 2KB and EEPROM of 1KB and one crystal oscillator is connected to it , this crystal oscillator gives the electrical signals to the microcontroller at constant frequency of 16MHz.

The power supply is given to the step down transformer , this transformer step down the voltage from 230V to 12V-0V-12V that is center tapped transformer . Maximum output will be 24V . this is given to the Rectifier that is Full wave Diode Bridge Rectifier

This rectifier which converts AC voltage to the DC voltage and the out put of this has some ripples which is reduced by the filter connected after the rectifier so pure DC output is obtained by the using of the 7805 voltage regulator the output of this voltage regulator will be 5V constant . This voltage is given to the supply input to the Arduino Nano because every basic electronic circuit will operate under regulated 5V DC.

There will be two loads where one will be the legal load and other will be the theft load that is we use bulbs as loads. In this prototype we connect the theft load manually to show that theft is detected when the illegal load is connected .

The working is ecplained in two cases, that is

Case-1: When theft load is not connected

Case-2: When theft load is connected

CASE-1: WHEN THEFT LOAD IS NOT CONNECTED

When only Legal load is connected , only that load is blown and the secondary currents at both the CT's are same, so the vector sum of secondary of the CT's will be same , this is given to the Arduino. so by the program which is written in the Arduino it compares the two currents and the currents is same then the output is displayed on the LCD screen that is the current value displayed on the screen and the buzzer will not blown.

CASE-2: WHEN THEFT LOAD IS CONNECTED

When the illegal load is connected , both the legal load and the theft load is blown and the secondary currents of both CT's are not same, then there is a difference in the vector sum of secondary of the CT's. this is given to the Arduino. By the program it compares the two currents and the currents are not same then the output s displayed on the LCD screen is "Theft detected" and the current value is displayed on the screen and the buzzer will blown.

CHAPTER-4

APPLICATIONS AND ADVANTAGES

APPLICATIONS AND ADVANTAGES

4.1 ADVANTAGES

- Real time Power monitoring.
- It will automatically find all the power theft.
- A data log can also be maintained which will be very useful to know what is the time and quantity of power theft and any judicial dispute.
- We can use the same project for measuring the fault using differential protection scheme.

4.2 APPLICATIONS

- Can be used in distribution feeders
- Can be used in industries and complexes where the power theft load will be there

CHAPTER -5

RESULT AND CONCLUSION

5.1 RESULTS

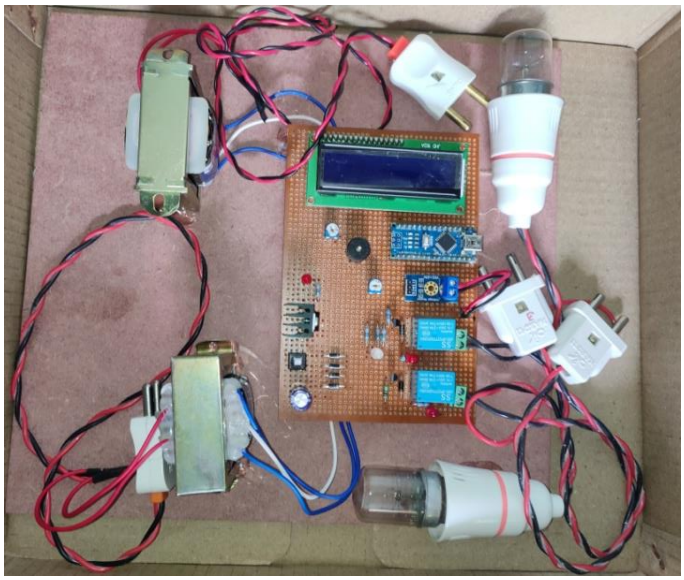


Fig. 5.1 shows the practical circuit of the power theft identification system using Differential Power Measurement.

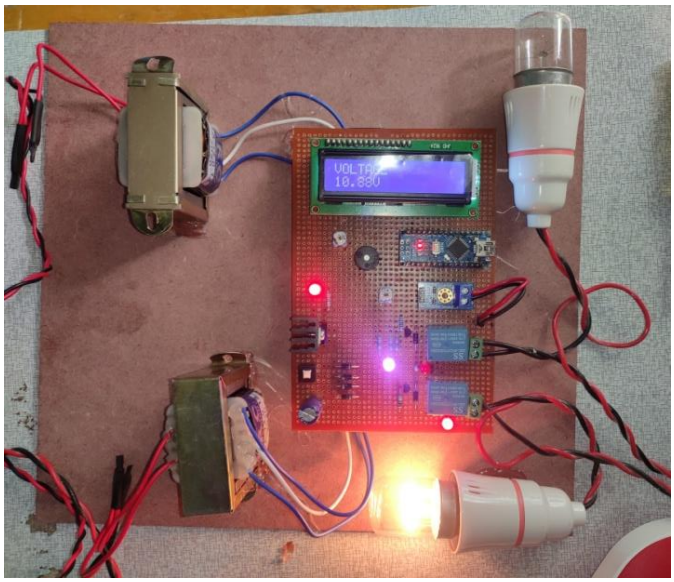


Fig.5.2 shows the when there is no power theft that is no illegal load is added and the voltage is displayed on the LCD screen

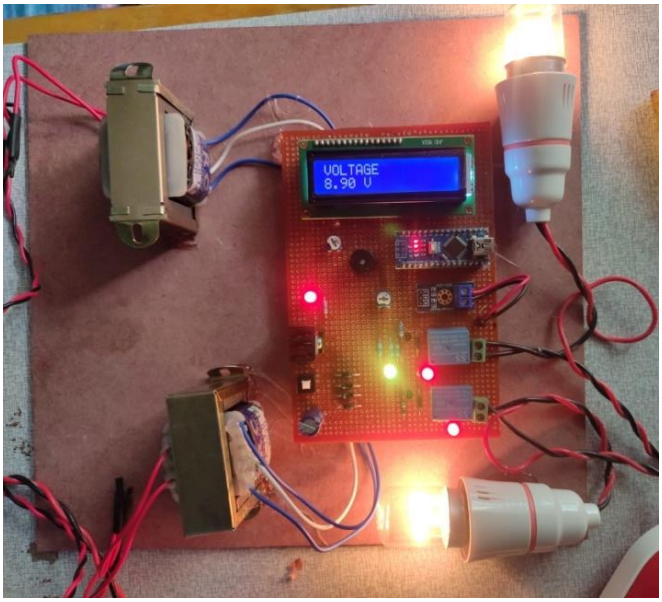


Fig.5.3 shows the when there is power theft that is illegal load is added, so illegal bulb is blown and the voltage is displayed on the LCD screen

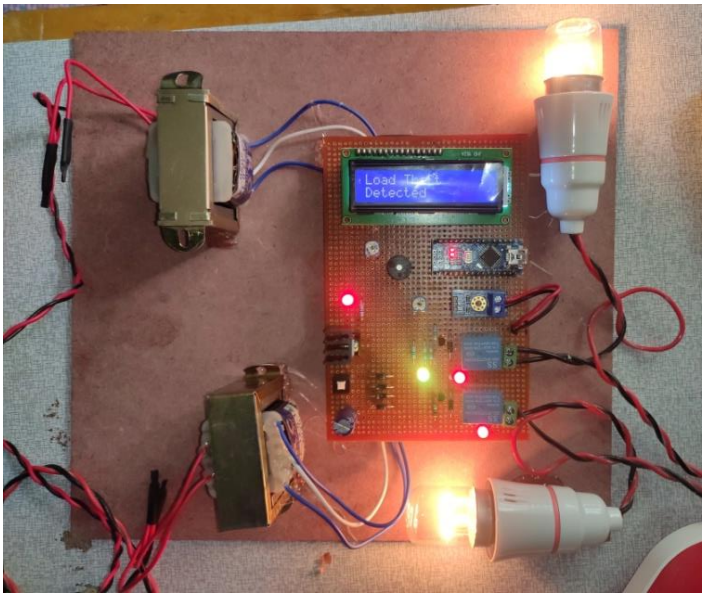


Fig.5.4 shows the when theft load that is illegal load is added, In the LCD "Load Theft Detected" is displayed on the screen

The above figures are the **"Result diagrams of Power theft Identification system of Distribution lines using Differential Power Measurement"**

The proposed Power Theft Identification System of Distribution Lines using Differential Power Measurement is cost effective and one of the simple way to find the power theft in distribution lines. By this it helps to increase our nation economy because power is used illegally which effect the nations economy directly and the installation cost is more but we can find the power theft in particular area and particular distribution line which reduces the time of identification of power theft now a days. Although installation cost is more it can last for many years. By using CT's, the secondary currents of main and load CT's is given to the Arduino Nano and with the help of program it compares the both currents , If there is difference between two currents then there is a theft in power. If the two currents is same then there is no power theft. This will help to tackle the problem of electricity theft which is very high in India.

5.2 CONCLUSION

It is found that overloading, due to various reasons such as power theft, unbalance condition due to loading of any phase are the prime cause of failure transformer. Most of them are caused due to low maintenance as many localities are situated at remote areas

so this system will help to prevent transformers from being damaged or overload condition. This will help to tackle the problem of electricity theft and transformer damage, as the failure rate is very high in INDIA, around 25% per annum, which is not favorably comparable to international norms of 1-2%

5.3 FUTURE SCOPE

Further this prototype is extended to find the power theft in effective manner by using modern techniques. Still research is going on this project. We believe that this project will reduce the power theft in our country

PROGRAM:

```
#include <LiquidCrystal.h>//import the LCD library

LiquidCrystal lcd(13, 12, 6, 5, 4, 3);// Pins used for RS,E,D4,D5,D6,D7

int x;

#define relay 7

#define buzzer 10

void setup()  {

  lcd.begin(16,2);//LCD 16x2 initialization

  pinMode(relay, OUTPUT);

  pinMode(buzzer, OUTPUT);

  digitalWrite(buzzer, LOW);

  digitalWrite(relay, LOW);

  lcd.setCursor(0,0); //Initially set the cursor position of LCD to 1st Columb 1st row.

  lcd.print("Engineers Garage");//After initialising print data

  lcd.setCursor(0,1); //Initially set the cursor position of LCD to 1st Columb 2nd row.

  lcd.print("               ");  //print blank to clear all the data on LCD
```

```
  delay(3000);
  lcd.setCursor(0,0);
  lcd.print(" LOAD DETECTION ");
  lcd.setCursor(0,1);
  lcd.print(" AND  SHUTDOWN  ");
  delay(3000);
  lcd.setCursor(0,0);
  lcd.print("                ");
  lcd.setCursor(0,1);
  lcd.print("                ");
   }


void loop() {
   x=analogRead(A0)*(5.0/1023.0)*100;
   lcd.setCursor(0,0);
```

```
  lcd.print("    OVER LOAD        ");
  lcd.setCursor(0,1);
  lcd.print("  DETECTION  ");
  lcd.setCursor(13,1);
  lcd.print(x);
if(x>385 && x <470){
  digitalWrite(relay, HIGH);
  lcd.setCursor(0,0);
  lcd.print("  LOAD DETECTED ");
  lcd.setCursor(0,1);
  lcd.print("                ");
  for(int i=0;i<3;i++){
  digitalWrite(buzzer,HIGH);
  delay(500);
  digitalWrite(buzzer,LOW);
```

```
    delay(500);

      }

      }

  else if(x<280){

    digitalWrite(relay, LOW);

     }

     else;



  } // end loop
#
```

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