A PROJECT ON SOLAR MONITORING SYSTEM

FULL SEMESTER INTERNSHIP REPORT

Submitted by

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in partial fulfillment for the award of the degree

of

BACHELOR OF TECHNOLOGY

in

ELECTRICAL AND ELECTRONICS ENGINEERING

GMR Institute of Technology, Rajam
Andhra Pradesh, India

OCTOBER 2023

GMR Institute of Technology
An Autonomous Institute Affiliated to JNTU-GV

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A PROJECT ON SOLAR MONITORING SYSTEM

Internship carried out at

NSIC-TECHNICAL SERVICE CENTRE, HYDERABAD

Report *Submitted by*

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BONAFIDE CERTIFICATE

Certified that this internship report **"A PROJECT ON SOLAR MONITORING SYSTEM"** is the bonafide work of **BARATAM ASHISH (20341A0207), BEHARA BHUVANESWARA RAO (20341A0209), BODEPU SAIKUMAR (20341A0214), CHINTADA GANESWARA RAO (20341A0223), CHOKKAKULA SAGAR (20341A0225)** who carried out full semester internship under our supervision at **NSIC-TECHNICAL SERVICE CENTRE, HYDERABAD.**

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ABSTRACT

The Solar Panel Monitoring System described in this project utilizes Arduino Uno and ESP8266 to create a comprehensive monitoring and display solution for solar panel installations. Solar energy is a crucial part of renewable energy systems, and efficient monitoring is essential to ensure optimal energy generation and system maintenance. In this system, various sensors are employed to measure critical parameters, including solar irradiance, panel temperature, and battery voltage. The Arduino Uno serves as the central control unit, gathering data from these sensors and processing it. Additionally, an ESP8266 module facilitates wireless communication, allowing for remote monitoring and control via a web-based interface.

However, the primary focus of this project is the real-time display of data on an LCD screen using the I2C communication protocol. The collected data, including solar panel output, battery status, and environmental conditions, is continuously updated and presented on the LCD. Users can conveniently access these values on-site, providing instant insights into the system's performance. This Solar Panel Monitoring System offers benefits such as improved efficiency in energy production, early detection of issues, and reduced maintenance costs. By providing a real-time view of critical data, it empowers users to make informed decisions about their solar panel installation. Furthermore, it contributes to the promotion of clean and sustainable energy sources and represents a practical application of IoT (Internet of Things) technology in the renewable energy sector.

LIST OF FIGURES

CHAPTER - 1
INTRODUCTION

1.1 Objectives of Internship

The main purpose of the internship is to merge our academic knowledge with practical knowledge of power plant. We would like to extend our knowledge in depth and breadth in a specific area. We took this program to fulfil our academic requirement. We are allotted to a power plant for this industrial training as an opportunity to receive a great experience in applying theoretical knowledge into a practical exposure mainly concentrating on what we do never know about. We believe in a successful internship can give us valuable information in making decisions about the direction of future studies or employment. In our internship, we have focused on general layout of the thermal power plant, operation and maintenance of Electrostatic Precipitator in detail.

1.2 Outcomes of Internship

The exact nature, activities and emphasis within an internship can be known throughout the time of an internship. Our awareness of community issues, motivate ourselves to create opportunities, embrace new ideas, and give direction to positive change as well as the experience, qualities and aspirations of the intern.

Students Will:

i. Bridge the gap between theoretical study and the professional world.

ii.. Find out exactly what engineers do in order to decide if they want to spend their lives as engineers.

iii Discover why they're studying mathematics, physics, and theory.

iv Become professionals who can take their learning in the classroom and adapt it to the workplace and develops professional behavior and social skills.

v. Get a head start on classroom learning by working with engineering principles on the job.

vi. Gain self-confidence and motivation and develop expertise in interacting with people.

vii. Become more attractive to employers because they're already trained and can be productive immediately.

1.3 The Institute Will Benefit Through

i. Better use of classrooms, laboratories and other facilities.

ii. Better relations with industry, government, and business.

iii. Better prepared students who are more desirable to employers and are ready to meet today's challenging work environment.

iv. Better educated students with leading edge technology training in the workplace as well as insight into professionalism and proper social behaviour.

v. Technology transfer fiscally responsible students.

vi. Better education to all students by students returning to school and sharing their experiences with professors and classmates.

1.4 Organization Will Get

i. The opportunity to pre-screen our most ambitious and enthusiastic students-the kind who thrive on challenge.

ii. The opportunity to evaluate temporary employees while deciding whether to make a permanent offer.

iii. An infusion of new ideas and methods.

iv. The opportunity to train an employee in your methods and processes.

v. Greater visibility on the institute campus.

vi. Increased opportunities for technology transfer.

1.5 Learnings at NSIC Industry

i. **Area Worked on:** A brief view on plant and an intensive study on Basics electronics and IOT in NSIC industry.

ii. **Literature Survey:** In our internship, we have focused on the basic electronics, IOT and logic gates by using ESP in detail. We have done a project on ESP working model and succeeded at end. The report outline will gives in detail.

iii. **Problems Existing in ESP Area:** Improper functioning of ESP due to mis-placement of heaters, harmful gases are released into atmosphere may cause pollution in the environment, improper sealing may lead to leakage of gases.

iv. **Brief Description to Shot Out the Problem:** To solve the above problems, all the heaters in an ESP should be placed outside. This ensures the easy replacement of the hopper heaters. So that the faults occurred can be reduced. Methods like de• sulfurization and similar methods can be implemented to reduce pollution. Proper sealing must be done during the maintenance of ESP so that the efficient functionality of the plant can be improved.

v. **Context of Working here in Internship:** No matter where our skills and understanding the professionalism lie, our internship is a chance to develop them even further in depth of the concept from engineering view and to enhance our knowledge as possible as we can.

vi. **Contribution from the Learning:** Have done a working model of an ESP and provided necessary requirements that can be implemented in the plant to improve efficiency and to reduce the pollution.

CHAPTER-2

PROFILE OF THE COMPANY

National Small Industries Corporation (NSIC), is an ISO 9001:2015 certified Government of India Enterprise under Ministry of Micro, Small and Medium Enterprises (MSME). NSIC has been working to promote, aid and foster the growth of micro, small and medium enterprises in the country. NSIC operates through countrywide network of offices and Technical Centres in the Country. In addition, NSIC has set up Training cum Incubation Centre managed by professional manpower.

2.1 Mission:

"To promote and support Micro, Small & Medium Enterprises (MSMEs) Sector" by providing integrated support services encompassing Marketing, Technology, Finance and other services.

2.2 Vision:

"To be a premier Organization fostering the growth of Micro, Small and Medium Enterprises (MSMEs) Sector".

2.3 Schemes of NSIC:

NSIC facilitates Micro, Small and Medium Enterprises with a set of specially tailored scheme to enhance their competitiveness. NSIC provides integrated support services under Marketing, Technology, Finance and other Support service.

2.4 Exhibitions and Technology Fairs:

To showcase the competencies of Indian MSMEs and to capture market opportunities, NSIC participates in select International and National Exhibitions and Trade Fairs every year. NSIC facilitates the participation of the small enterprises by providing concessions in rental etc. Participation in these events exposes MSMEs to international practices and enhances their business prowess.

2.5 Technology Support:

Technology is the key to enhancing a company's competitive advantage in today's dynamic information age. Small enterprises need to develop and implement a technology strategy in addition to financial, marketing and operational strategies and adopt the one that helps integrate their operations with their environment, customers and suppliers.

NSIC offers small enterprises the following support services through its Technical Services Centres and Extension Centres:

1. Advise on application of new techniques
2. Material testing facilities through accredited laboratories
3. Product design including CAD
4. Common facility support in machining, EDM, CNC, etc.
5. Energy and environment services at selected centres
6. Classroom and practical training for skill upgradation.

2.6 International Cooperation:

NSIC facilitates sustainable international partnerships. The emphasis is on sustainable business relations rather than on one-way transactions. Since its inception, NSIC has contributed to strengthening enterprise-to-enterprise cooperation, south south cooperation and sharing best practices and experiences with other developing countries, especially those in the African, Asian and Pacific regions. The features of the scheme are:

1. Exchange of Business / Technology missions with various countries.
2. Facilitating Enterprise to Enterprise cooperation, JVs, Technology Transfer & other form of sustainable collaboration.
3. Explore new markets & areas of cooperation:
4. Identification of new export markets by participating in sector- specific exhibitions all over the world.
5. Sharing of Indian experience with other developing countries

2.7 International Consultancy Services:

For the last five decades, NSIC has acquired various skill sets in the development process of small enterprises. The inherent skills are being networked to offer consultancy services for other developing countries. The areas of consultancy are as listed below:

1. Capacity Building
2. Policy & Institutional Framework
3. Entrepreneurship Development

CHAPTER-3

BASICS OF ELECTRICITY

3.1 Resistors:

A resistor is an electrical component that is used to restrict the flow of electric current in an electrical circuit. It does so by providing resistance to the flow of electrons. Resistors are fundamental components in electronics and are used for various purposes, including voltage division, current limiting, signal conditioning, and temperature sensing.

Resistors are characterized by their resistance value, which is measured in ohms (Ω). The resistance value determines how much the resistor limits the current in a circuit. Resistors come in various types, each designed for specific applications. Here are some common types of resistors:

Types of Resistors:

1. Fixed Resistors:
    - Carbon Film Resistor: These resistors are made by depositing a carbon film on a ceramic substrate. They are inexpensive and widely used in various electronic devices. In CFR we have four colours first and second are the numbers and third one is the multiplier and the fourth one is the tolerance.
    - Metal Film Resistor: Metal film resistors have a thin metal film on a ceramic substrate. They offer better precision and stability than carbon film resistors. In MFR we have five colours first second and third are the numbers and forth one is the multiplier and the fifth one is the tolerance.
    - Surface Mount Resistors (SMD): These are miniature resistors designed for surface-mount technology (SMT) applications, where components are mounted directly onto the surface of a printed circuit
2. Variable Resistors:
    - Potentiometer: Also known as a variable resistor or pot, it allows the user to manually adjust the resistance within a specific range. Potentiometers are often used for volume control and tuning in electronic devices.
    - Rheostat: Similar to a potentiometer but designed for higher power applications, rheostats are used to vary the current in a circuit, such as in motor speed control.
    - Light-Dependent Resistor (LDR): LDRs vary their resistance with changes in light intensity, making them suitable for light-sensing applications.

3.1.2 Color Coding:

The color coding of resistors is a system used to indicate the resistance value of a resistor using a series of colored bands. Each color represents a number, and by reading the colors in the correct order, you can determine the resistor's resistance value.

a) Identify the color Bands: Examine the resistor's color bands, typically located on one end. There are usually three to four colored bands.

b) Determine the First Digit: Look at the color of the first band from the left. Match it to the corresponding number from the color code chart: Black: 0 Brown: 1 Red: 2 Orange: 3 Yellow: 4 Green: 5 Blue: 6 Violet: 7 Gray: 8 White: 9

c) Determine the Second Digit: Check the color of the second band (next to the first one) and match it to the corresponding number as you did for the first band.

d) Determine the Multiplier: The third band represents the multiplier, indicating how many zeros should be added to the first two digits to calculate the resistance value.

3.2 Capacitors:

A capacitor is an electrical component that stores and releases electrical energy in an electrical circuit. It consists of two conductive plates separated by an insulating material called a dielectric. When a voltage is applied across the plates, it creates an electric field between them, causing the capacitor to store electrical charge. Capacitors are used in various electronic circuits for tasks such as energy storage, filtering, timing, and coupling. Capacitors come in a variety of types, each designed for specific applications based on their characteristics. Here are some common types of capacitors:

1. Fixed Capacitor:

i. Polarized Capacitor:

a) Electrolytic Capacitors: Electrolytic capacitors have a liquid or gel-like electrolyte as the dielectric. They offer high capacitance values, making them suitable for applications where larger capacitance is required. Electrolytic capacitors are polarized, meaning they have a positive and a negative lead, and they must be connected in the correct orientation.

b) Tantalum Electrolytic Capacitors: Tantalum capacitors are smaller in size than aluminium capacitors and are used in compact electronic devices.

ii. Non-Polarized Capacitor:

a) Ceramic Capacitors: These capacitors use a ceramic material as the dielectric. They are small in size, inexpensive, and widely used in various applications. They are available in different capacitance values and voltage ratings. Ceramic capacitors are typically non-polarized, meaning they can be connected in either direction.

b) Polyester Capacitors: Polyester capacitors use a polyester film as the dielectric material. The polyester film is a type of plastic that provides good electrical insulating properties.

c) Polypropylene Capacitors: Polypropylene capacitors use a polypropylene film as the dielectric. Polypropylene is a high-quality plastic material known for its excellent dielectric properties.

2. Variable Capacitor:

a) Gang Condenser (Ganged Capacitor): A gang condenser is a type of variable capacitor where multiple individual capacitors, also known as sections or gangs, are mechanically linked together and adjusted simultaneously.

b) Trimmer Capacitors: Trimmer capacitors, also known as variable capacitors or tuning capacitors, are single capacitors with a variable capacitance that can be manually adjusted within a specified range.

3.3 Coil/Inductor/Choke:

a) Coil: A coil is a generic term used to describe a wire wound into a spiral or cylindrical shape. It can be a simple coil of wire without a core or it can have a core made of various materials, such as iron or ferrite. Coils are used in a wide range of applications, including as inductors and transformers. In some contexts, "coil" may refer to any type of wound wire, including those used in electromagnets, solenoids, and more.

b) Inductor: An inductor is a type of coil that stores electrical energy in the form of a magnetic field when current flows through it. The primary property of an inductor is its inductance, measured in henrys (H), which indicates its ability to resist changes in current flow. Inductors are commonly used to filter out high-frequency noise in circuits, store energy temporarily, and control the rate of change of current. They are often found in power supply circuits, audio circuits, and RF (radio frequency) circuits.

c) Choke: A choke is a type of inductor designed specifically to block or impede the flow of high-frequency alternating current (AC) while allowing direct current (DC) or lower-frequency AC to pass through. Chokes are used for noise filtering, reducing electromagnetic interference (EMI), and improving the performance of power supplies. Common types of chokes include common-mode chokes (used to suppress common-mode noise) and differential-mode chokes (used to suppress differential-mode noise). In power supply applications, a choke can help smooth out voltage and current fluctuations.

3.4 Tube light with choke and stater:

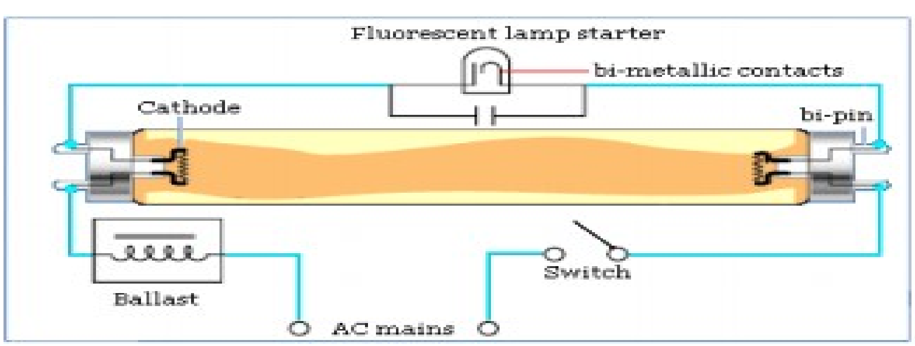


Fig: 3.1 Tube light with choke and starter

- It is a device which emits the photons by using electric energy
- In the tube light the tube contains the Argon Gas and Mercury which contains more Resistance.
- We have to reduce the Resistance to flow the photons in the tube one end to another end. We can reduce the resistance by increasing the temperature in the tube, to increase the heat we give the high voltage that is nearly 800-1000v at initial stage.
- But we have 230v as input voltage to increase the voltage to high we use the combination circuit of Inductor and Starter. To increase the spark voltage.

3.5. Electronic Ballast:

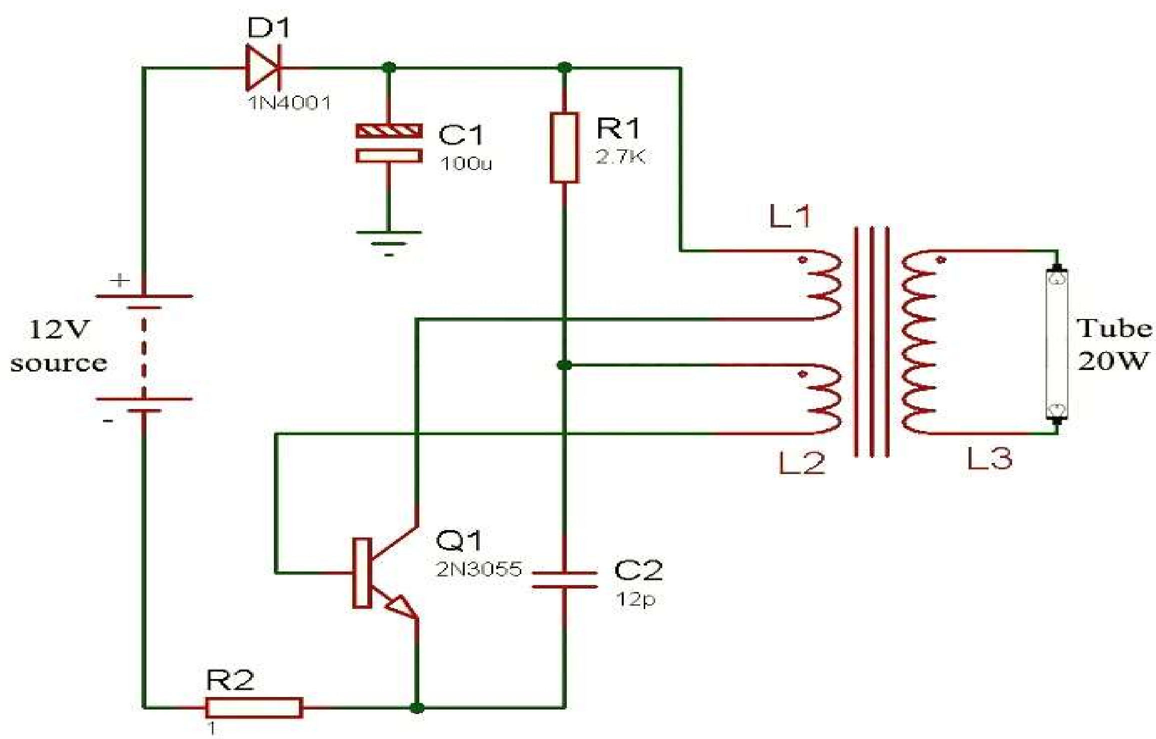


Fig: 3.2 Circuit diagram of Electronic Ballast

- Electronic Ballast is the updated type of Choke tube light. It is also containing the tube with photons to emit the light with the different working principle. In this electronic ballast we simplify the working of circuit by replacing the Choke and Starter with Transformer.
- We can convert the Ac into Dc by using Bridge Rectifier.

- We convert the Ac into Dc to operate the Transistor and Diode'
- The whole working of transformer is depending upon the transistor.
- The efficiency is about 75%.
- In electronic ballast VDR will opposes the current above 230v.
- The transistor will on and off 600 times per sec.
- The magnetic field is generated and it will supply to the other end with a generation of 800v to 1000v.

3.6. LED Tube light:

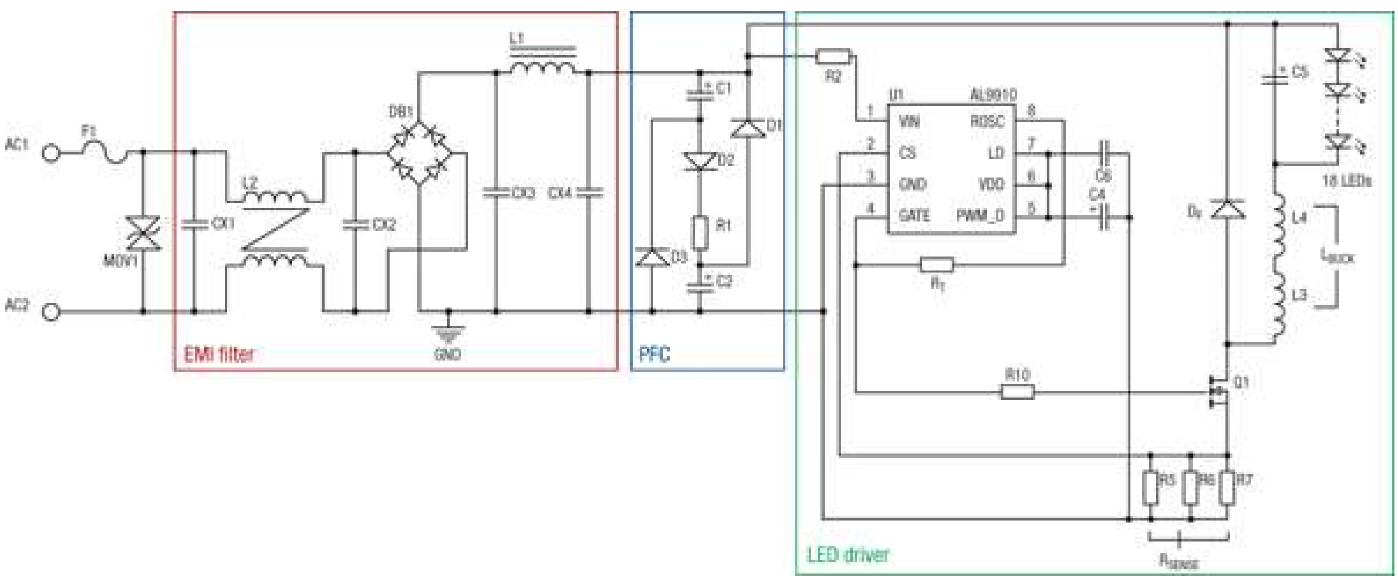


Fig: 3.3 Circuit diagram of LED Tube light

- Led Tube Light is modern technology to invent for the low consume ofcurrent and produces the high efficiency.
- According to the circuit the led tube light circuit is bit complex than tube light and electronic ballast.
- It contains electronic IC and it is operated by the Mosfet /Transistor.
- In this circuit also we are using transformer instead of Choke and Starter.
- Here we are using feedback and Current Sensor to regulates the drop and high in voltage and current. The voltage and current is differ by either Input voltage and sort or damage in Led.
- It has high efficiency nearly to 95%.
- It has low consumption of electricity comparing to other tube lights.

CHAPTER-4
TRANSFORMERS

An electrical transformer is a passive electrical device used to transfer electrical energy between two or more circuits by means of electromagnetic induction. It consists of two coils of wire, known as the primary winding and the secondary winding, which are usually wound around a common magnetic core. The key principle behind transformers is Faraday's law of electromagnetic induction, which states that a change in magnetic flux within a coil induces a voltage in the coil.

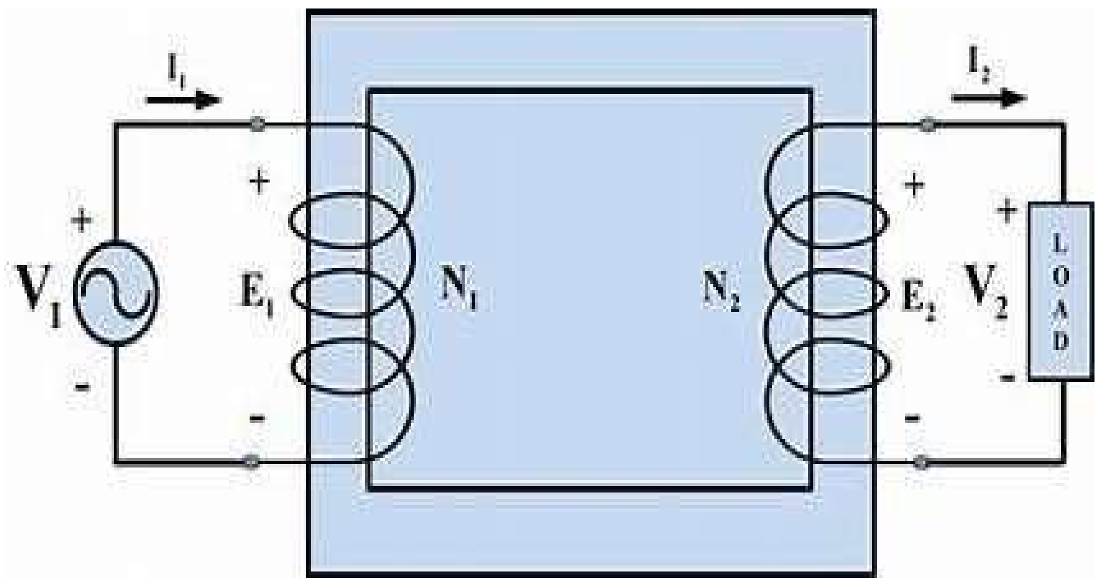


Fig. 4.1 Ideal Transformer

4.1 Tyes of transformers

i. Step-up transformer
ii. Step-down transformer

Step-up transformer: A step-up transformer is an electrical device designed to increase the voltage level of an alternating current (AC) signal. It accomplishes this by having more turns in its secondary winding compared to the primary winding.

The primary winding is connected to the source of electrical power, while the secondary winding is connected to the load or device that needs a higher voltage. The primary function of a step-up transformer is to transfer electrical energy from one circuit to another while changing the voltage level. As a result, the output voltage on the secondary side is higher than the input voltage on the primary side. This voltage increase is achieved through electromagnetic induction, which is based on Faraday's law of electromagnetic induction.

Applications: Step-up transformers are commonly used in various applications, including electrical power transmission and distribution.

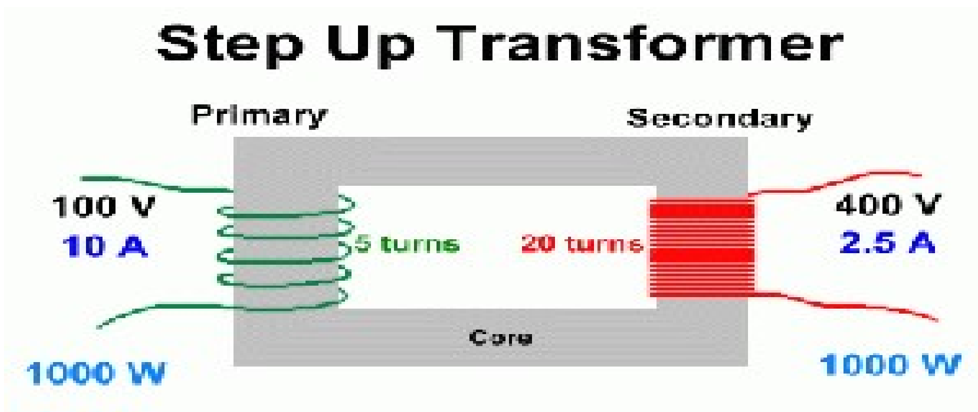


Fig 4.2 Step Up Transformer

Step-down transformer: A step-down transformer is an electrical device designed to decrease the voltage level of an alternating current (AC) signal. It achieves this by having fewer turns in its secondary winding compared to the primary winding.

The primary winding is connected to the source of electrical power, while the secondary winding is connected to the load or device that requires a lower voltage. The primary function of a step-down transformer is to transfer electrical energy from one circuit to another while reducing the voltage level. As a result, the output voltage on the secondary side is lower than the input voltage on the primary side. This voltage reduction is achieved through the principles of electromagnetic induction, which are based on Faraday's law of electromagnetic induction.

Applications: Step-down transformers are commonly used in various electrical applications, including electrical power distribution and voltage conversion.

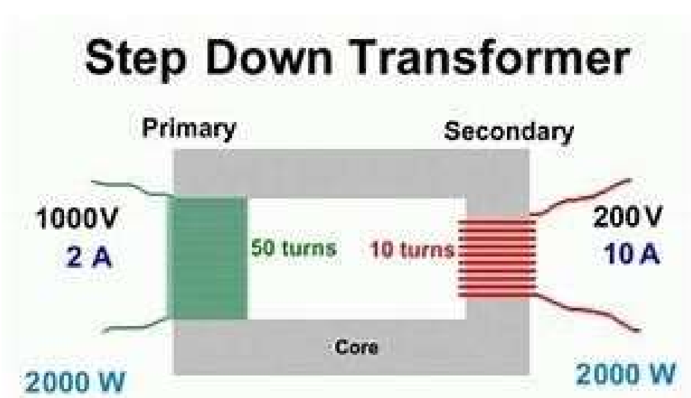


Fig 4.3 Step Down Transformer

4.2 Methods to find primary & secondary windings of a transformer

There are two types of windings included in making of a transformer. They are

i)Primary Winding
ii) Secondary Winding

We can identify whether it is primary or secondary by using three ways those are

1) By using the multimeter reading.

- If the resistance value is more when measuring with multimeter, then it should be considered as primary winding.
- If the resistance value is less when measuring with multimeter, then it should be considered as secondary winding.

2) By Using Series Lamp Test:

- In this we have to connect one lamp in series with transformer.
- If the brightness of the lamp is less, then it is primary winding otherwise it is considered as secondary winding.

3) By Identifying the Thickness of the Wire:

- By measuring the thickness of the gauge(wire),we can identify primary& secondary windings of a transformer.
- If the thickness of the gauge is thin then it is primary winding otherwise it is secondary winding.

4.3 Types of cores

- In between the windings a core is present that may be iron are may be a ferrite.
- Core is in shape of EI. Iron core is two types,They are

Fig 4.4 Shape of Iron Core

i)Cold rolled grain oriented (CRGO).
ii)Cold rolled non oriented (CRNO).

CHAPTER-5

DIODES

A diode is a two-terminal electronic component that primarily allows the flow of electrical current in one direction while blocking it in the opposite direction. It is a fundamental semiconductor device used in electronics and plays a crucial role in various applications.

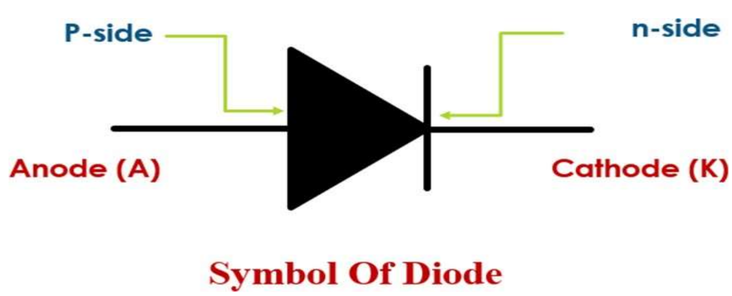


Fig: 5.1 Symbol of Diode

5.1. Types of Diodes:

5.1.1. Rectifier diode:

A rectifier is a special type of diode that converts alternating current (AC) into direct current (DC). This is an important process, as alternating current is able to reverse direction periodically, while direct current consistently flows in a single direction, making it simple to control.

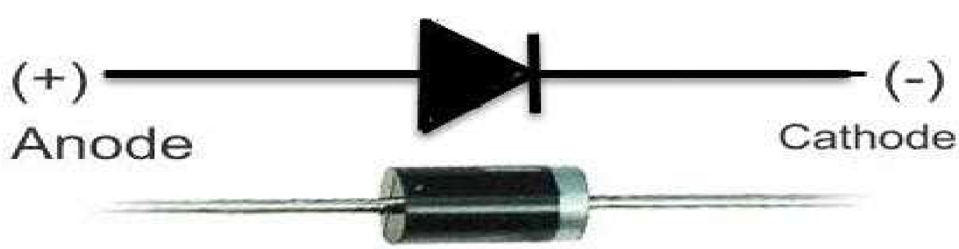


Fig: 5.2 Symbol of Rectifier diode

5.1.2. Zener diode:

It is the most useful type of diode as it can provide a stable reference voltage. These are operated in reverse bias and break down on the arrival of a certain voltage. If current passing through the resistor is limited, a stable voltage is generated. Zener diodes are widely used in power supplies to provide a reference voltage.

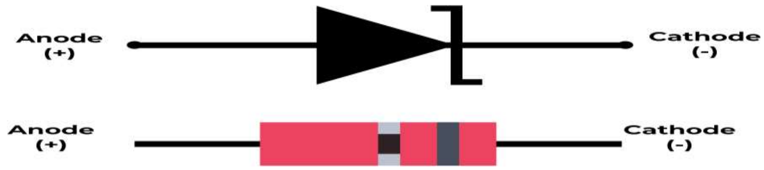


Fig: 5.3 Symbol of Zener Diode

5.1.3. Schottky diode:

It has a lower forward voltage than other silicon PN junction diodes. The drop will be seen where there is low current and at that stage, voltage ranges between 0.15 and 0.4 volts. These are constructed differently in order to obtain that performance. Schottky diodes are highly used in rectifier applications.

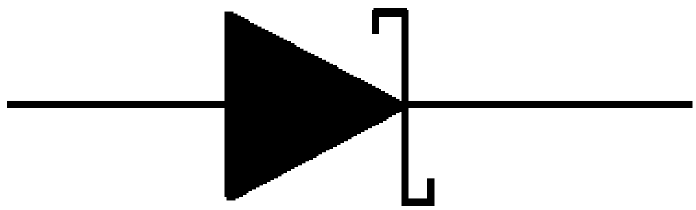


Fig: 5.4 Symbol of Schottky Diode

5.1.4. Switching diode:

A switching diode is a type of diode that is specifically designed for fast switching applications. These diodes are optimized for rapid transition between the conducting (forward-biased) and non-conducting (reverse-biased) states. They are characterized by their low capacitance and fast switching speed.

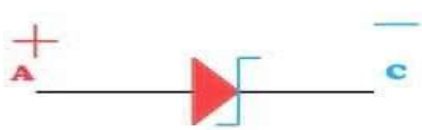


Fig: 5.5 Symbol of Switching Diode

5.1.5. Light Emitting diode:

When an electric current between the electrodes passes through this diode, light is produced. In other words, light is generated when a sufficient amount of forwarding current passes through it. In many diodes, this light generated is not visible as there are frequency levels that do not allow visibility. LEDs are available in different colours.

There are tricolour LEDs that can emit three colours at a time. Light colour depends on the energy gap of the semiconductor used.

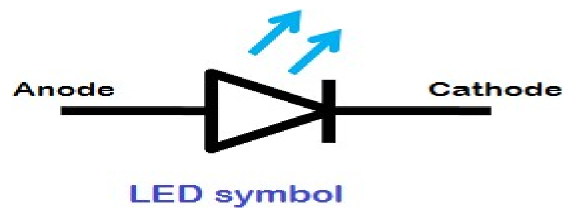


Fig: 5.6 Symbol of Light Emitting Diode

5.2. Rectifiers:

A rectifier is an electrical device or circuit that converts alternating current (AC) into direct current (DC). It allows the flow of electrical current in one direction while blocking it in the opposite direction. The primary purpose of a rectifier is to convert AC voltage or current into a steady DC voltage or current.

5.2.1 Half Wave Rectifier:

A half-wave rectifier is a simple type of rectifier circuit used to convert alternating current (AC) into direct current (DC). It allows only one-half (either the positive or negative half) of the AC input cycle to pass through, resulting in a pulsating DC output.

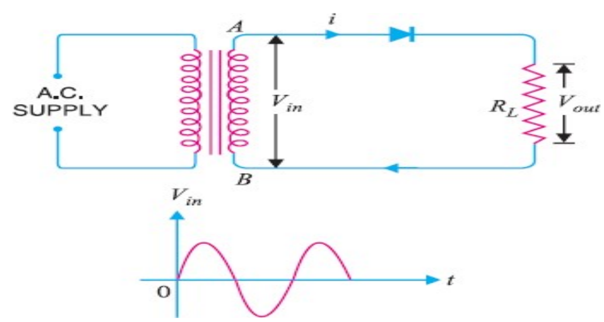


Fig:5.7 Circuit Diagram of Half Wave Rectifier

Operation of a Half-Wave Rectifier:

During the positive half-cycle of the AC input voltage, the voltage across the diode's anode is greater than the voltage at its cathode. This forward-biases the diode, allowing it to conduct current. Current flows through the diode and the load resistor (RL), resulting in a positive half-cycle of the output voltage across the load. This represents the rectified portion of the input AC waveform. During the negative half-cycle of the AC input voltage, the voltage at the diode's cathode is greater than the voltage at its anode. This reverse-biases the diode, effectively blocking current flow. As a result, there is no current flow during the negative half-cycle, and the output voltage remains at zero volts.

5.2.2 Full Wave Rectifier:

A full-wave rectifier is an electrical circuit that converts alternating current (AC) into direct current (DC) by allowing both halves of the AC input cycle to pass through, resulting in a smoother and more continuous DC output compared to a half-wave rectifier.

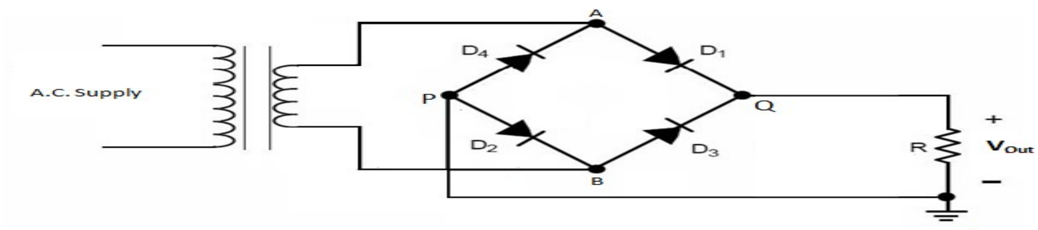


Fig: 5.8 Circuit Diagram of Bridge Rectifier

Operation of a Bridge Rectifier:

During the positive half-cycle of the AC input voltage, two diodes become forward-biased and conduct current, allowing current to flow through the load resistor in one direction. During the negative half-cycle of the AC input voltage, the other two diodes become forward-biased, conducting current in the opposite direction through the load resistor. As a result, the bridge rectifier converts both the positive and negative half-cycles of the AC input into a continuous DC output across the load resistor. This results in a more stable and higher-average DC voltage compared to a half-wave rectifier.

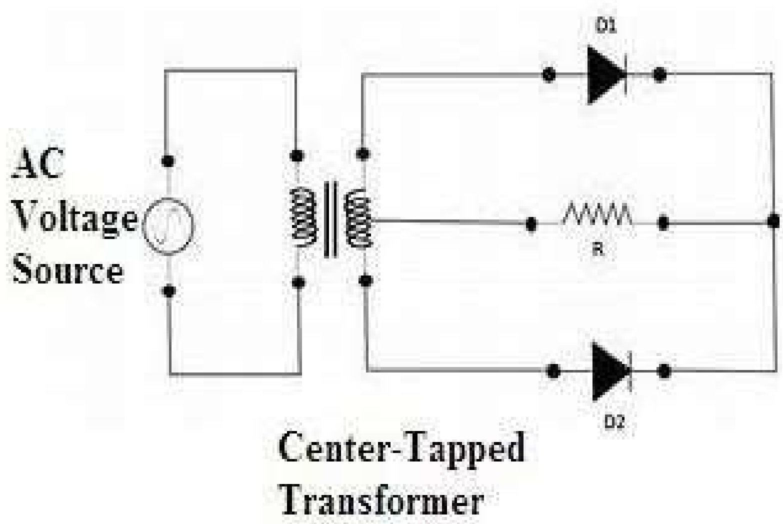


Fig: 5.9 Circuit Diagram of Center Tapped Rectifier

Operation of a Center-Tapped Rectifier:

During the positive half-cycle of the AC input voltage, the voltage at one of the outer terminals becomes more positive than the center tap. This forward-biases one of the diodes, allowing current to flow through the load resistor in one direction. During the negative half-cycle of the AC input voltage, the voltage at the other outer terminal becomes more positive than the center tap, forward-biasing the other diode and allowing current to flow in the opposite direction through the load resistor. As a result, the center-tapped rectifier also converts both the positive and negative half-cycles of the AC input into a continuous DC output across the load resistor, similar to the bridge rectifier.

CHAPTER-6

TRANSISTORS

Transistors are semiconductor devices that serve as fundamental building blocks in electronics. They are used for a wide range of applications, including amplification, switching, signal modulation, and more. Transistors come in various types, each designed for specific functions and characteristics.

Types of Transistors

Transistors are two types they are:

1. NPN transistor
2. PNP transistor

In this transistor three terminals are there:

1. Base
2. Emitter
3. Collector

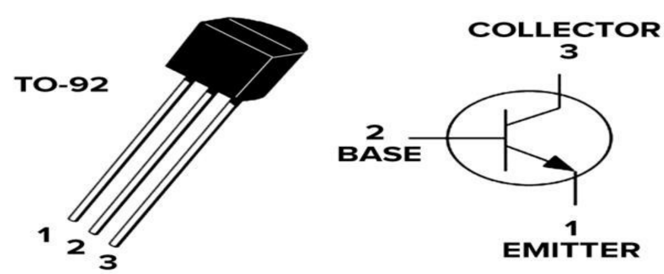


Fig: 6.1 Symbol of Transistors

6.1. NPN TRANSISTOR:

The NPN transistor is made of semiconductor materials like silicon or germanium. When a p-type semiconductor material is fused between two n-type semiconductor materials, an NPN transistor is formed. When we give negative cycle of current given to the base then the current passed to the collector to emitter.

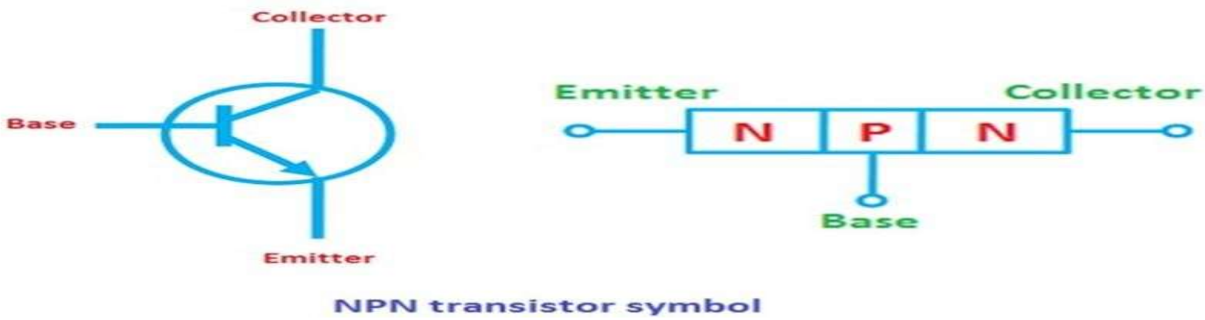


Fig:6.2 Symbol of NPN Transistor

6.2.PNP TRANSISTOR

The PNP transistor is a type of transistor in which one n-type material is doped with two p-type materials. It is a device that is controlled by the current. Both the emitter and collector currents were controlled by the small amount of base current. When we give the negative cycle of current given to the base then current passed to emitter to collector.

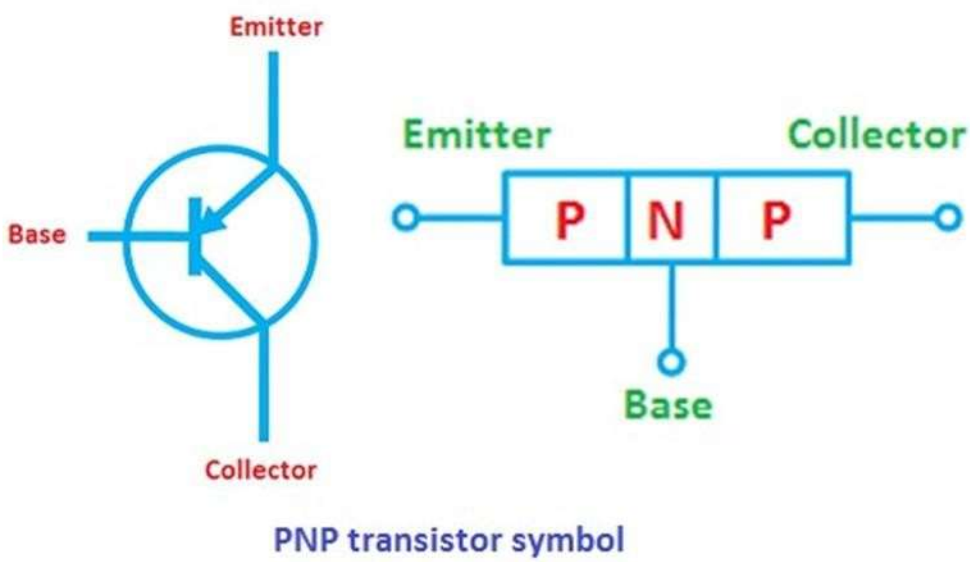


Fig:6.3 Symbol of PNP Transistor

CHAPTER-7

POWER SUPPLY

7.1 Introduction

The power supply can be defined as it is an electrical device used to give electrical supply to electrical loads. The main function of this device is to change the electrical current from a source to the accurate voltage, frequency and current to supply the load. Sometimes, these power supplies can be named to as electric power converters. Some types of supplies are separate pieces of loads, whereas others are fabricated into the appliances that they control.

7.2 Types of Power Supply

1. Variable AC Power Supply
2. Unregulated Linear Power Supply
3. Regulated Linear Power Supply
4. Voltage Regulator
5. Switch Mode Power Supply (SMPS)
6. Uninterruptible Power Supply (UPS)

1. Variable AC Power Supply

The different AC voltages are generated by using a transformer. The transformer may have multiple windings or taps, in which case the instrument uses switches to select the different voltage levels. Alternatively, a variable transformer (adjustable autotransformer) can be used to continuously vary the voltages. Some variable AC supplies are included meters to monitor the voltage, current, and/or power.

2. Unregulated Linear Power Supply

Unregulated power supplies contain a step-down transformer, rectifier, filter capacitor, and a bleeder resistor. This type of power supply, because of simplicity, is the least costly and most reliable for low power requirements. The main disadvantage is that the output voltage is not constant. It will vary with the input voltage and the load current, and the ripple is not suitable for electronic applications. The ripple can be reduced by changing the filter capacitor to an LC (inductor-capacitor) filter, but the cost becomes more.

Components Explanation

Input Transformer

The input transformer is used to convert the incoming line voltage down to the required level of the power supply. It also isolates the output circuit from the line supply. Here we are using a step-down transformer.

Rectifier

The rectifier used to convert the incoming signal from an AC format into raw DC. Please refer these links, Different types of rectifiers available are half wave rectifier and full-wave rectifier.

Filter Capacitor

The pulsated DC from the rectifier is fed to the smoothing capacitor. It will remove the unwanted ripples in the pulsated DC.

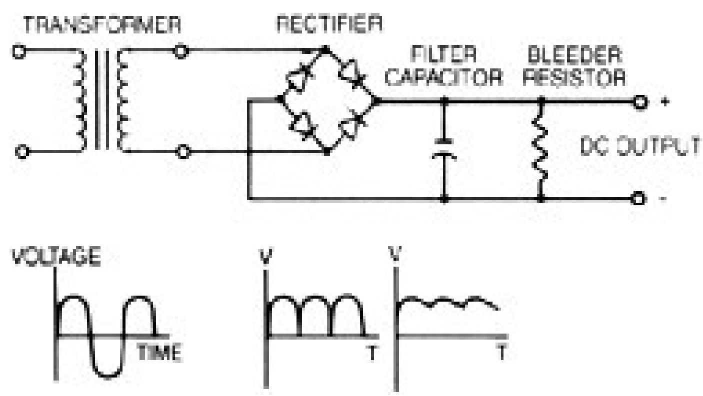


Fig.7.1 Unregulated Power Supply

Bleeder Capacitor

Bleeder Resistor is also known as a power supply drain resistor. It is connected across the filter capacitors to drain their stored charge so that the power system supply is not dangerous.

3.Regulated Linear Power Supply

Regulated linear power supplies are same as the unregulated linear power supply except that a 3-terminal regulator is used in place of the bleeder resistor. The main aim of this supply is to provide the required level of DC power to the load. The DC power supply uses an AC supply as the input. Different applications require different levels of attributes voltages, but nowadays the DC power supplies provide an accurate output voltage. And this voltage is regulated by an electronic circuitry so that it provides a constant output voltage over a wide range of output loads.

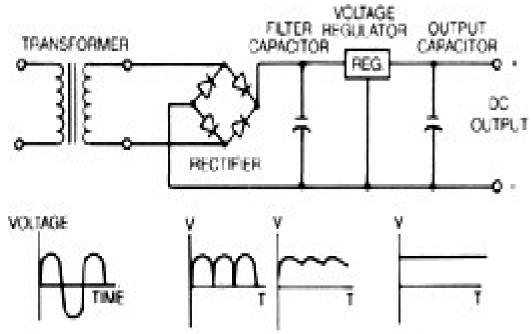


Fig.7.2 Regulated Power Supply

4.Voltage Regulator

A linear regulator has an active (BJT or MOSFET) pass device (series or shunt) controlled by a high gain differential amplifier. It compares the output voltage with a precise reference voltage and adjusts the pass device to maintain a constant level output voltage. There are two main types of linear power supplies.

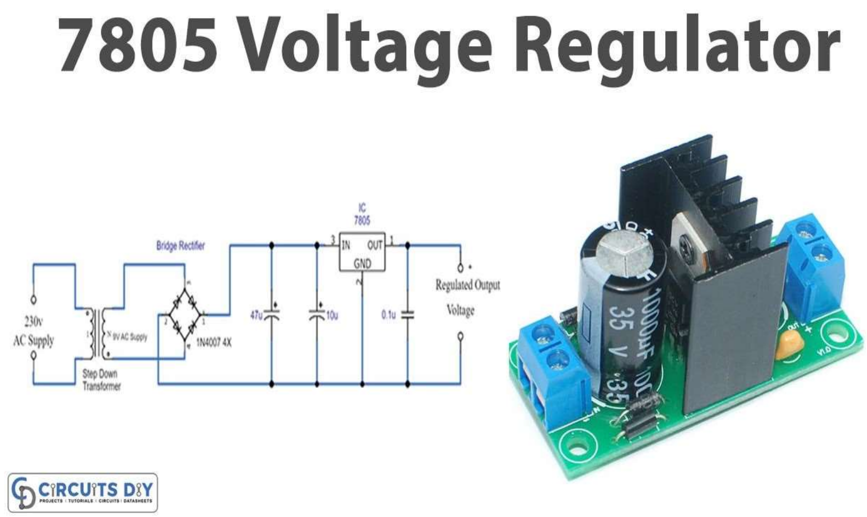


Fig.7.3 Voltage Regulator

Series pass voltage Regulator

This is the most widely used regulators for linear power supplies. As the name implies a series element is placed in the circuit as shown in below figure, and its resistance varied via the control electronics to ensure that the correct output voltage is generated for the current taken.

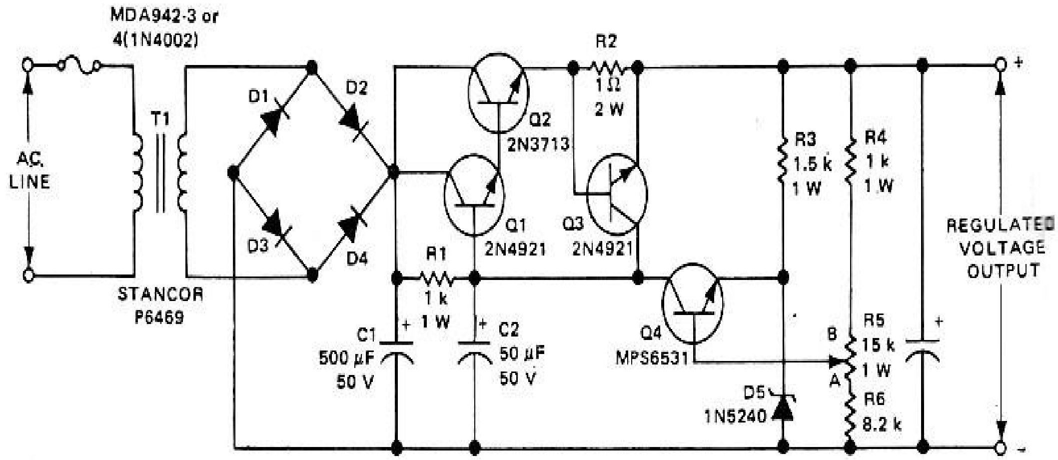


Fig.7.4 Series pass voltage Regulator

5. Switch Mode Power Supply (SMPS)

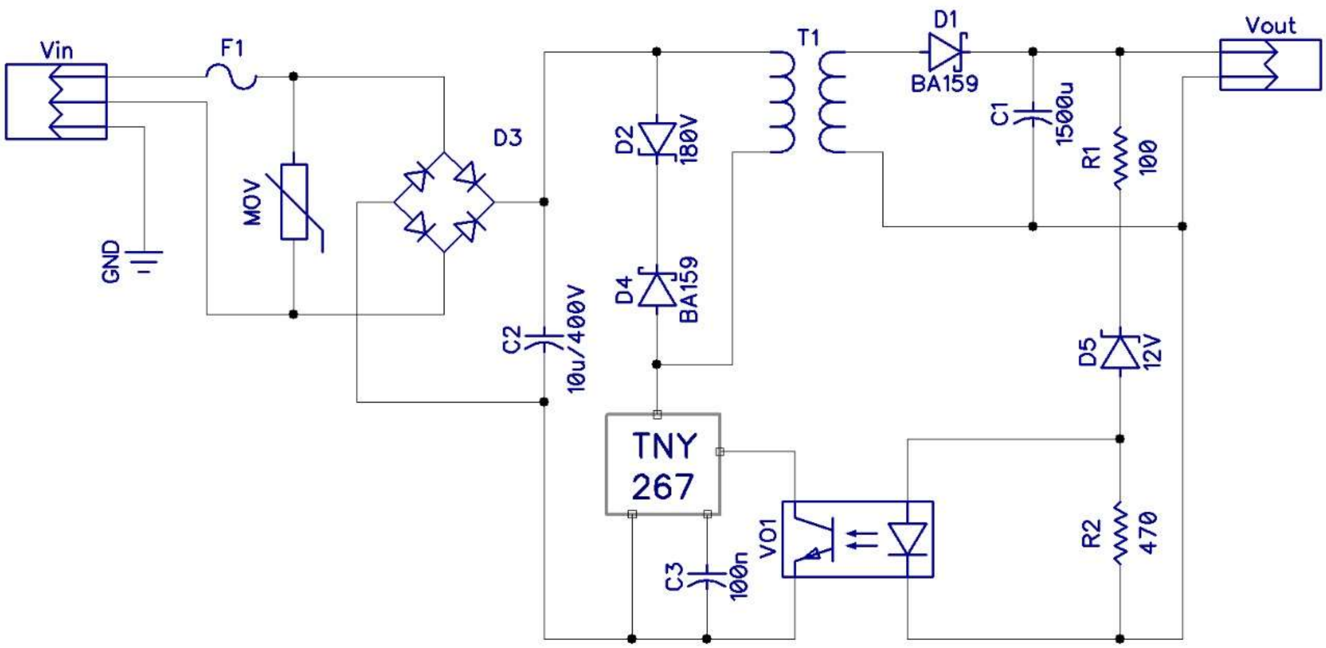


Fig.7.5 Switch Mode Power Supply (SMPS)

An SMPS transfers power from a DC or AC source to DC loads, such as a personal computer. While converting voltage and current characteristics. Unlike a linear power supply. The pass transistor of a switching-mode supply continually switches between low-dissipation, full-on and dissipates full-off states, and spends very little time in the high dissipation transitions, which minimizes wasted energy. A hypothetical ideal switched-mode power supply no power. Voltage regulation is achieved by varying the ratio of on-to-off time (duty cycles). In contrast, a linear power supply regulates the output voltage by continually dissipating power in the pass transistor. The switched-mode power supply's higher electrical efficency is an important advantage.

6.Uninterruptible Power Supply (UPS)

Ups is used for continues backup for the systems. It is same as the Invertor circuit ,In this we are using SCR driver to control the SCR's and also we replace the bridge rectifier with SCR. In the ups there is no change over time in this the change over time is <20m/s, it gives continuity. In relays the change over time is >20m/s. Ups also contain offline and online ups. Offline ups is used in small pc's. Online ups is used in multi national companies. In UPS we are using Insulated gate bipolar transistors instead of transistors banks because of a large transistor banks are equal to a single IGBT.

Inverter

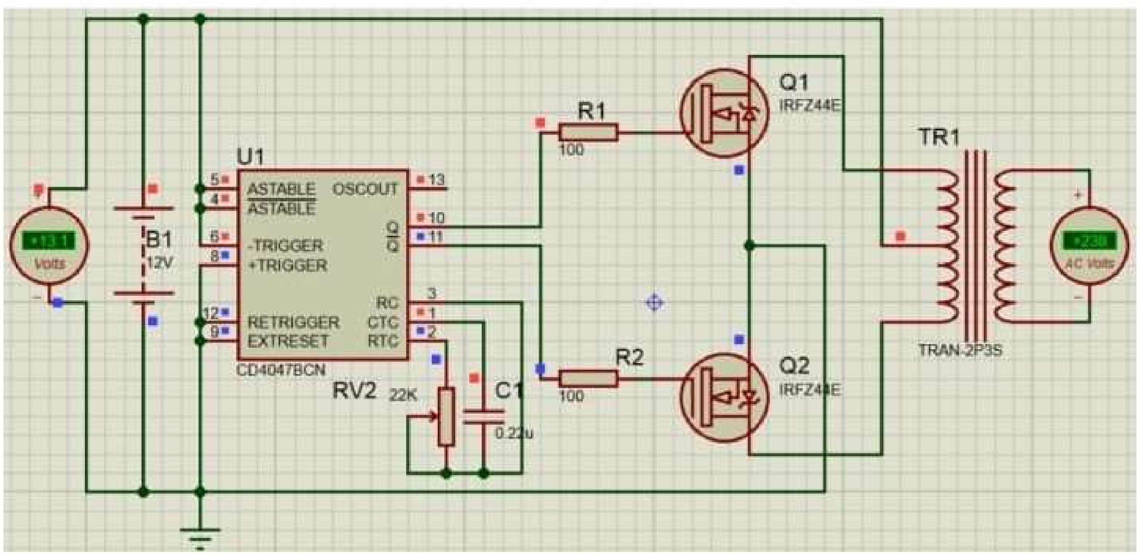


Fig.7.6 Inverter

Invertor is a device which is able to convert DC into AC, we get normal supply at absence of power supply, it provide supply by battery at power cut time. We are using separate transformer to charge the battery, It contain two transistors banks. To operate at the time of power cut the whole circuit is depends upon IC. There are two relays one is for operating the normal supply and one for operating at battery supply the battery inputed relay is at normal open when the normal power is present the input connected relay is at normal open to relay output. When the power is off battery connected relay is shifted to normal close then the Ic will be on then then entire circuit is on then the second relay is shifted to output pin to normal close then the socket get supply from battery.

CHAPTER 8

CONVERTERS

8.1 Introduction

Power Converters have turned out to be a crucial component of the household as well as commercial equipment. In our previous content, we have discussed that power electronic technology handles the controlling process of conversion of one form of electric energy into another form. This conversion of energy provides voltage and current in such a form that suits various user requirements.

8.2 Types of converters

1. Buck-converter
2. Boost-converter

1.Buck-converter

A **buck converter** or **step-down converter** is a DC-to-DC converter which steps down voltage from input to output . It is a class of switched-mode power supply. Switching converters (such as buck converters) provide much greater power efficiency as DC-to-DC converters than linear regulators, which are simpler circuits that lower voltages by dissipating power as heat, but do not step up output current. The efficiency of buck converters can be very high, often over 90%, making them useful for tasks such as converting a computer's main supply voltage.

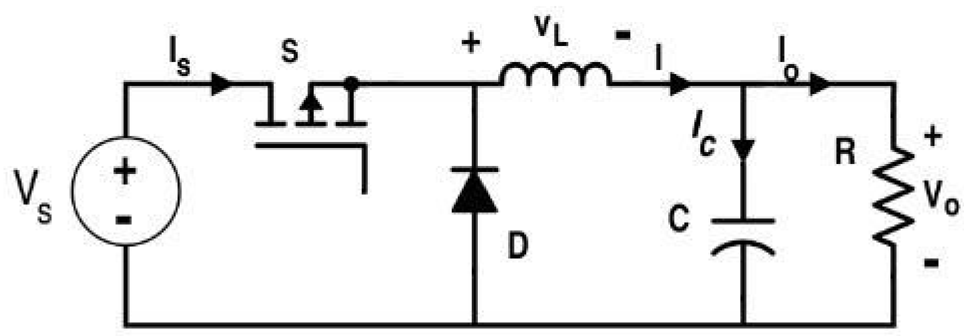


Fig.8.1 Buck-converter

Buck Converter Working

The inductor L is the initial source of current. If the first transistor is OFF by using the control unit then the current flow in the buck operation. The magnetic field of the inductor is collapsed and the back e.m.f is generated collapsing field turn around the polarity of the voltage across the inductor. The current flows in the diode D2, the load and the D1 diode will be turned ON.

The discharge of the inductor L decreases with the help of the current. During the first transistor is in one state the charge of the accumulator in the capacitor. The current flows through the load and during the off period keeping Vout reasonably. Hence it keeps the minimum ripple amplitude and Vout closes to the value of Vs.

2.Boost Converter

A boost converter, also known as a step-up converter, is a type of DC-DC converter used in electronics to increase the voltage of a DC power source. It takes in a lower voltage input and converts it into a higher voltage output. This is achieved by storing energy in an inductor and then releasing it to the output, effectively "boosting" the voltage.

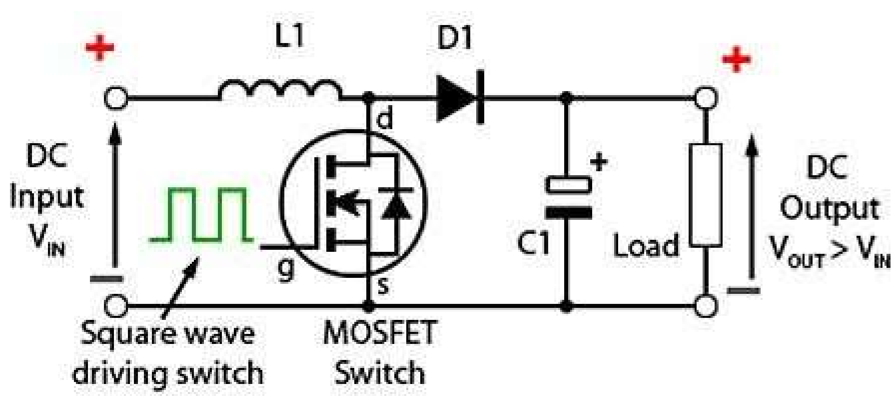


Fig.8.2 Boost-converter

Boost Converter Working

By charging the capacitor C the load is applied to the entire circuit in the ON State and it can construct earlier oscillator cycles. During the ON period the capacitor C can discharge regularly and the amount of high ripple frequency on the output voltage. The approximate potential difference is given by the equation below.

VS + VL

During the OFF period of second transistor the inductor L is charged and the capacitor C is discharged. The inductor L can produce the back e.m.f and the values are depending up on the rate of change of current of the second transistor switch. The amount of inductance the coil can occupy. Hence the back e.m.f can produce any different voltage through a wide range and determined by the design of the circuit. Hence the polarity of voltage across the inductor L has reversed now.

The input voltage gives the output voltage and atleast equal to or higher than the input voltage. The diode D2 is in forward biased and the current applied to the load current and it recharges the capacitors to VS + VL and it is ready for the second transistor.

CHAPTER 9

LOGIC GATES USING TRANSISTORS

9.1 Introduction:

In the fields of electronics and computer science, logic gates are essential components of digital circuits that are used extensively.These gates generate binary outputs by applying logical operations to binary inputs (0 and 1).The transistor is one of the essential parts that makes it possible for logic gates to operate.Electronic switches called transistors are semiconductor devices.Based on the input voltage applied to a third terminal, they can be used to regulate the flow of electrical current between two terminals.Transistors are used to generate and modify binary signals in the context of logic gates.Bipolar junction transistors (BJTs) and metal-oxide-semiconductor field effect transistors (MOSFETs) are the two main transistor types utilized in digital logic circuits.

9.2 Different types of logic gates using transistors

NOT Gate (inverter):

The NOT gate (also known as an inverter) carries out the logical action of negation.

• There is only one input and output.
• The output is low (0) when the input is high (1), and vice versa.
• A single transistor and a few resistors can be used to build inverter circuits.
• If there is only one input A, the output may be calculated using the Boolean equation **Y=A'**.

NOT Gate using transistor:

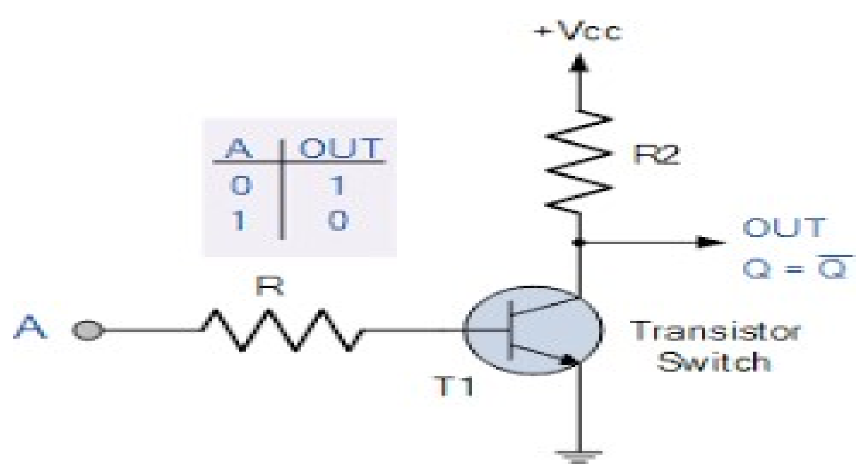


Fig: 9.1 NOT Gate Circuit diagram and Truth table

AND Gate:

- Only when all of the inputs to the AND gate are high (1) does it produce a high output.
- To construct it, normally, several transistors connected in series are needed.

- The AND gate's Boolean logic is **Y=A.B** if there are two inputs A and B.

AND Gate using transistor:

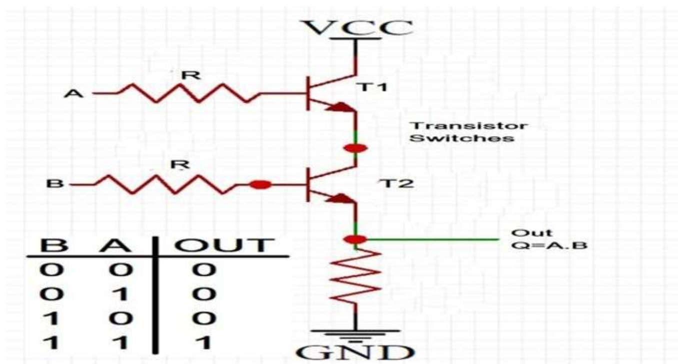


Fig: 9.1.1 AND Gate Circuit diagram and Truth table

OR Gate:

- When at least one of its inputs is high (1), the OR gate generates a high output (1).

- Typically, it is built by connecting several transistors in parallel.

- The OR gate's output will be given by the following mathematical procedure if there are two inputs A and B: Y=A+B.

OR Gate using transistor

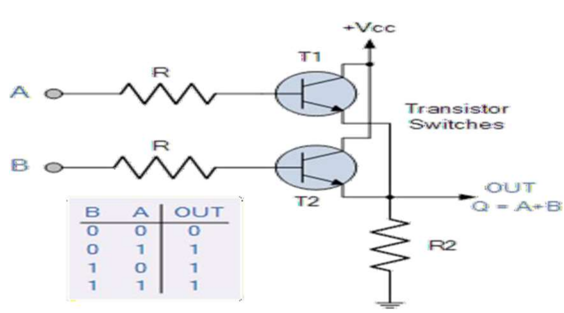


Fig: 9.1.2 OR Gate Circuit diagram and Truth table

NOR Gate:

- A NOR gate, sometimes known as a "NOT-OR" gate, consists of an OR gate followed by a NOT gate.
- This gate's output is 1 only when all of its inputs are 0. Alternatively, when all of the inputs are low, the output is high.
- The Boolean statement for the NOR gate is Y=(A+B)' if there are two inputs A and B.

NOR Gate using transistor:

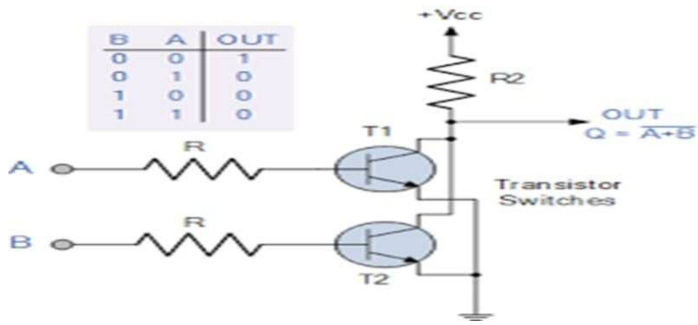


Fig:9.1.3 NOR Gate Circuit diagram and Truth table

NAND Gate:

- A NAND gate, sometimes known as a 'NOT-AND' gate, is essentially a Not gate followed by an AND gate.
- This gate's output is 0 only if none of the inputs is 0. Alternatively, when all of the inputs are not high and at least one is low, the output is high.
- If there are two inputs A and B, the Boolean expression for the NAND gate is Y= (A.B)'.

NAND Gate using transistor:

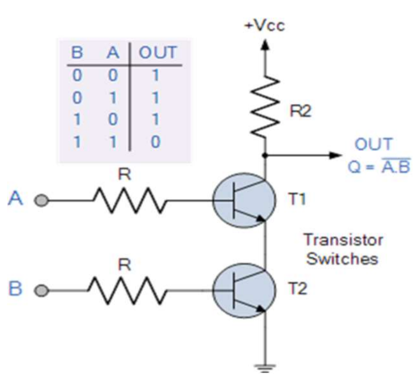


Fig:9.1.4 NAND Gate Circuit diagram and truth table

XNOR Gate:

- The Exclusive-NOR or ‘EX-NOR’ gate is a digital logic gate that accepts more than two inputs but only outputs one.
- If both inputs are ‘High,’ the output of the XNOR Gate is ‘High.’ If both inputs are ‘Low,’ the output is ‘High.’ If one of the inputs is ‘Low,’ the output is ‘Low.’
- If there are two inputs A and B, then the XNOR gate’s Boolean equation is: Y=A.B+A’B’.

XNOR Gate using transistor:

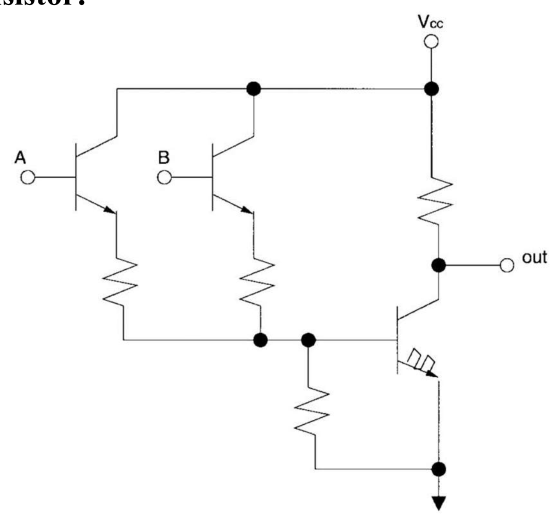


Fig:9.1.5 XNOR Gate Circuit diagram and truth table

XOR Gate:

- The Exclusive-OR or ‘Ex-OR’ gate is a digital logic gate that accepts more than two inputs but only outputs one value.
- If any of the inputs is ‘High,’ the output of the XOR Gate is ‘High.’ If both inputs are ‘High,’ the output is ‘Low.’ If both inputs are ‘Low,’ the output is ‘Low.’
- The Boolean equation for the XOR gate is Y=A’.B+A.B’ if there are two inputs A and B.

XOR Gate using transistor:

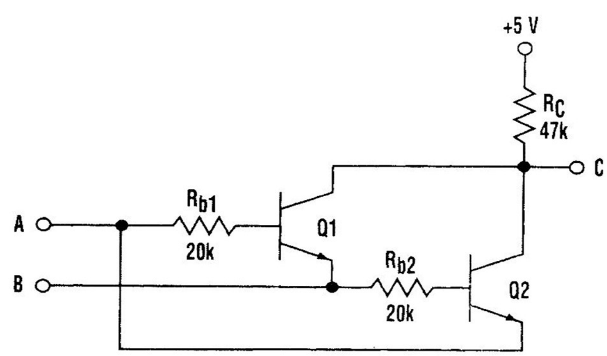


Fig:9.1.6 XOR Gate Circuit diagram and truth table

9.3 Operational Amplifier:

An operational Amplifier, also called an Op-Amp, is an integrated circuit, which can be used to perform various linear, non-linear, and mathematical operations. An op-amp is a directly coupled high-gain amplifier. You can operate op-amp both with AC and DC signals. This chapter discusses the characteristics and types of op-amps.

Construction of operational Amplifier:

An op-amp consists of a differential amplifier(s), a level translator, and an output stage. A differential amplifier is present at the input stage of an op-amp and hence an op-amp consists of two input terminals. One of those terminals is called the inverting terminal and the other one is called the non-inverting terminal. The terminals are named based on the phase relationship between their respective inputs and outputs.

Characteristics of operational Amplifier:

- Open loop voltage gain
- Output offset voltage
- Common Mode Rejection Ratio
- Slew Rate

Types of operational Amplifiers:

An op-amp is represented with a triangle symbol having two inputs and one output. Op-amps are of two types: Ideal Op-Amp and Practical Op-Amp.

Ideal Op-Amp:

An ideal op-amp exists only in theory, and does not exist practically. The equivalentcircuit of an ideal op-amp is shown in the figure given below

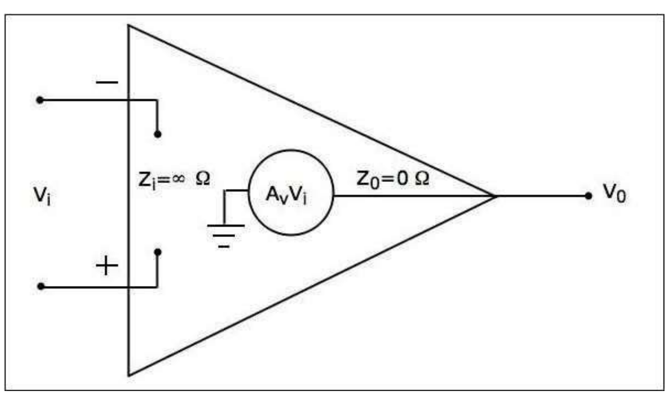


Fig: 9.2 Ideal Op-Amp

An ideal op-amp exhibits the following characteristics-

- Infinite open-loop gain G = v_{out} / v. ...
- Infinite input impedance R_{in}, and so zero input current.
- Zero input offset voltage.
- Infinite output voltage range.
- Infinite bandwidth with zero phase shift and infinite slew rate.

Practical Op-Amp:

Practically, op-amps are not ideal and deviate from their ideal characteristics because of some imperfections during manufacturing. The equivalent circuit of a practical op-amp isshown in the following figure –

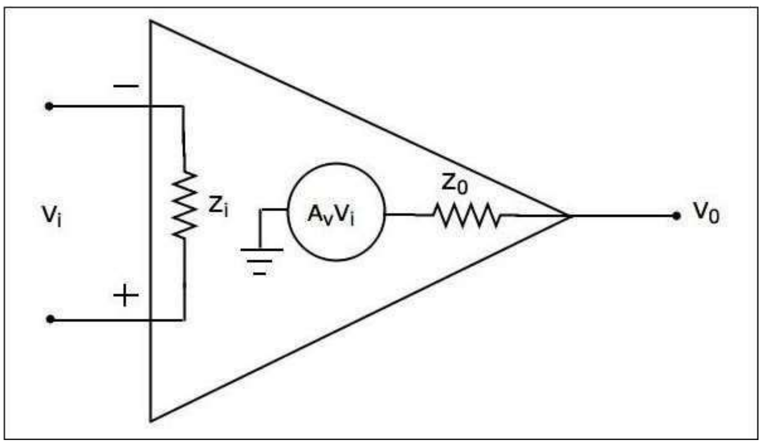


Fig: 9.3 Practical Op-Amp

A practical op-amp exhibits the following characteristics –

- Input impedance, Zi in the order of Mega ohms.
- Output impedance, Z0 in the order of few ohms.
- Open loop voltage gain, Av will be high.

Note − IC 741 op-amp is the most popular and practical op-amp.

9.4 comparators:

A comparator is an electronic circuit, which compares the two inputs that are applied to it and produces an output. The output value of the comparator indicates which of the inputs is greater or lesser. Please note that comparator falls under non-linear applications of ICs. An op-amp consists of two input terminals and hence an op-amp based comparator compares the two inputs that are applied to it and produces the result of comparison as the output. This chapter discusses about op-amp based comparators.

Types of Comparator:

Comparators are of two types : Inverting and Non-inverting. This section discusses about these two types in detail.

Inverting Comparator:

An inverting comparator is an op-amp-based comparator for which a reference voltage is applied to its non-inverting terminal and the input voltage is applied to its inverting terminal. This comparator is called as inverting comparator because the input voltage, which has to be compared is applied to the inverting terminal of op-amp.

The circuit diagram of an inverting comparator is shown in the following figure.

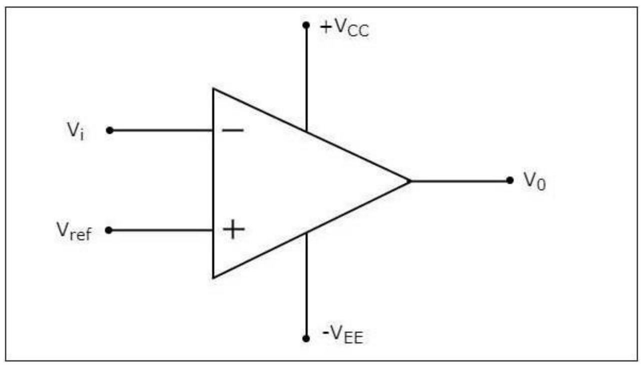


Fig: 9.4 Inverting Comparator

The operation of an inverting comparator is very simple. It produces one of the two values, +Vsat and −Vsat at the output based on the values of its input voltage Vi and the reference voltage Vref.

- The output value of an inverting comparator will be −Vsat, for which the input Vi voltage is greater than the reference voltage Vref.
- The output value of an inverting comparator will be +Vsat, for which the input Vi is less than the reference voltage Vref.

Non-Inverting Comparator:

A non-inverting comparator is an op-amp-based comparator for which a reference voltage is applied to its inverting terminal and the input voltage is applied to its non-inverting terminal. This op-amp-based comparator is called a non-inverting comparator because the input voltage, which has to be compared is applied to the non-inverting terminal of the op-amp.

The circuit diagram of a non-inverting comparator is shown in the following figure

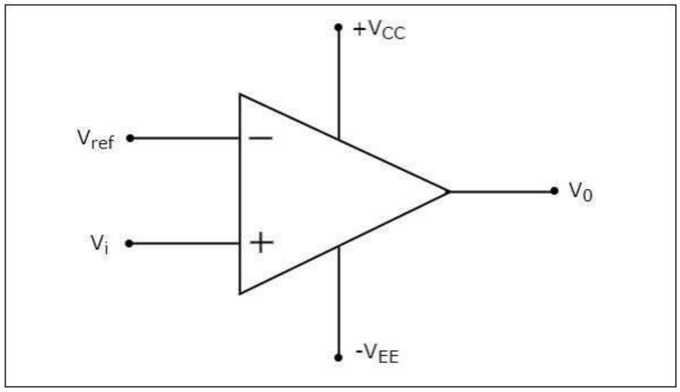


Fig: 9.5 Non-Inverting Comparator

The operation of a non-inverting comparator is very simple. It produces one of the two values, +Vsat and −Vsat at the output based on the values of input voltage Vt and the reference voltage +Vref.

- The output value of a non-inverting comparator will be +Vsat, for which the input voltage Vi is greater than the reference voltage +Vref.
- The output value of a non-inverting comparator will bee −Vsat, for which the input voltage Vi is less than the reference voltage +Vref.

9.5 NE555 TIMER

The NE555 is one of the handiest chips to be invented and specially designed to operateas a multivibrator. They can give off time from microseconds to several hours.
It is a TTL device. Thus, it is not sensitive to static electricity. But its power consumption is more than a CMOS chip. Therefore, we must especially attend to this point, when designing for battery operation.

The NE555 takes 10mA from the supply when the output is "high", and 1mA when the output is "low". When operating as an oscillator, we can consider the power consumed to be equal to that of an LED.

A CMOS version has been introduced with part number LM7555. But it is considerably more expensive. When the price falls it will be a very good choice as it consumes only 120uA.

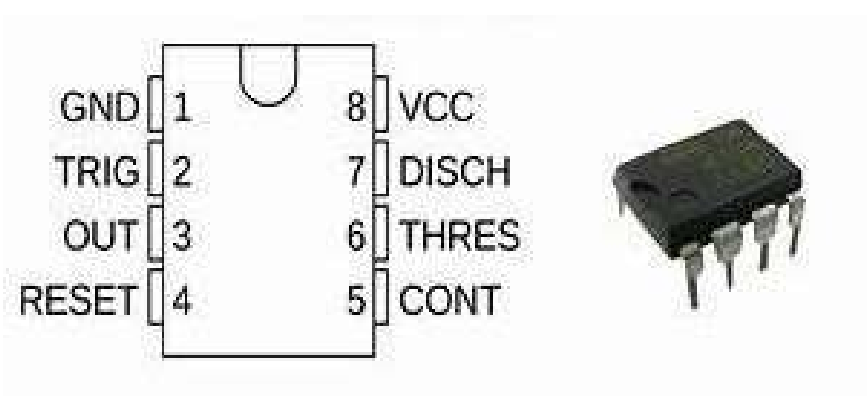


Fig: 9.6 NE555 TIMER

- It is acting as astable multivibrator and mono stable multivibrator.
- We can design simple timer with it.
- It act as an oscillator and produce frequency pulse.
- Output frequency is determined by R1,R2,C.
- Output frequency is depend upon R1 and R2 because it depends on capacitor charging and discharging time.
- Charging time depends upon R1,R2 and C.
- Device which produce any kind of ac wave form such as square sine ramp, triangular at the output are called as oscillator

9.6 Astable Mutlivibrator

An astable multivibrator is a type of multivibrator that does not require a triggering pulse thus, sometimes known as a **free-running multivibrator**. It necessarily provides square wave as its output.

Astable multivibrator is called so because both the states present here are unstable i.e., **quasi-stable**. This means output swings between 0 and 1 and neither 0 nor 1 is the stable state.

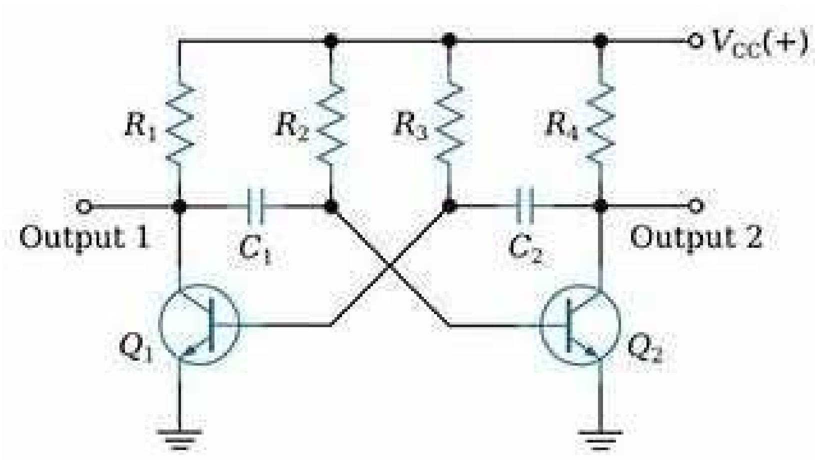


Fig: 9.7 Astable Multivibrator

Here, the successive transition is made from one quasi-state to other after some pre-decided time interval.

In this section, we will discuss the operation of an astable multivibrator by collector coupling and by using a complementary pair of transistors. Let us first understand collector coupled astable multivibrator.

Advantages of Astable Multivibrator:

1. Due to continuous oscillation between 2 unstable states, it is **power efficient**.
2. Its design is simple.
3. It is inexpensive.

Disadvantages of Astable Multivibrator:

The feedback provided in case of astable multivibrator does not completely provide entire output to the input.

Applications of Astable multivibrator:

These are widely used in radio equipment, in timing circuits and the systems that require square wave as output.

9.7 Mono-stable Multivibrator:

Monostable Multivibrator is a type of multivibrator that has single stable state. MONO means one thus the name itself indicates one state stable and a quasi-stable state. It is also known as a one-shot multivibrator.However, no any triggering pulse is provided to have transition from quasi to a stable state. After a pre-determined time interval, the quasi-state returns automatically to the stable state.

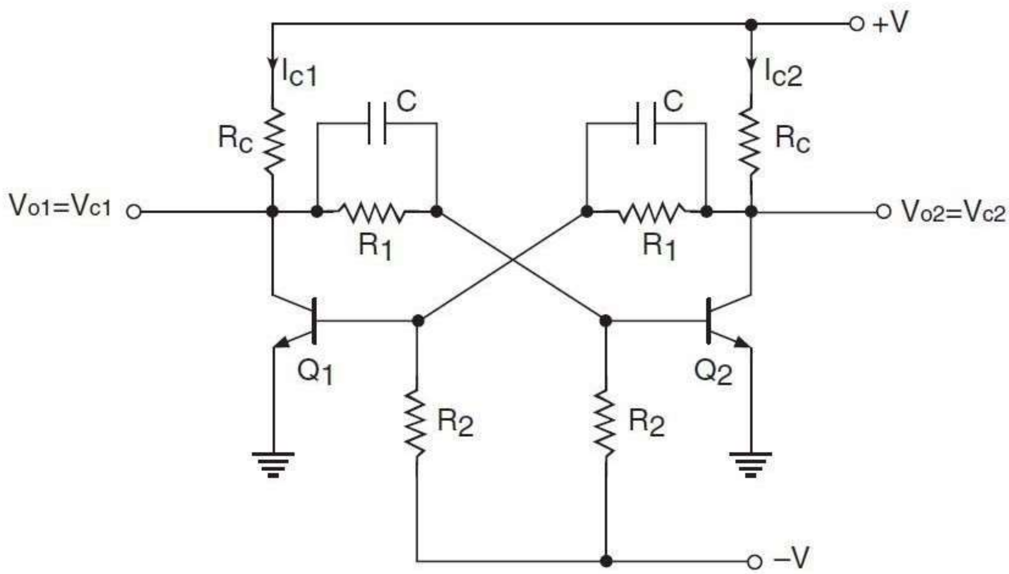


Fig: 9.8 Mono-stable Multivibrator

Advantages of Monostable Multivibrator:

- These are inexpensive.
- The circuit design is simple.

Disadvantages of Monostable Multivibrator:

- To provide sufficient charging and discharging time to the capacitor. The time to apply the upcoming trigger pulse must be more than the predetermined time constant.

Applications of Monostable Multivibrator:

A monostable multivibrator is basically used in the **regeneration of a distorted pulse**. It provides a sharp pulse from a distorted pulse. Also, the output of the monostable multivibrator is used to **trigger any other pulse generator circuit**.

9.8 Automatic Street Light Controller using LDR:

To save energy and electricity you may have seen that many countries are adopting those electronic LED street lights which turn ON automatically after the sunset. Basically, theseLED lights use LDR in their circuit. LDR, is a Light-dependent resistor, as the name implies resists the light. Hence, resistance increases as the light intensity got increases. At dark, the circuit starts working and that's why suitable for street light circuitry. So, in this tutorial, we are going to" Automatic Street Light Controller using LDR ". For the output, we are using a 230V bulb. In other words, you can say that circuit can easily operate an AC appliance of 230V.

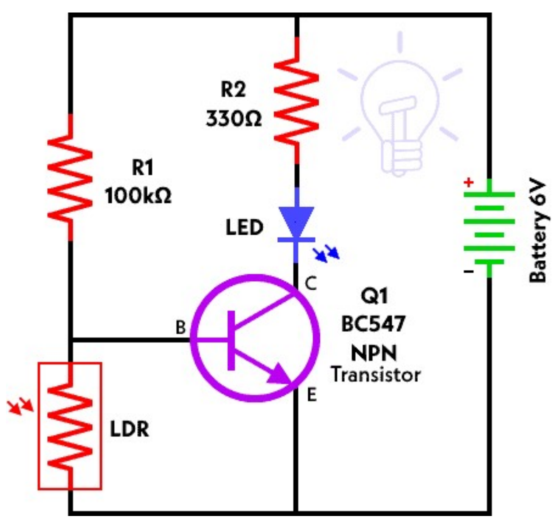


Fig: 9.9 Automatic Street Light Controller using LDR

Working Explanation:

In this circuit of Automatic Street Light Controller using LDR, when the light falls on LDR it becomes an element that is less resistive and therefore allows bias to appear at transistor Q1 base. It turns ON the transistor Q1. Since there is no bias at the base of transistor Q2, therefore it remains OFF. In this condition, the Relay coil is not getting the supply, hence remaining OFF. When no light falls on LDR, now it becomes a highly resistive element and there. In this case, no bias appears at the base of the Q1 transistor, so Q1 turns OFF, and bias arrives at the base of the transistor and turns ON the transistor Q2. Now the Relay coil gets power and therefore becomes energized and makes the contact. As a result output bulb starts to glow.

Application:

This circuit is mainly to make the street lights circuits.

9.9 Calling Bell using BT66:

The **BT66T** is an easy to use 3 terminal Melody generator IC. It is mainly used in circuits where a tone has to be played as a notification for the user. This IC is easy to use because it can work on low voltage (0.3V to 3.5V) and consumes very little current (1uA) during operation. It can also be easily interfaced with a normal Piezo electric speaker (even buzzer) or to a 6 ohm speaker through a NPN transistor as shown below.

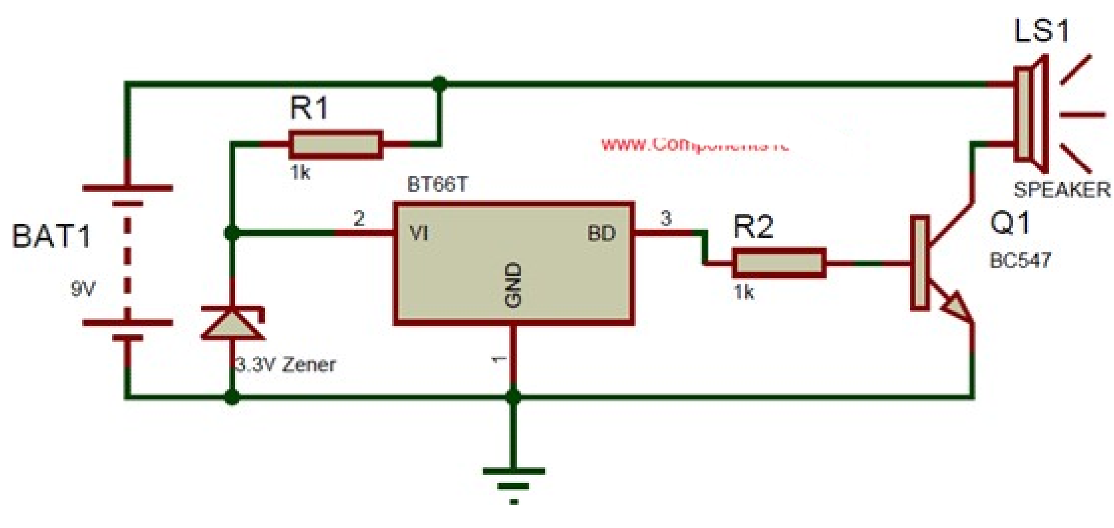


Fig: 9.9.1 Calling Bell using BT66

The BT66T can operate only below voltage range 3.5V, so we use a 3.3V Zener diode to regulate this voltage across the positive (pin 2) of the IC. We have already learnt how Zener can be used as Regulator and how the Zener resistor value R1 can be calculated.

The output of the IC that is the melody can be obtained at the pin BD (pin3). But this pin will not be able to source enough current to drive a speaker (6/8ohm speaker). So, we use a NPN transistor like BC547 to run the speakers. Basically, the output pin (pin 3) turns on and off in a particular fashion to provide the tone. We connect this output to the Base of BC547 which will also switch on and off in the same tone. The speaker is connected in series with the transistor so that the tone can be played in the speaker.

Applications of BT66T:

- Used to play melody
- Make project more attractive using sound
- Notify users through a melody

CHAPTER-10

EMBEDDED SYSTEMS & IOT

10.1 Arduino UNO

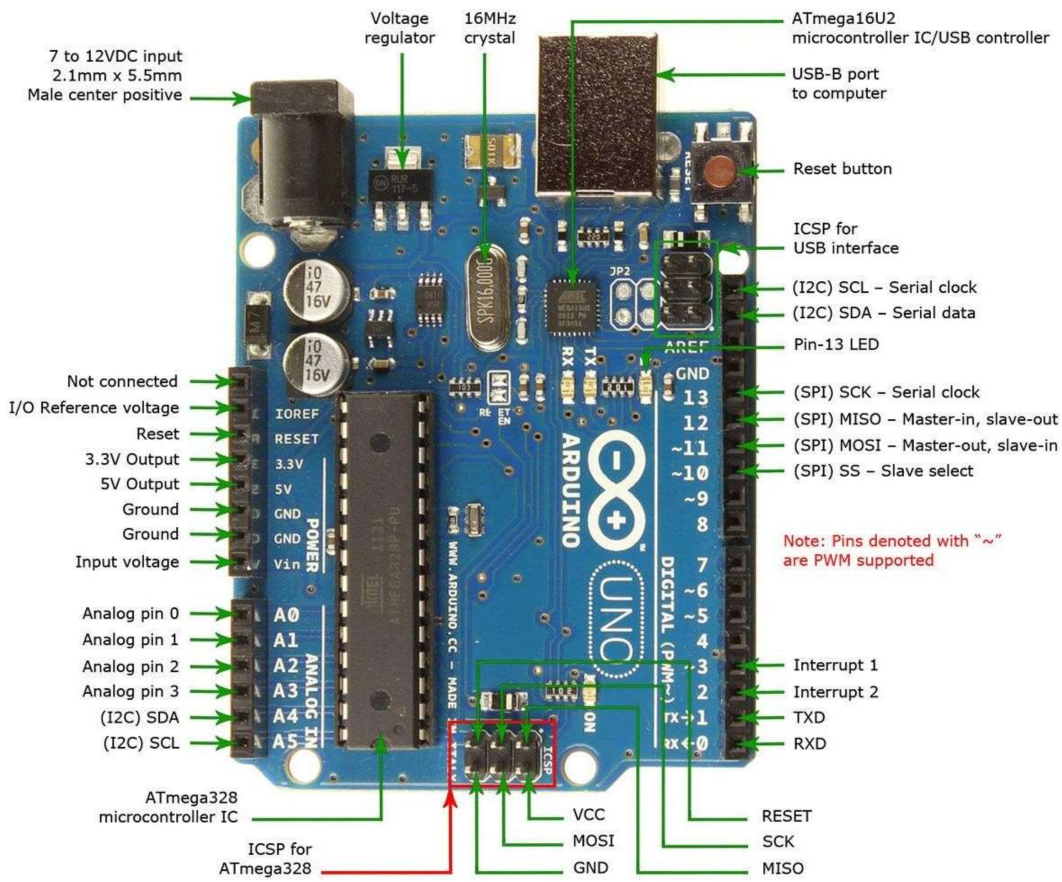


Fig 10.1 Explanation of Arduino UNO Diagram

There are four major parts involved in construction of Arduino UNO. They are

1)Timers

2)Memory

3)Registers

4)Serial Communication

1. Timers:

They are Six types of Timers in Arduino UNO. They are

i. Timer-0
ii. Timer-1
iii. Timer-2
iv. 8-bit Timer
v. 16-bit Timer
vi. Watch dog Timer: It is used for finding an error in the system.

i. Timer/Counter 0 (8-bit):

- Timer/Counter 0 is an 8-bit timer, meaning it can count from 0 to 255.
- It is commonly used for basic timing functions and is the timer behind the `millis()` and `micros()` functions in Arduino.
- Timer/Counter 0 can be configured to generate interrupts at specific intervals.

ii. Timer/Counter 1 (16-bit):

- Timer/Counter 1 is a 16-bit timer, allowing it to count from 0 to 65535.
- It provides more precise timing intervals compared to Timer/Counter 0.
- Timer/Counter 1 can be configured in different modes, including normal mode, CTC (Clear Timer on Compare Match) mode, and PWM (Pulse Width Modulation) mode.
- It can generate interrupts, and its PWM capabilities make it suitable for controlling motor speeds and generating analog-like output signals.

iii. Timer/Counter 2 (8-bit):

- Timer/Counter 2 is another 8-bit timer similar to Timer/Counter 0.
- It is often used for generating PWM signals on specific pins (e.g., pins 3 and 11 on Arduino Uno).
- Timer/Counter 2 can be configured in PWM mode, allowing for precise control of pulse widths.

1) Memory:

In an Arduino Uno and similar microcontroller-based systems, "memory" typicallyrefers to the various types of memory that the microcontroller uses to store and manage data during program execution.

There are three types of memories in Arduino UNO.They are

i) Static Random Access Memory (SRAM):

The memory size of SRAM is 2KB.SRAM is used to temporarily store data that the microcontroller needs while executing your Arduino program (sketch). This data may include variables, arrays, and other information necessary for calculations and decision- making during program execution.

ii) Read Only Memory (ROM):

In an Arduino Uno, as in most microcontroller-based systems, Read-Only Memory (ROM) is used to store the firmware or program that controls the behavior of the microcontroller. In the context of the Arduino Uno, ROM typically refers to the flash memory where your Arduino sketch (program) is stored.

iii) Electrically Erasable Programmable Read Only Memory(EEPROM):

In an Arduino Uno and many other microcontroller-based systems, Electrically Erasable Programmable Read-Only Memory (EEPROM) is a type of non-volatile memory used to store data that needs to be retained even when the power is turned off or the microcontroller is reset.

2) Registers:

Registers are used for a variety of purposes, including controlling hardware peripherals, configuring the microcontroller, and manipulating data.In Arduino programming, you can access and manipulate these registers directly when needed, although it is generally recommended to use the Arduino libraries and functions provided by the Arduino IDE to abstract low-level hardware details and simplify coding for most applications. However, understanding registers becomes valuable when you need to optimize code for performance or interface directly with hardware peripherals.

There are three types of registers in Arduino UNO.They are

i) Data Direction Register: Data direction register informs to CPU whether the connected device is Input/Output.

ii) PORT Register: PORT register detects High/Low whether the Input/Output port.

iii) PIN Register: PIN register will detect (or) monitor status of the port register whether it is in ON/OFF position.

3) Serial Communication:

Serial communication in Arduino Uno refers to the process of transmitting and receiving data between the microcontroller (ATmega328P) on the Arduino board and external devices, such as a computer, sensors, displays, or other microcontrollers. Arduino Uno supports serial communication using hardware UART (Universal Asynchronous Receiver-Transmitter) ports.

There are three types of serial communication ports in Arduino Uno.They are

i) Serial Peripheral Interface (SPI):

Serial Peripheral Interface (SPI) is a synchronous serial communication protocol used for communication between microcontrollers, sensors, displays, memory devices, and other peripheral devices in embedded systems like the Arduino Uno.

ii) Inter Integrated Circuit (I2C):

Inter Integrated Circuit (I2C) is a popular serial communication protocol used in the Arduino Uno and many other microcontroller-based systems. It's commonly used for communication between the Arduino and various peripheral devices, such as sensors, displays, real-time clocks, EEPROMs, and more.

iii) Universal Asynchronous Receiver & Transmitter (UART):

The Universal Asynchronous Receiver/Transmitter (UART) is a critical hardware component in the Arduino Uno and many other microcontroller-based systems. UART provides asynchronous serial communication capabilities, allowing the Arduino Uno to transmit and receive data with external devices like sensors, displays, GPS modules, and more.

10.2 LED Blink using Arduino Uno:

To make an LED blink using an Arduino Uno, you'll need the following components:

1. Arduino Uno board
2. LED (any color)
3. 220-330 ohm resistor (exact resistance may vary depending on your LED)
4. Jumper wires
5. Breadboard (optional)

Here's a step-by-step guide to create a simple LED blinking circuit and program it using the Arduino IDE:

Circuit Connections:

Connect the anode (longer leg) of the LED to one leg of the resistor.

Connect the other leg of the resistor to any of the digital pins on the Arduino Uno (e.g., Pin 13).

Connect the cathode (shorter leg) of the LED to the ground (GND) pin on the Arduino.

Here's a simplified schematic:

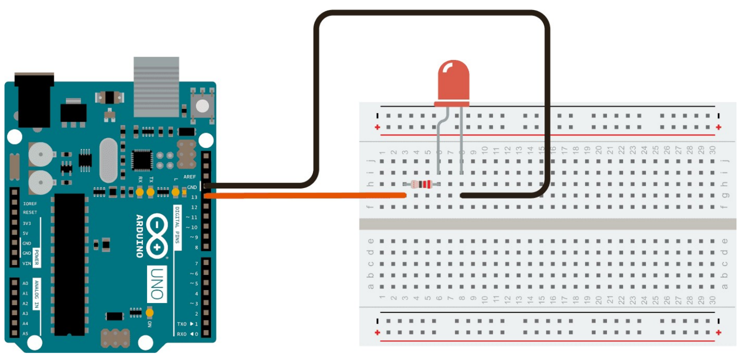


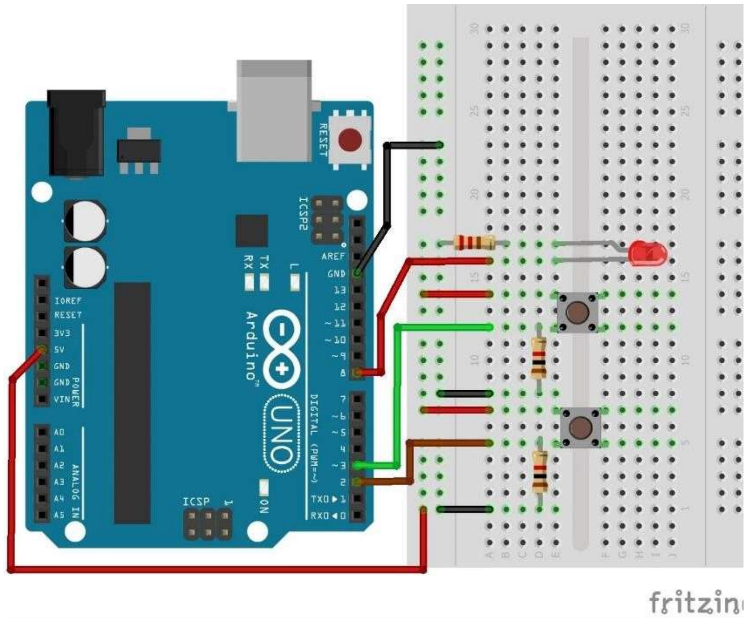
Fig.10.2 LED Blink using Arduino uno

Arduino Uno Code:

```
// Define the LED pin
int ledPin = 13;
void setup() {
// Initialize the LED pin as an OUTPUT
  pinMode(ledPin, OUTPUT);
}
void loop() {
  // Turn the LED on
  digitalWrite(ledPin, HIGH);
  // Wait for a moment
  delay(1000); // 1000 milliseconds = 1 second
  // Turn the LED off
  digitalWrite(ledPin, LOW);
  // Wait for another moment
  delay(1000);
}
```

10.3 Logic gates using Arduino Uno:

10.3.1. AND GATE:



Truth table:

A	B	Y
0	0	0
0	1	0
1	0	0
1	1	1

Fig. 10.3.1 AND GATE

Arduino uno code:

```
int led=8;
int button1=3;
int button2=2;
void setup() {
pinMode(led, OUTPUT);
pinMode(button1, INPUT);

pinMode(button2, INPUT);
}
void loop() {
button1=digitalRead(3);
button2=digitalRead(2);
if(button1==1 && button2==1){
digitalWrite(led, HIGH);
   }
else {
     digitalWrite(led, LOW);
     }
}
```

10.3.2. OR GATE:

Truth table:

A	B	Y
0	0	0
0	1	1
1	0	1
1	1	1

Arduino uno code:

```
int led=8;
int button1=3;
int button2=2;
void setup() {
  pinMode(led, OUTPUT);
  pinMode(button1, INPUT);
  pinMode(button2, INPUT);
}

void loop() {
  button1=digitalRead(3);
  button2=digitalRead(2);
  if(button1==0 && button2==0){
  digitalWrite(led, LOW);

    }
    else{
      digitalWrite(led, HIGH);
    }
}
```

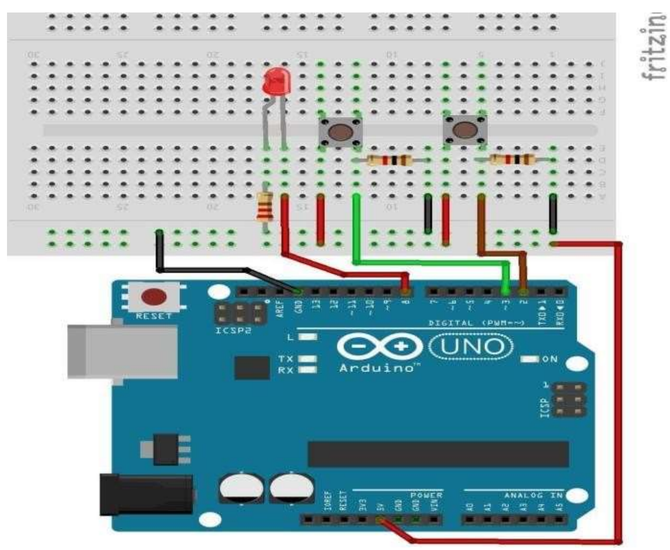
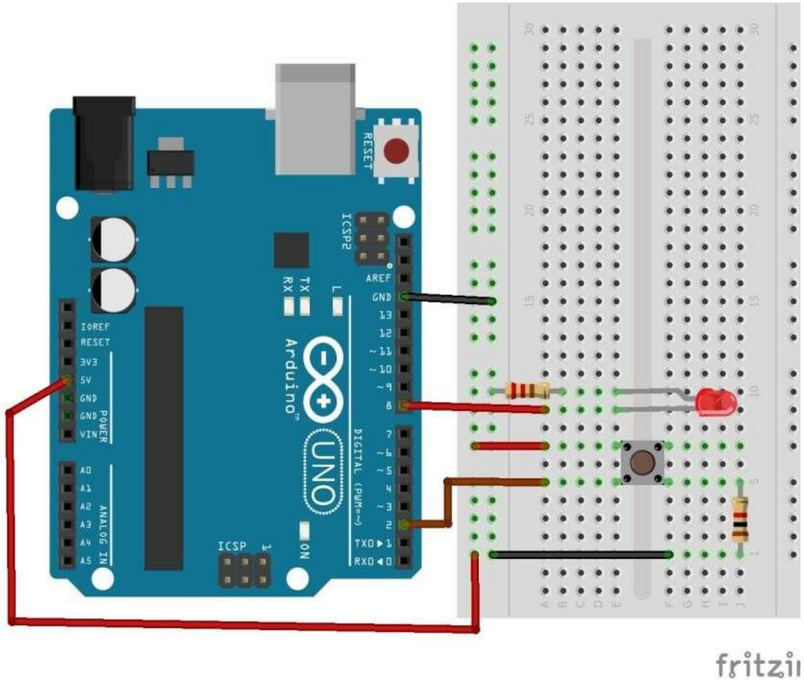


Fig. 10.3.2 OR GATE

10.3.3. NOT GATE:



Truth table:

A	Y
0	1
1	0

Fig. 10.3.3 NOT GATE

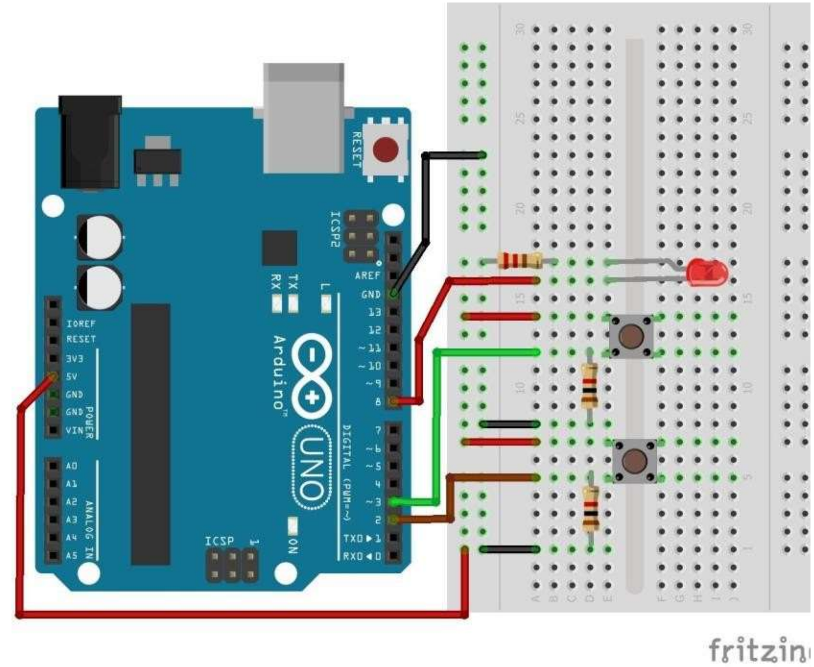
Arduino Uno code:

```
int led=8;
int button1=2;
void setup() {
pinMode(led, OUTPUT);
pinMode(button1, INPUT);
}

void loop() {
button1=digitalRead(2);
if(button1==1){
digitalWrite(led,LOW);

}
```

10.3.4.NOR GATE:



Truth table:

Truth table:

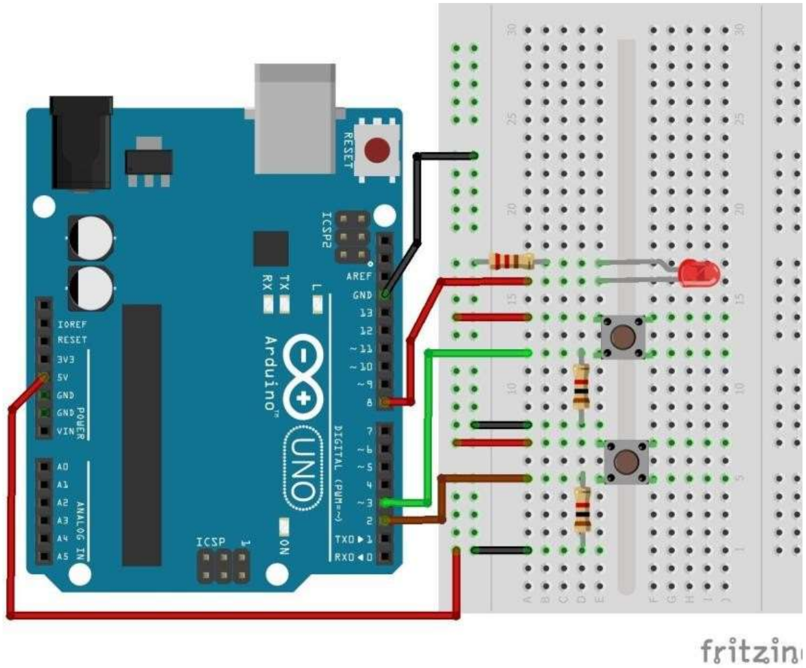
A	B	Y
0	0	1
0	1	1
1	0	1
1	1	0

Fig. 10.3.4 NOR GATE

Arduino Uno code:

```
int led=8;
int button1=3;
int button2=2;
void setup() {
pinMode(led, OUTPUT);
pinMode(button1, INPUT);
pinMode(button2, INPUT);
}
void loop() {
button1=digitalRead(3);
button2=digitalRead(2);
if(button1==0 && button2==0){
digitalWrite(led, HIGH);
}
 else{
digitalWrite(led, LOW);
 }
}
```

10.3.5. NAND GATE:



Truth table:

A	B	Y
0	0	1
0	1	0
1	0	0
1	1	0

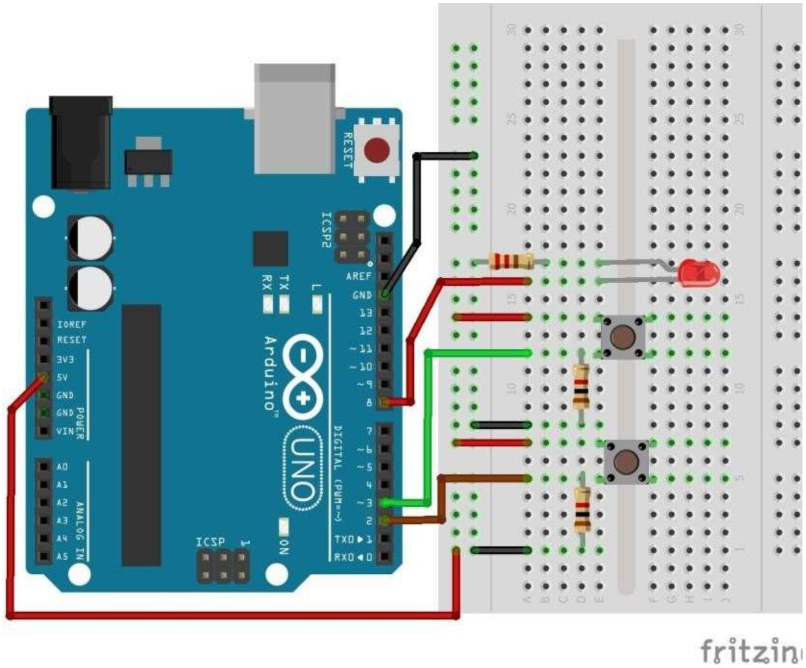
Fig. 10.3.5 NAND GATE

Arduino Uno code:

```
int led=8;
int button1=3;
int button2=2;
void setup() {
  pinMode(led, OUTPUT);
  pinMode(button1, INPUT);
  pinMode(button2, INPUT);
}
void loop() {

  button1=digitalRead(3);
  button2=digitalRead(2);
  if(button1==1 && button2==1){
  digitalWrite(led, LOW);
   }
    else{
    digitalWrite(led, HIGH);
    }
}
```

10.3.6. XNOR GATE:



Truth table:

A	B	Y
0	0	0
0	1	1
1	0	1
1	1	0

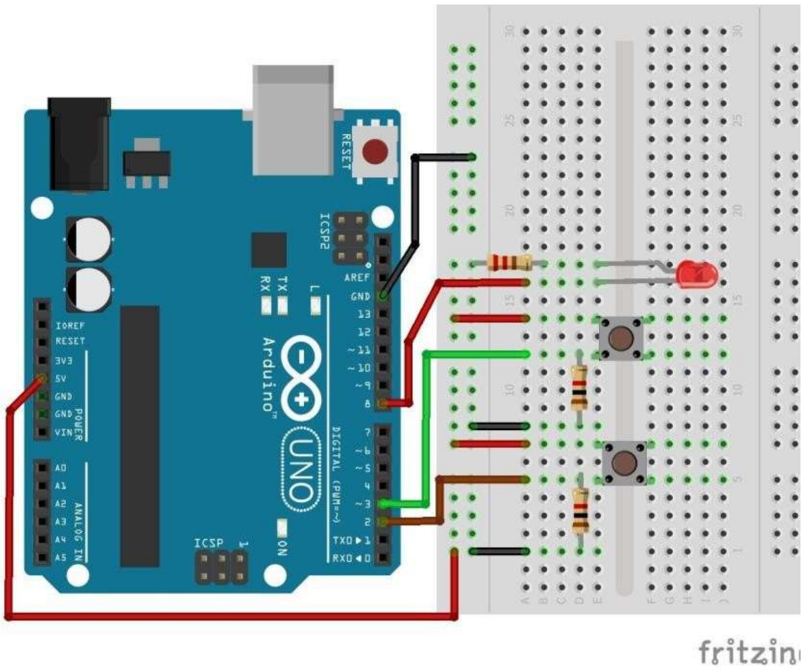
Fig. 10.3.6 XNOR GATE

Arduino uno code:

```
int led=8;
Arduino Uno code:
int button1=3;
int button2=2;
void setup() {
pinMode(led,OUTPUT);

  pinMode(button1, INPUT);
  pinMode(button2, INPUT);
}
void loop() {
  button1=digitalRead(3);
  button2=digitalRead(2);
  if(button1==0 && button2==0){
  digitalWrite(led, HIGH);
    }
    else if(button1==1 && button2==1){
      digitalWrite(led, HIGH);
      }
    else{
      digitalWrite(led, LOW);
    }
}
```

10.3.7. XOR GATE:



Truth table:

A	B	Y
0	0	1
0	1	0
1	0	0
1	1	1

Fig. 10.3.7 XOR GATE

Arduino uno code:

```
int led=8;
int button1=3;
int button2=2;
void setup() {
pinMode(led,OUTPUT);
pinMode(button1,INPUT);
pinMode(button2,INPUT);
}

void loop() {
button1=digitalRead(3);
button2=digitalRead(2);
if(button1==0 && button2==0){
digitalWrite(led, LOW);

}
else if(button1==1 && button2==1){
digitalWrite(led, LOW);
 }
 else{
 digitalWrite(led, HIGH);
 }
}
```

10.4. HALF ADDER:

Arduino uno code:

```
int led1=9;
int led2=8;
int button1=5;
int button2=4;
void setup()
{
  pinMode(led1, OUTPUT);
  pinMode(led2, OUTPUT);
  pinMode(button1, INPUT);
  pinMode(button2,INPUT);
}

void loop()
{
  button1=digitalRead(5);
  button2=digitalRead(4);
  if(button1==0 && button2==0){
  digitalWrite(led1,0);
  digitalWrite(led2,0);

  }
  else if(button1==1 && button2==1){
  digitalWrite(led1,0);
  digitalWrite(led2,1);
  }
else{
  digitalWrite(led1,1);
  digitalWrite(led2,0);
  }
}
```

Truth table:

A	B	SUM	CARRY
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

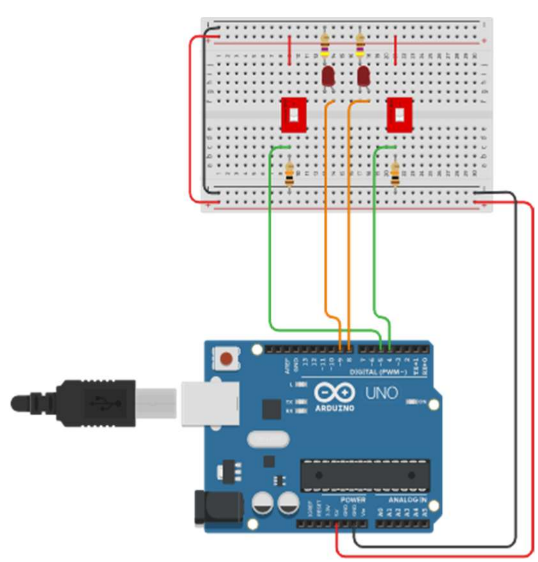


Fig. 10.3.8 Half Adder

10.5. Ultrasonic Sensor with LED:

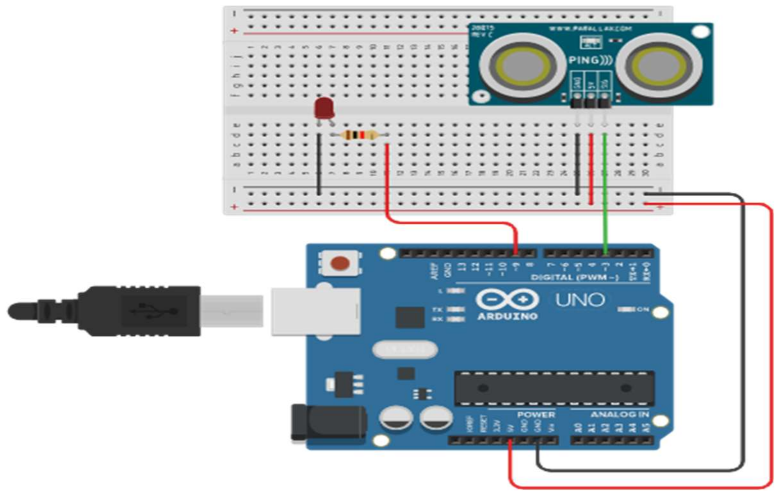


Fig. 10.4 Ultrasonic Sensor

Ultrasonic rangefinders use sound waves to bounce off objects in front of them, much like bats using echolocation to sense their environment. The proximity sensor sends out a signal and measures how long it takes to return. The Arduino program receives this information and calculates the distance between the sensor and object.

Code for Ultrasonic Sensor:

```
// Define the pins for the ultrasonic sensor
const int trigPin = 9;
const int echoPin = 10;

// Define the pin for the buzzer
const int buzzerPin = 7;

void setup() {
  // Initialize the serial communication
  Serial.begin(9600);

  // Initialize the ultrasonic sensor pins
  pinMode(trigPin, OUTPUT);
  pinMode(echoPin, INPUT);

  // Initialize the buzzer pin
  pinMode(buzzerPin, OUTPUT);
}

void loop() {
  // Trigger the ultrasonic sensor
```

```
 digitalWrite(trigPin, LOW);
  delayMicroseconds(2);
  digitalWrite(trigPin, HIGH);
  delayMicroseconds(10);
  digitalWrite(trigPin, LOW);

  // Measure the echo time
  long duration = pulseIn(echoPin, HIGH);

  // Calculate the distance in centimeters
  int distance = duration / 58;

  // Print the distance to the Serial Monitor
  Serial.print("Distance: ");
  Serial.print(distance);
  Serial.println(" cm");

  // Check if an object is within a certain range (e.g., 20 cm)
  if (distance < 20) {
    // Turn on the buzzer
    digitalWrite(buzzerPin, HIGH);
  } else {
    // Turn off the buzzer
    digitalWrite(buzzerPin, LOW);
  }
  // Wait for a short time before taking another measurement
  delay(100);
}
```

10.6. PIR Motion Sensor with Arduino:

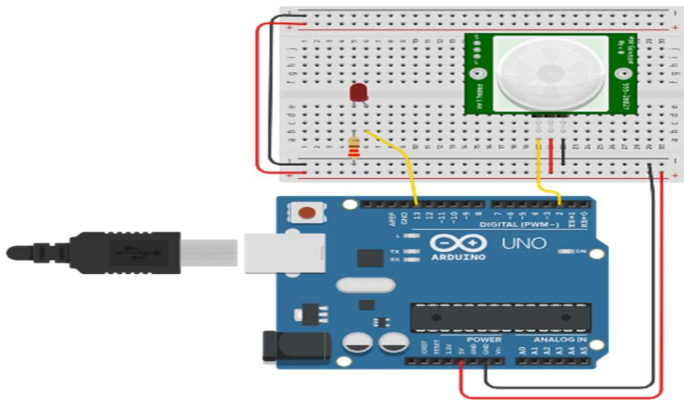


Fig. 10.5 PIR Motion Sensor

A Passive Infrared (PIR) sensor is a type of motion sensor commonly used in embedded systems and security applications. It detects changes in infrared radiation within its field of view to detect the presence of moving objects, humans, or animals. PIR sensors may detect motion within a defined field of view or detection zone. Typically, this zone has a pyramidal or cone shape.

Code for PIR Motion Sensor:

```
int sensorState = 0;

void setup()
{
  pinMode(2, INPUT);
  pinMode(LED_BUILTIN, OUTPUT);
}

void loop()
{
  // read the state of the sensor/digital input
  sensorState = digitalRead(2);
  // check if sensor pin is HIGH. if it is, set the
  // LED on.
  if (sensorState == HIGH) {
    digitalWrite(LED_BUILTIN, HIGH);
  } else {
    digitalWrite(LED_BUILTIN, LOW);
  }
  delay(10); // Delay a little bit to improve simulation performance
}
```

10.7. Arduino interfacing with LCD (Liquid Crystal Display):

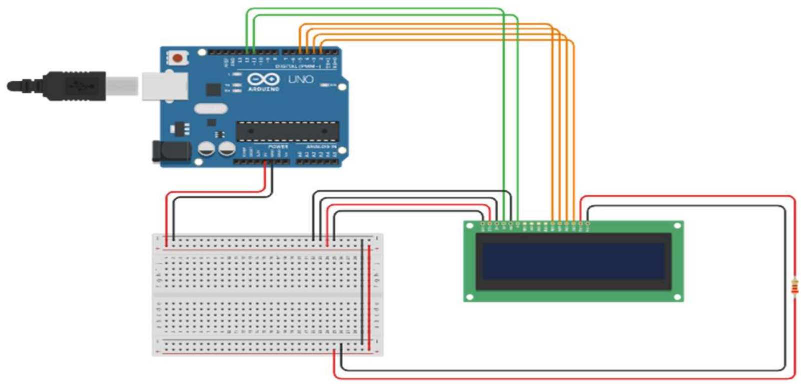


Fig. 10.6 Liquid Crystal Display

Interfacing an Arduino with an LCD (Liquid Crystal Display) is a common and useful task in embedded systems and electronics projects. LCDs provide a visual output that can be used to display information, such as sensor data, messages, or status updates. Character LCDs, which can show text in rows and columns, are the LCDs most frequently used with Arduino. 16x2 and 20x4 are common sizes, with 2 or 4 rows and 16 characters per row.

Code for Liquid Crystal Display:

```
#include <LiquidCrystal.h>

const int rs = 12, en = 11, d4 = 5, d5 = 4, d6 = 3, d7 = 2;
LiquidCrystal lcd(rs, en, d4, d5, d6, d7);

void setup() {
  //set up the LCD's number of columns and rows:
  lcd.begin(16,2);

  //Print a message to the LCD.
  lcd.print("Hello!");
}
void loop() {

  lcd.setCursor(4,2);
  lcd.print("WORLD");

}
```

10.8. Controlling Servo Motor with Arduino:

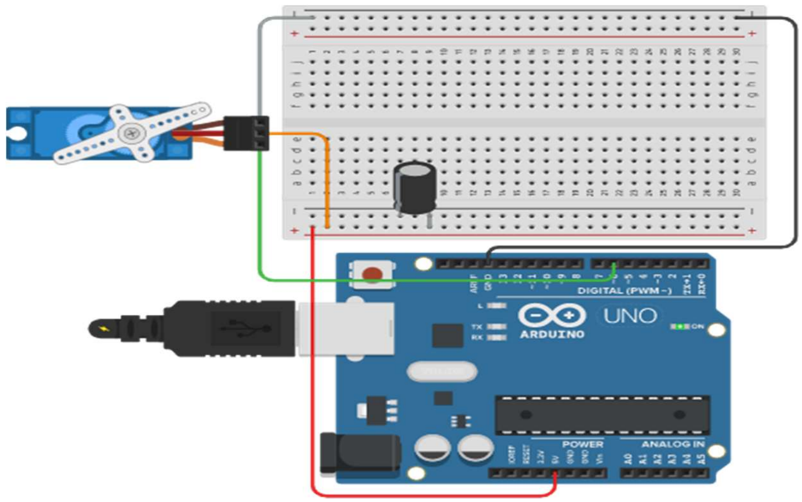


Fig. 10.7 Servo Motor

A servo motor is a type of rotary actuator that is commonly used in embedded systems and robotics. It's designed to provide precise control of angular position, velocity, and acceleration. Standard servo motors have a limited range of motion (usually 180 degrees) and are commonly used for tasks like steering in RC cars and moving robot limbs. In embedded systems, servo motors are essential components for achieving precise and controlled motion. They offer a wide range of applications across various industries and are particularly valuable in robotics, where precise movement and positioning are critical.

Code for Servo Motor:

```
#include <Servo.h>
Servo myservo; //name the pin of servo motor as myservo

//int angle = 0; //current angle
//int direc = 0; //currrent direction;0=clockwise;1=anti-clockwise
void setup(){
  myservo.attach(6); //pwm to D6
}
void loop(){
  for(int ang=0; ang<180; ang++){ //clockwise
    myservo.write(ang); //rotate pin of servo motor
    delay(50); //for 0.05 second
  }
  for(int ang=180; ang>0; ang--){ //anti-clockwise
    myservo.write(ang);
    delay(50);
  }
}
```

10.9. ESP32:

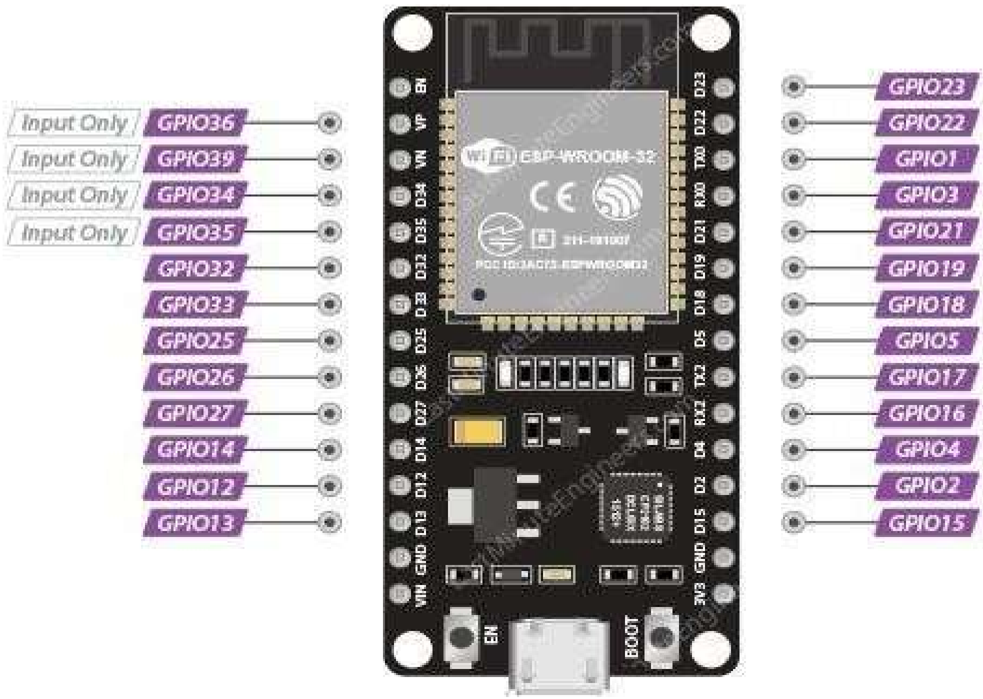


Fig. 10.8 Symbol of ESP32

The ESP32 is a powerful and versatile microcontroller and system-on-chip (SoC) designed by Espressif Systems. It's widely used for various Internet of Things (IoT) applications due to its robust features and capabilities.

Key Features:

Dual-Core Processor:

The ESP32 features a dual-core Tensilica LX6 processor, allowing for parallel processing andbetter performance.

Wireless Connectivity:

Wi-Fi: It supports IEEE 802.11 b/g/n standards, providing wireless internet connectivity.

Bluetooth: It has built-in Bluetooth support, including both Classic Bluetooth and BluetoothLow Energy (BLE).

Low Power Consumption:

The ESP32 is designed with power efficiency in mind, making it suitable for battery-poweredand energy-conscious applications.

Rich Peripherals:

GPIO (General Purpose Input/Output) pins allow interfacing with various sensors, actuators,and other hardware components.

I2C, SPI, UART, and other communication interfaces for connecting to a wide range ofdevices.

Analog-to-Digital Converter (ADC) for reading analog sensors.

Security Features:

It includes features like Secure Boot, Flash Encryption, and Secure Digital Signature toenhance the security of IoT applications.

Programming Options:

Programming can be done using the Arduino IDE, MicroPython, or the Espressif IoT Development Framework (ESP-IDF), which provides a more in-depth level of control.

Open-Source Community:

The ESP32 has a vibrant and active open-source community that contributes to itsdevelopment, provides libraries, and shares knowledge.

Code for ESP32:

AND GATE:

```
int led=22;

int button1=14;

int button2=27;

void setup() {
pinMode(led,OUTPT);
pinMode(button1, INPUT);
pinMode(button2, INPUT);
}
void loop() {
button1=digitalRead(14);
button2=digitalRead(27);
if(button1==1 &&
button2==1){
digitalWrite(led, HIGH);
}
else {
```

```
digitalWrite(led, LOW);

}

}
```

10.9.1 ESP8266:

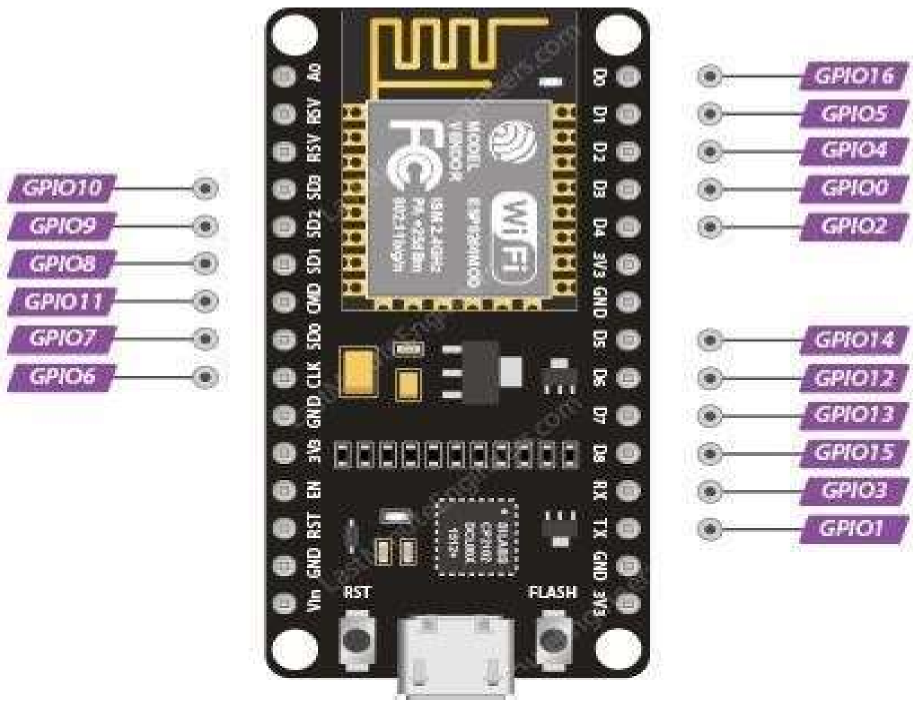
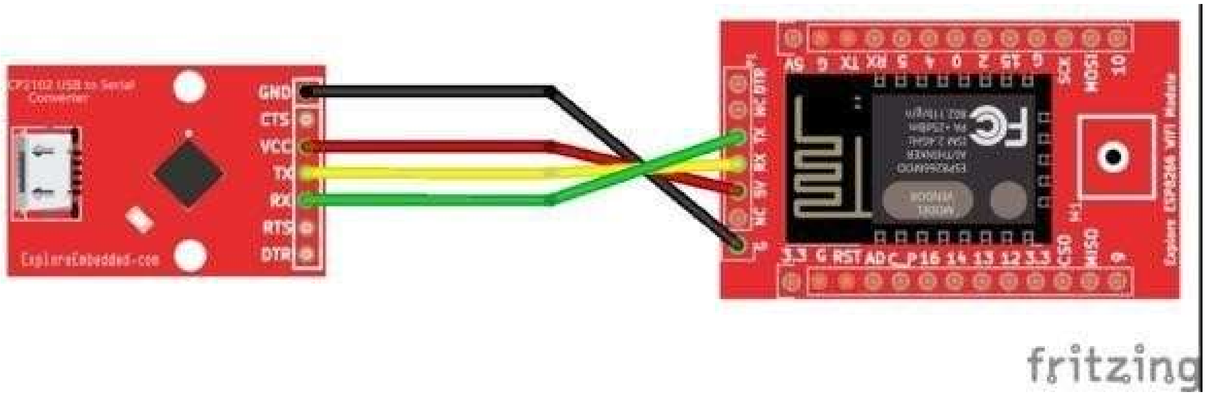


Fig. 10.9 Symbol of ESP8266

The ESP8266 is a low-cost Wi-Fi microchip, with built-in TCP/IP networking software, and microcontroller capability, produced by Espressif Systems in Shanghai, China. ESP8266.ESP8266-IC. Manufacturer. Espressif Systems.

Wi-Fi: the ESP8266 can generate its own Wi-Fi network (access point) or connect to other Wi-Fi networks (station) to get access to the internet. This means the ESP8266 can access online services to make HTTP requests or save data to the cloud, for example. It can also actas a web server so that you can access it using a web browser and be able to control and monitor your boards remotely.

To program ESP8266, you need a USB to serial converter. Image below shows connections made from Explore USB to Serial and Explore Wifi boards. Note that the Explore Wifi boardhas on board 3.3v regulator and circuitry to reset the board and put it in programming mode.



Code for ESP8266:

```
#include
 "ESP8266WiFi.h"
 void setup()
{

  Serial.begin(115200);
 WiFi.mode(WIFI_ST
 A); WiFi.disconnect();
 delay(100);
 Serial.println("Setup
 done");
}

 void loop()

{

  Serial.println("scan start");
  int n = WiFi.scanNetworks();
  Serial.println("scan  done"); if (n == 0)
    Serial.println("no networks
  found");else
  {

    Serial.print(n);

    Serial.println(" networks found");
    for (int i = 0; i < n; ++i)
    {

      Serial.print(i + 1); Serial.print(":
      "); Serial.print(WiFi.SSID(i));
      Serial.print(" ("));
```

```
        Serial.print(WiFi.RSSI(i));
        Serial.print(")");
        Serial.println((WiFi.encryptionType(i) == ENC_TYPE_NONE)?" ":"*");
        delay(10);
      }

    }

    Serial.printl
     n("");
     delay(5000
     );
}
```

10.9.2 Arduino Uno as Soil Moisture Sensor:

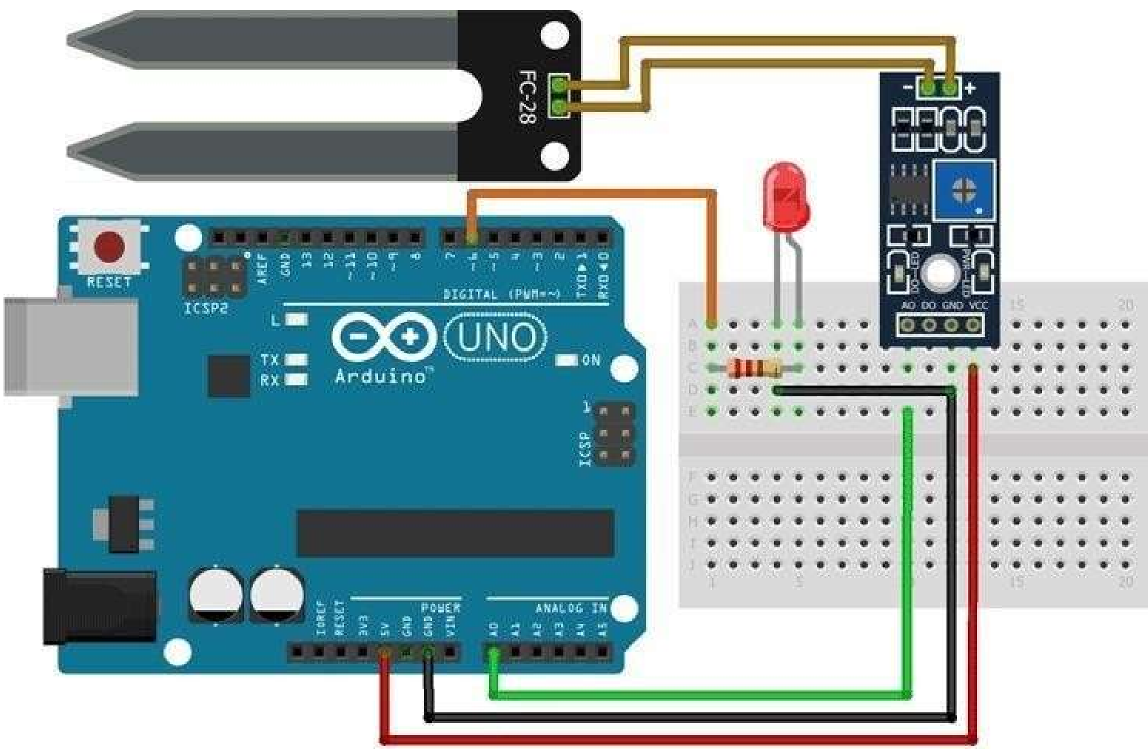


Fig. 10.9.1 Arduino Uno as Soil Moisture Sensor

Soil sensors play a pivotal role in modern agriculture and environmental monitoringby providing real-time data on soil conditions. These devices are designed to measure the moisture content in the soil, offering valuable insights into the water status of the ground. Byfacilitating precise irrigation management, soil sensors contribute to resource efficiency, improved crop yields, and sustainable agricultural practices.

CHAPTER-11

VERY LARGE -SCALE INTEGRATION

1. Definition:

VLSI refers to the process of creating an integrated circuit (IC) by combining thousands oreven millions of transistors on a single chip.

2. Evolution:

The term VLSI originated as a step beyond Large Scale Integration (LSI) in the 1970s. With technological advancements, the number of transistors that could be integrated into a single chip increased dramatically.

3. Importance:

VLSI is a cornerstone of modern electronics. It enables the creation of complex electronic systems with high functionality in a compact form, leading to the development of powerful computers, smartphones, and a myriad of other digital devices.

4. Design Process:

Specification: The process starts with defining the functionality and specifications of the integrated circuit.

Architecture: Designers create a high-level architecture outlining the major components andtheir interactions.

Logic Design: The logical structure of the circuit is defined using hardware description languages (HDLs) like Verilog or VHDL.

Circuit Design: The logical design is then translated into a detailed circuit design, specifyingindividual components and their interconnections.

Layout: This involves placing and routing the components on the physical chip, consideringfactors like power consumption, heat dissipation, and signal integrity.

5. Challenges:

Miniaturization: Shrinking the size of transistors and other components poses challenges related to heat dissipation and quantum effects.

Power Consumption: As the number of transistors increases, managing power-consumption becomes critical.

Signal Integrity: Ensuring that signals propagate correctly and without interference is crucialin high-density circuits.

VLSI design using LT spice:

LTspice is commonly used for analog and digital circuit simulation and incorporating VLSI into the mix can open up a whole new world of possibilities.

In VLSI, you're dealing with the design and fabrication of integrated circuits (ICs) with thousands or even millions of transistors on a single chip. Now, to bring this into LTspice, you'd typically start by modelling the individual components at a higher level of abstraction.

Component Modeling: Instead of modeling each transistor individually, you'd likely usehigher-level models that capture their behavior. This could include using parameters likethreshold voltage, mobility, and so on.

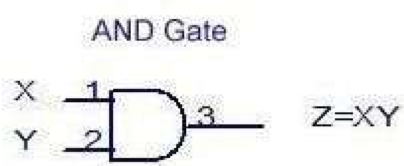
Subcircuits: For more complex components or modules, you might create subcircuits. This allows you to encapsulate a part of your design and treat it as a single component in the maincircuit.

Digital Components: If you're dealing with digital VLSI, you can use digital models for gates,flip-flops, etc. There are standard digital models available, or you can create your own based on the specifications of your VLSI design.

11.1 And gate:

Truth table:

2 Input AND Gate



TRUTH TABLE

INPUTS		OUTPUT
X	Y	Z
0	0	0
0	1	0
1	0	0
1	1	1

Layout:

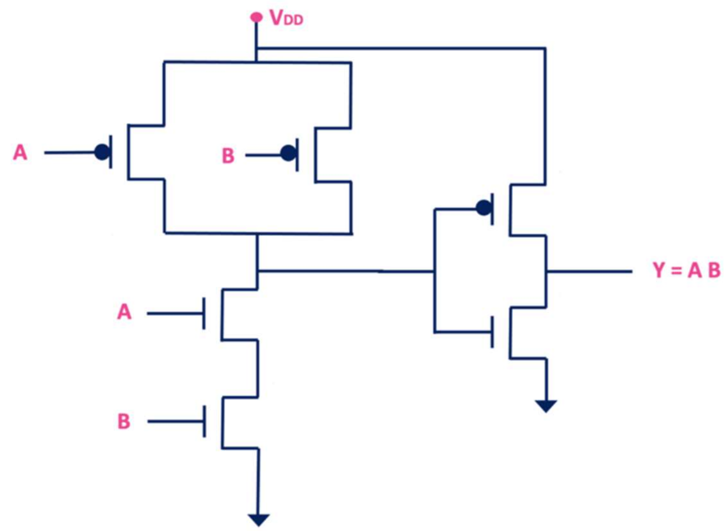
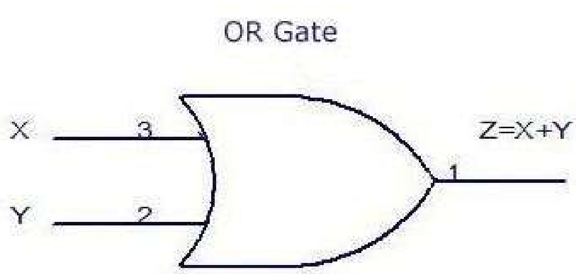


Fig. 11.1 And gate using Cmos logic

11.2 OR gate:

Truth table:

2 Input OR Gate



TRUTH TABLE

INPUTS		OUTPUT
X	Y	Z
0	0	0
0	1	1
1	0	1
1	1	1

Layout:

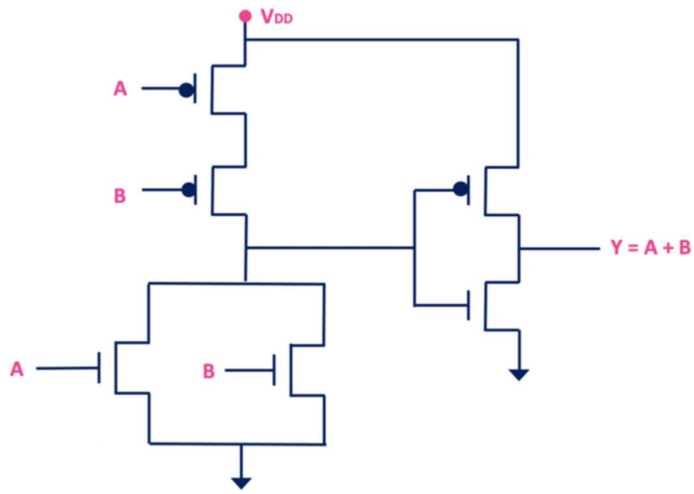


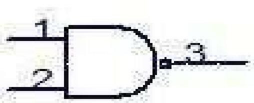
Fig. 11.2 OR gate using Cmos logic

11.3 Nand gate:

Truth table:

2 Input NAND Gate

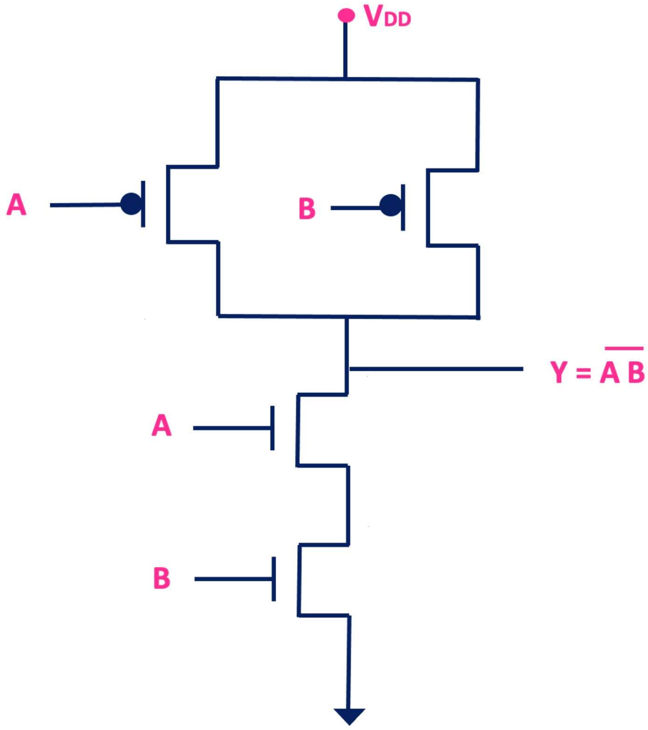
NAND Gate



TRUTH TABLE

INPUTS		OUTPUT
X	Y	Z
0	0	1
0	1	1
1	0	1
1	1	0

Layout:



Truth Table

A	B	Y
0	0	1
0	1	1
1	0	1
1	1	0

Fig. 11.3 NAND gate using Cmos logic

11.4 NOR gate:

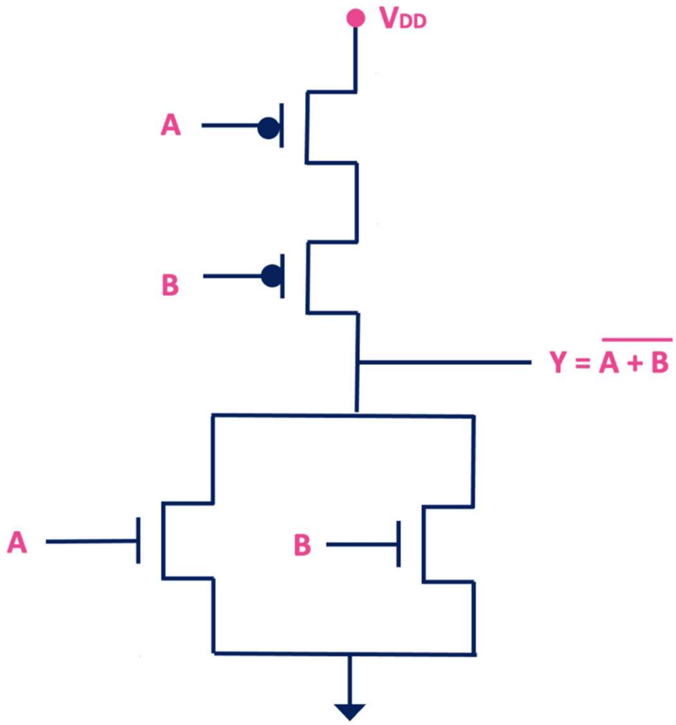
Truth table:

2 Input NOR Gate

TRUTH TABLE

INPUTS		OUTPUT
X	Y	Z
0	0	1
0	1	0
1	0	0
1	1	0

Layout:



Truth Table

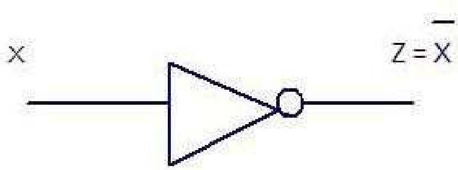
A	B	Y
0	0	1
0	1	0
1	0	0
1	1	0

Fig. 11.4 NOR gate using Cmos logic

11.5 Not gate:

Truth table:

NOT Gate



TRUTH TABLE

INPUT	OUTPUT
X	Z
0	1
1	0

Layout:

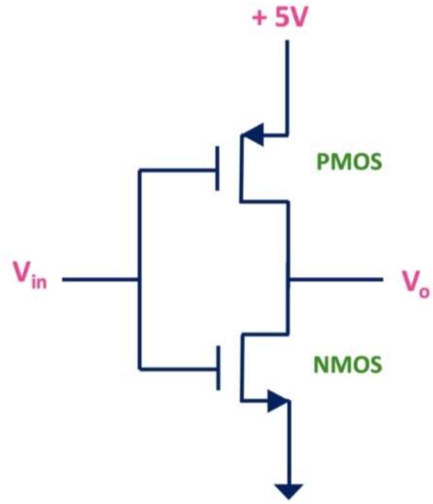


Fig. 11.5 NOT gate using Cmos logic

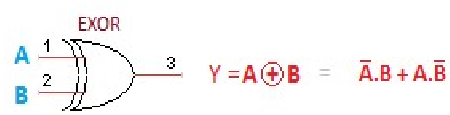
11.6 XOR gate:

Truth table:

Truth table

Two Input XOR gate		
A	B	$Y = A \oplus B$
0	0	0
0	1	1
1	0	1
1	1	0

Symbol



Layout:

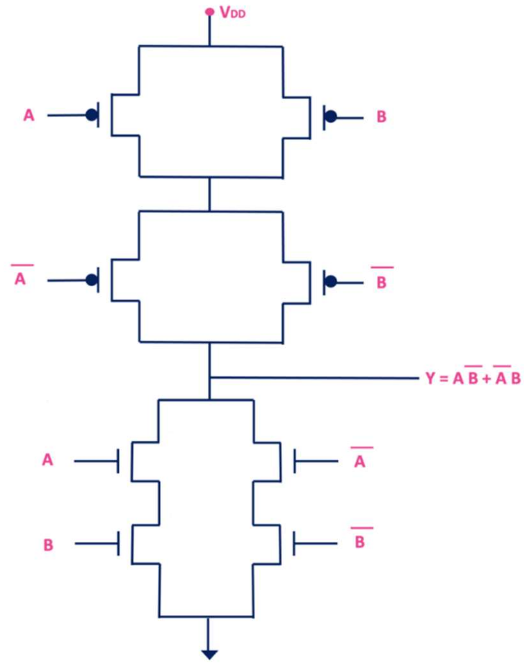


Fig. 11.6 XOR gate using Cmos logic

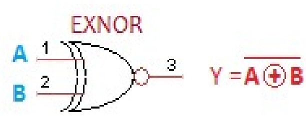
11.7 XNOR Gate:

Truth table:

Truth table

Two Input XNOR gate		
A	B	$Y = \overline{A \oplus B}$
0	0	1
0	1	0
1	0	0
1	1	1

Symbol



Layout:

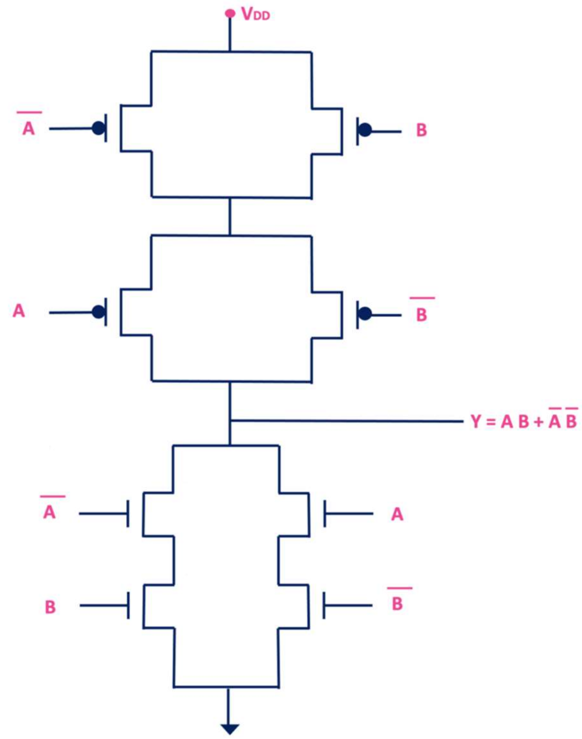


Fig. 11.7 XNOR gate using Cmos logic

CHAPTER-12

PRINTED CIRCUIT BOARD

Definition:

A Printed Circuit Board (PCB) is a flat board made of non-conductive material with conductive pathways etched or printed onto the board. These pathways serve to electricallyconnect and mechanically support electronic components.

Structure:

PCBs are typically composed of layers. The basic structure includes a substrate layer (often fiberglass or composite epoxy) and a conductive layer (usually copper) that forms the circuittraces.

Components:

Electronic components like resistors, capacitors, integrated circuits, and connectors are mounted on the PCB. These components are soldered onto the conductive traces, forming anintegrated and compact electronic circuit.

Types of PCBs:

Single-Sided PCBs: Components are mounted on one side of the board. Double-Sided PCBs: Components are mounted on both sides of the board.
Multi-Layer PCBs: Consists of multiple layers with interconnected traces. These are used forcomplex and compact designs.

Advantages:

Compact Design: PCBs allow for a high density of components in a compact space.

Ease of Manufacturing: Mass production of PCBs is relatively efficient and cost-effective.

Reliability: PCBs enhance the reliability of electronic circuits due to stable connections andreduced chances of loose wiring.

Design Process:

Schematic Design: The electronic circuit is designed using a schematic diagram.

PCB Layout: The components are arranged on the PCB, and the layout is designed, considering factors like signal integrity, power distribution, and thermal management.

Applications:

PCBs are integral to a wide range of electronic devices, including computers, smartphones,medical devices, automotive systems, and more.

Future Trends:

Advances in PCB technology include flexible and rigid-flex PCBs, which offer increased design flexibility and are suitable for applications where traditional rigid boards may not fit.

PCBs are the backbone of modern electronics, enabling the creation of sophisticated and compact electronic devices that have become an integral part of our daily lives. Anythingspecific you're curious about regarding PCBs

Design process:

Create a New Project:

Launch PADS Logic.

Create a new project and set up project properties like project name, location, etc.Schematic

Design:

Start by creating a new schematic sheet.

Place components onto the sheet from the library. Connect components using nets to represent

connections.

Add power symbols, ground symbols, and other necessary elements.Component Libraries:

Make sure you have the required component libraries loaded. Create new components or

modify existing ones if necessary.Netlist Generation:

Generate a netlist once your schematic is complete. This file will be used to link yourschematic to the PCB layout.

Launch PADS Layout:

Open PADS Layout, the PCB layout editor.

Import the netlist you generated in PADS

Logic.Placement:

Place components on the PCB layout. Arrange components in a logical and efficient way,considering factors like signal integrity, thermal management, and ease of manufacturing.

Routing:

Route traces to connect the components based on the netlist.

Follow design rules for trace width, clearance, and other specifications.Design Rule Check (DRC):
Run a design rule check to ensure your layout complies with the specified design rules.Verification and Simulation:
Simulate your design if needed to ensure proper functionality. Review the layout visually to catch any errors or improvements.Generate Output Files:
Generate files necessary for manufacturing, such as Gerber files, NC drill files, and assemblydrawings.

Documentation:

Add any necessary documentation to your design, including fabrication notes, assemblyinstructions, and test points.

Final Checks:

Perform a final check of your design, looking for errors or issues.Generate Reports:
Generate any reports required for manufacturing or documentation purposes.Export:
Export your final design files for manufacturing.

Remember that this is a simplified overview, and each step involves various sub-steps and considerations. Additionally, PADS Logic and Layout may have updates or changes, so it's always a good idea to refer to the specific documentation or help resources for your versionof the software.

Circuit diagram:

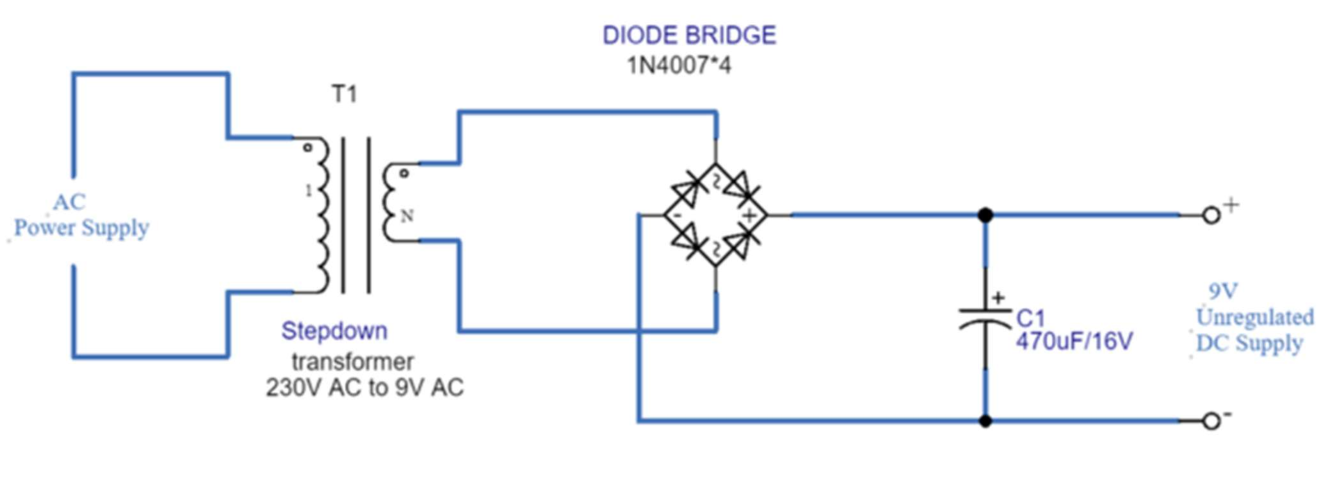
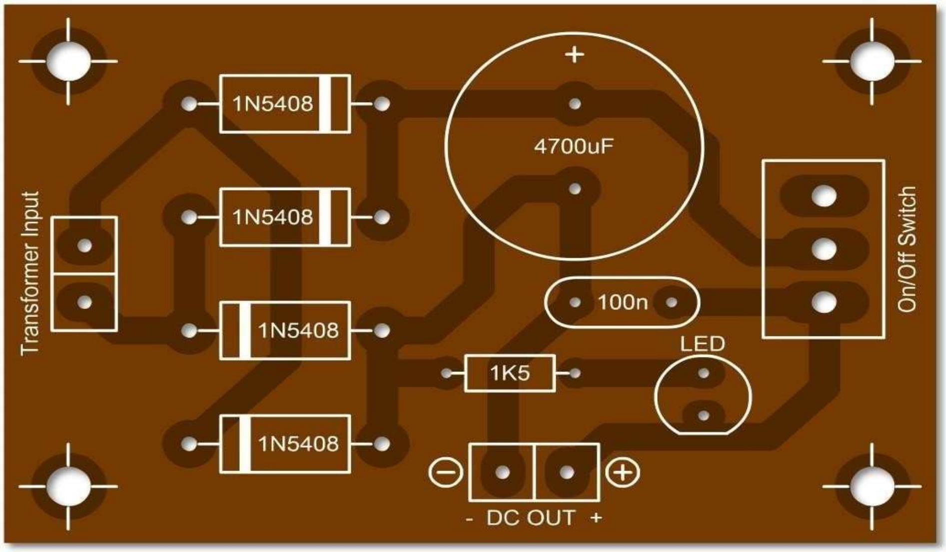


Fig: 12.1 Bridge Rectifier Circuit Schematic

PCB Layout:



Considerations for PCB Layout:

1. Component Placement:
   Position the diodes, capacitor, and other components on the PCB layout, ensuring proper spacing and alignment. Placing components strategically can minimize signal interference and optimize the overall layout.

2. Routing Traces:
   Design traces on the PCB to connect the components according to the schematic diagram. Ensure that traces carrying higher currents (such as those between the diodes and the capacitor) are wider to handle the load efficiently and prevent overheating.

3. Ground Plane:
   Establish a ground plane on the PCB layout. Grounding is crucial for the stability and noise reduction of the rectified DC signal. Connect the ground terminals of all components to the ground plane.

4. Isolation:
   Ensure proper isolation between the AC input side and the DC output side to prevent any electrical hazards. Place a physical barrier or maintain a safe distance between high-voltage components and low-voltage components.

5. Labeling and Documentation:
   Properly label components, connectors, and terminals on the PCB layout. Include a reference designator for each component, making it easier to assemble and troubleshoot the circuit. Provide detailed documentation, including a bill of materials and assembly instructions.

A PROJECT ON SOLAR MONITORING SYSTEM

TABLE OF CONTENTS

1. PROJECT INTRODUCTION:

In this project we will monitor voltage, current, temperature and sunlight intensity with help of sensors which send the data to ESP32 microcontroller. We display the data over Arduino IoT cloud server and also on 16X2 LCD display which is connected to the micro controller. Lets see which sensors we are using for what and their respective pinout diagram below.

1.1 Voltage:

For Measuring voltage, we are using 0-25v DC voltage sensor. This sensor uses the voltage divider which reduces the voltage by 5 times using 2 resistors R1= 30000Ω and R2=7500Ω. As we all know Arduino ADC input voltage ranges from 0-5v but ESP32 has a maximum input of 3.3v only. So with the help of this voltage divider we can measure from 0-16v with ESP32.

- 3.3vX5times=16.5v(MAX)

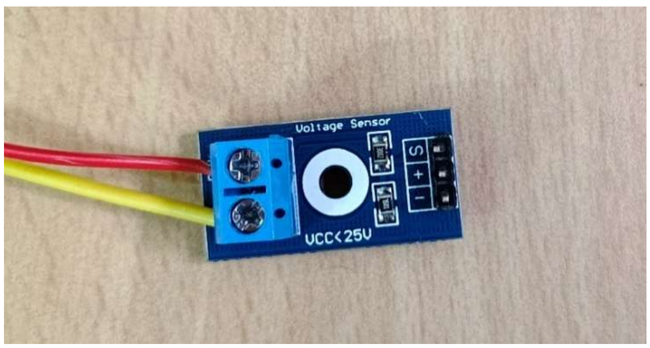


Fig 1.1 Voltage Detection Sensor

1.2 Current:

For measuring current we are using ACS712 5A current sensor. This sensor uses hall effect principle to measure the <u>current</u>, there are 3 variants 5A, 20A and 30A choose according to your need. For this board lower capacity one's give more accurate results than the higher variants. For this sensor we need to use the voltage divider to reduce the sensor output from 5v to 3.3v. So we use 2 resistors R1= 1kΩ and R2= 2kΩ.

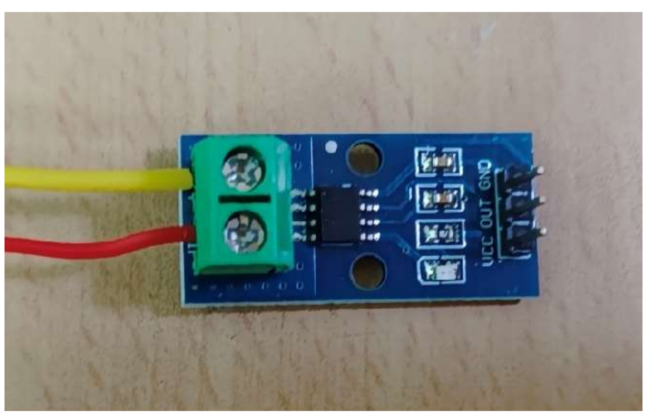


Fig 1.2 ACS712 Current Sensor Module

1.3 Temperature:

To measure temperature we are using DS18B20 temperature sensor. This sensor has the capacity to measure temperature values between -55ºC to +125ºC. We need a 4.7kΩ resistor to connect to the signal from 5v supply. This sensor has very low power consumption of nearly 1mA. We can use waterproof or non water proof sensor according to the requirement.

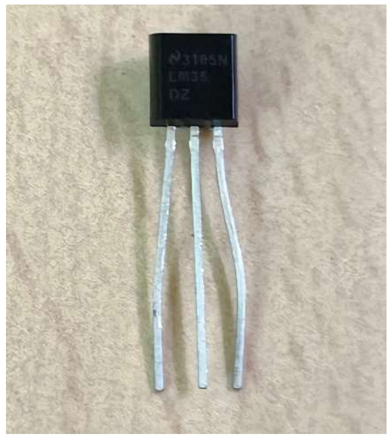


Fig 1.3 DS18B20 Temperature Sensor

1.4 Sunlight intensity:

To measure sunlight intensity we are using BH1750 light intensity sensor which can measure Lux range with a high resolution from 1 to 65535lx. But direct sunlight intensity is higher than 100000lx, we can use filters to reduce the light and compensate the amount of it. But sometimes this sensor measures lux values more than 1 lakh. Here in our casewe just need to know weither the light intensity is high or not

Fig 1.4 BH1750 Light Intensity Sensor

2 BILL OF MATERIALS:

PRODUCT	QUANTITY
Arduino + Wifi Module	1
Voltage Sensor(0-25V)	1
ACS712 Current Sensor Module	1
DS18B20 Temperature Sensor	1
BH1750 Ambient Light Intensity Sensor	1
LCD 16X2 module with or without I2C adapter	1
1k Resistor	1
5V power supply (Micro USB or External	1
Jumper wires	1

3 CIRCUIT DIAGRAM:

Now connect all the required components as shown in the below schematic diagram to build an ESP32 based solar power monitoring system**.**

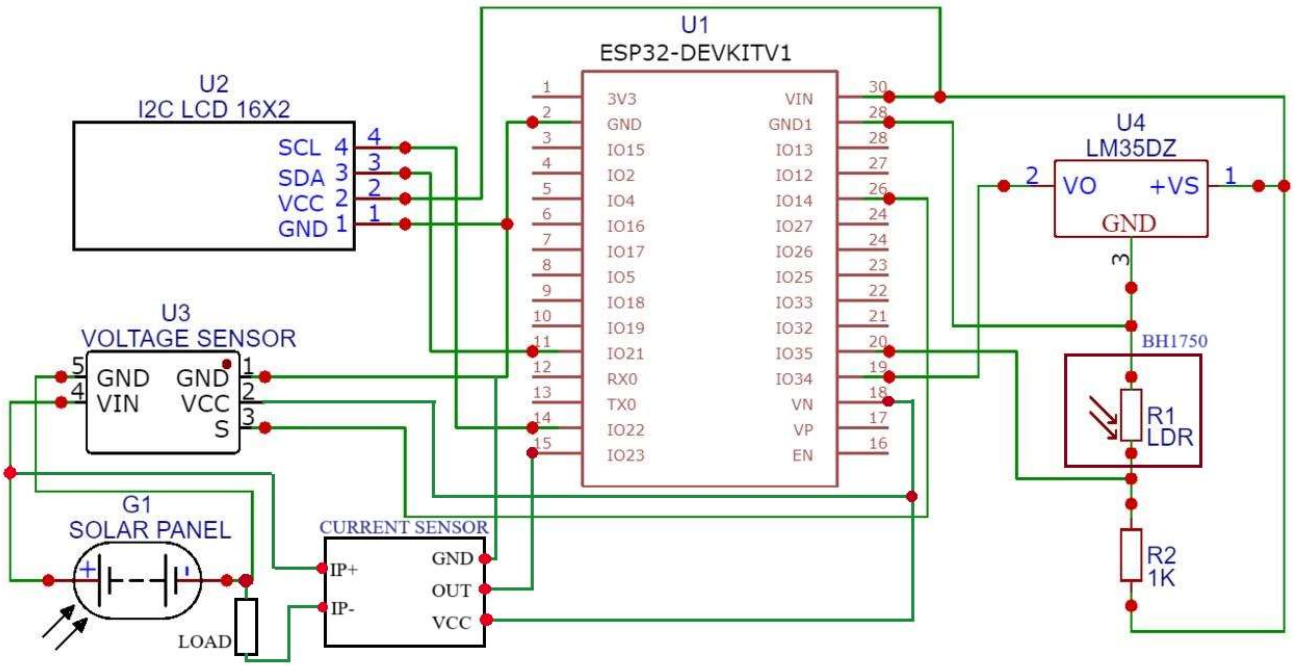


Fig 3 Circuit Diagram of Solar Monitoring System

As you can see from the above circuit diagram we connected 4 sensors, 1 LCD display with ESP32. You can use an external 5v power supply to give all the components a stable voltage without heating up our ESP32.

Voltage sensor with ESP32:

Voltage sensor has 3 pins +, -, and S. + and – pins are connected to 5v and GND terminals of 5v power supply. S pin which is signal pin, connected to analog pin D27 of ESP32.

We need to connect the solar panel terminals in parallel with screw terminals of sensor to measure the voltage of it.

ACS712 current sensor with ESP32:

ACS712 has 3 pins VCC, OUT and GND. VCC and GND pins are connected to 5v and GND terminals of 5v power supply. OUT of ACS712 is connected to D34 of ESP32 along with a voltage divider to reduce the voltage from 5v to 3.3v for ADC.

DS18B20 temperature sensor with ESP32:

Here we used a non-water proof version as we stick it to the solar panel. it has 3 pins VCC on the Right, Signal on the centre and GND on the left. VCC and GND pins of DS18B20 are connected to 3.3V and GND pins of ESP32 respectively. Signal pin is connected to D15 of ESP32 along with a 4.7K ohm resistor to pull up the signal.

BH1750 light sensor with ESP32:

BH1750 sensor uses I2C communication so the data pins SDA and SCL are connected to D21 and D22 of ESP32 respectively. And powered with 5v power supply.

LCD display with ESP32:

LCD display also uses I2C communication so we are connecting SDA and SCL pins of LCD to the same D21 and D22 of ESP32. We can differentiate devices with the I2C address.

4 PROGRAM CODE TO JUST DISPLAY ON LCD DISPLAY:

4.3 Required Libraries:

i. Download LiquidCrystal_I2

ii. Download BH1750 Library

iii. Download Dallas Temperature Library

4.4 Program Code:

```
#include <Wire.h>

#include <LiquidCrystal_I2C.h>

#include <BH1750.h>

// Define the I2C address for your LCD module (typically 0x27 or 0x3F, check your
module)

 LiquidCrystal_I2C lcd(0x27, 16, 2); // Change the values based on your LCD size (16x2,
 20x4, etc.)

// Define the analog pins for the voltage, current, and temperature sensors

const int voltageSensorPin = A1;

const int currentSensorPin = A0;

const int temperatureSensorPin = A2;
```

```
// Create an instance of the BH1750 light intensity sensor
BH1750 lightSensor;
void setup() {
// Initialize the LCD
lcd.init();
lcd.backlight(); // Turn on the backlight (if available on your module)
lcd.clear();     // Clear the LCD screen
// Initialize the BH1750 sensor
lightSensor.begin();
// Initialize serial communication for debugging
Serial.begin(9600);
}
void loop() {
// Read the voltage from the sensor
int voltageSensorValue = analogRead(voltageSensorPin);
// Convert the analog reading to voltage (0-5V)
float voltage = voltageSensorValue * (5.0 / 1023.0);
// Read the current from the sensor
int currentSensorValue = analogRead(currentSensorPin);
// Convert the analog reading to current (assuming a Hall effect sensor calibration)
// You may need to calibrate this conversion based on your specific current sensor.
float current = map(currentSensorValue, 0, 1023, 0, 5); // Assuming a 0-5 Amp range
// Read the temperature from the LM35 sensor and convert it to Celsius
int temperatureSensorValue = analogRead(temperatureSensorPin);
float temperatureCelsius = (temperatureSensorValue / 1024.0) * 500.0;
// Read light intensity from the BH1750 sensor
float lightIntensity = lightSensor.readLightLevel();
// Display voltage, current, temperature, and light intensity on the LCD
lcd.clear();
```

```
lcd.setCursor(0, 0);
lcd.print("V:");
lcd.setCursor(3, 0);
lcd.print(voltage, 2); // Display voltage with 2 decimal places
lcd.setCursor(6, 0);
lcd.print("C:");
lcd.setCursor(8, 0);
lcd.print(current, 2); // Display current with 2 decimal places
lcd.setCursor(0, 1);
lcd.print("T:");
lcd.setCursor(3, 1);
lcd.print(temperatureCelsius, 2); // Display temperature with 2 decimal places
lcd.print(" C");
lcd.setCursor(5, 1);
lcd.print("L:");
lcd.setCursor(7, 1);
lcd.print(lightIntensity, 2); // Display light intensity with 2 decimal places
lcd.print(" lx");
// Display voltage, current, temperature, and light intensity on the serial monitor for debugging
Serial.print("Voltage: ");
Serial.print(voltage, 2);
Serial.print(" V\t");
Serial.print("Current: ");
Serial.print(current, 2);
Serial.print(" A\t");
Serial.print("Temperature: ");
Serial.print(temperatureCelsius, 2);
Serial.print(" C\t");
```

```
Serial.print("Light Intensity: ");
Serial.print(lightIntensity, 2);
Serial.println(" lx");
// Add a delay if needed
delay(1000);  // 1-second delay (adjust as needed)
}
```

4.5 Output on LCD Display:

After uploading the code through ArduinoIDE you can see the sensor values on LCD display as shown in the below image.

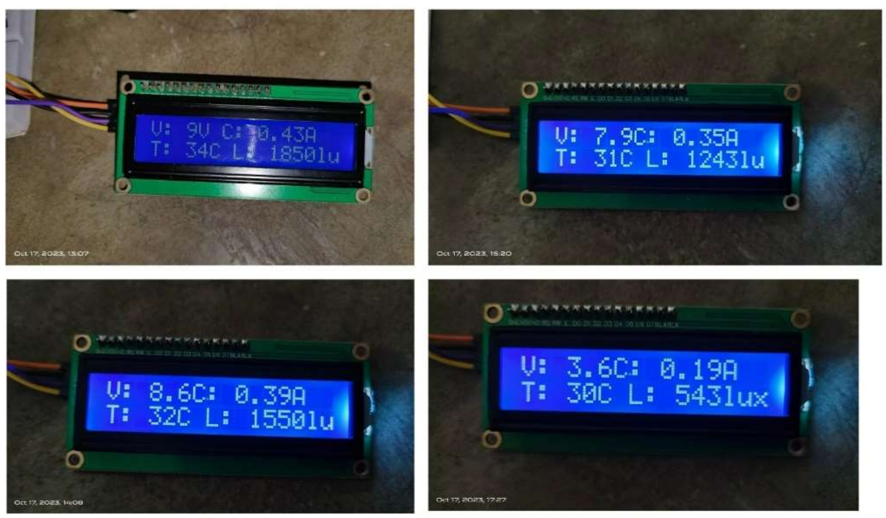


Fig 4.3 Output Display of voltage, current, Light intensity, Temperature

The image's LCD display provides essential data about the solar panel's performance, encompassing voltage (U), current (C), temperature (T), and light intensity (L). The top row presents the current parameter values, while the bottom row indicates these values at a prior point in time, along with the date and time of that previous reading, specifically on October 17, 2023, at 13:07.

These parameters play a pivotal role in monitoring the solar panel's operational efficiency. For instance, if the voltage or current readings are too low, it could be indicative of potential issues with the solar panel or its wiring, necessitating troubleshooting. Elevated temperatures may suggest reduced efficiency, prompting actions to mitigate overheating. Conversely, insufficient light intensity could hinder the solar panel's energy production.

By maintaining continuous surveillance of these parameters, you can promptly detect and rectify any irregularities or complications, ensuring that your solar panel system functions optimally and generates the maximum possible electricity. This real-time feedback is invaluable for preserving the performance and durability of your solar panel installation.

5 PRACTICAL IMAGE OUTCOME OF THE PROJECT:

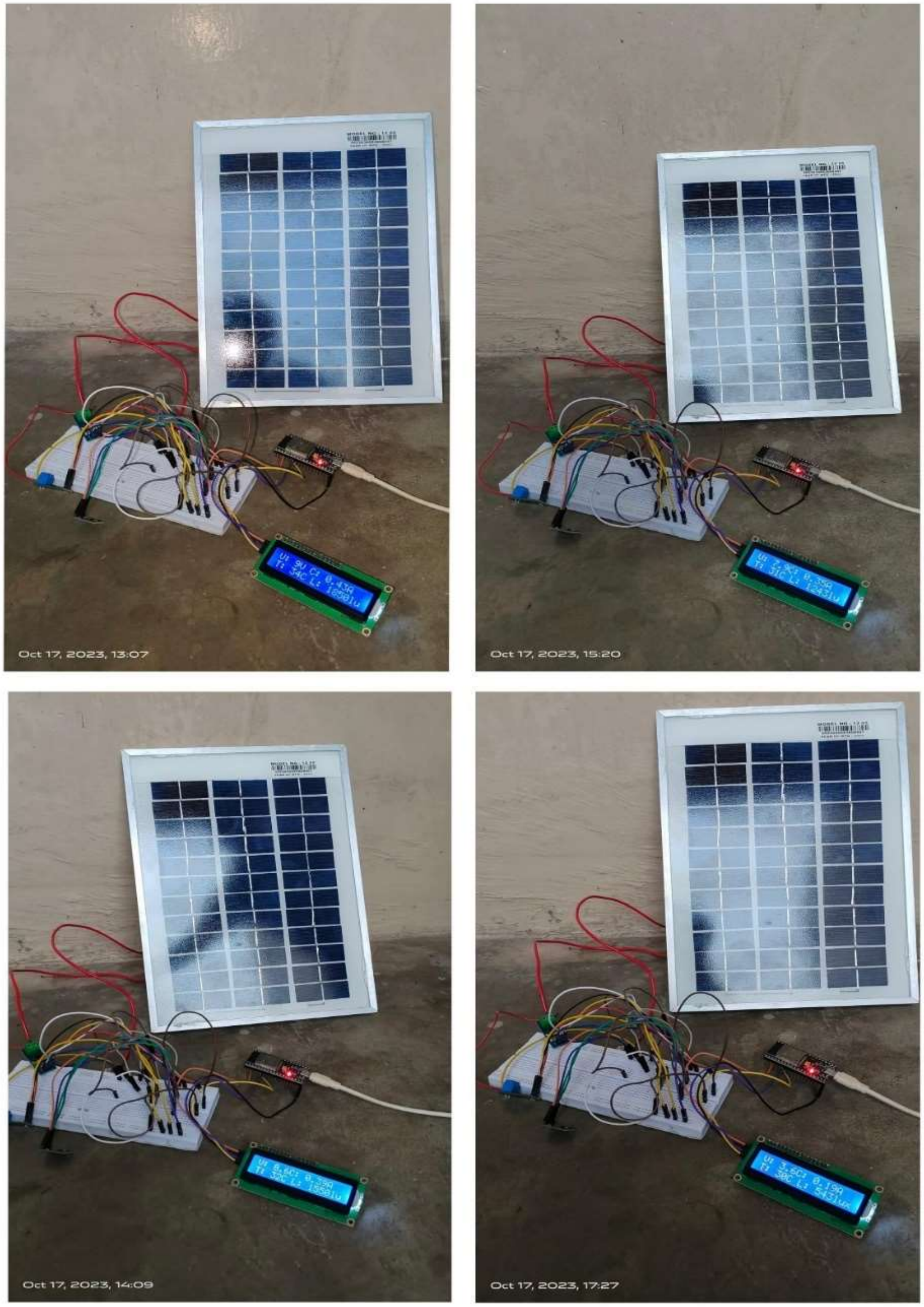


Fig 4.4 Output Display of All Parameters Like Current, Voltage, Light Intensity, Temperature

Conclusion

The solar power monitoring system project, leveraging the Arduino Uno R3, CH340, ESP8266, and LCD I2C display, represents a comprehensive solution that empowers users to harness the full potential of their solar panels. Beyond its immediate benefits, this project aligns with the broader goals of promoting sustainability and clean energy usage.

The LCD I2C display serves as the project's user interface, providing real-time data on crucial solar power parameters. This user-friendly feature simplifies the monitoring process, making it accessible to individuals, businesses, and even educational institutions interested in tracking their solar power system's performance. Users can quickly gauge the effectiveness of their panels and identify any potential issues or inefficiencies.

One of the standout features is remote monitoring facilitated by the ESP8266 module. This capability allows users to access vital data remotely, offering flexibility and convenience. Whether homeowners are on vacation or businesses are managing multiple solar installations, the ability to monitor and manage systems from afar ensures optimal performance and peace of mind.

Moreover, the data collected by the Arduino Uno R3 isn't just a snapshot of current performance—it's a valuable historical record. This data logging and analysis feature enables users to track trends over time, detect any deviations from expected output, and make data-driven decisions to enhance efficiency. By optimizing energy production and consumption, users can reduce electricity costs and contribute to a more sustainable energy future.

The scalability of this system is another advantage. It can easily accommodate additional sensors or integration with broader home automation systems, making it adaptable to a wide range of applications and future expansion needs.

In conclusion, the solar power monitoring system project is more than just a technical solution; it's a step toward a cleaner and greener future. By harnessing the power of solar energy efficiently and effectively, users can reduce their carbon footprint, cut energy costs, and promote the use of renewable energy sources, all while enjoying the convenience of real-time and remote monitoring capabilities. This project embodies the principles of sustainability and environmental responsibility while providing practical benefits to individuals and businesses alike.

References:

1."Solar Energy Engineering: Processes and Systems" by Soteris A. Kalogirou - This comprehensive textbook covers various aspects of solar energy, including monitoring and control systems.

2."Photovoltaic Systems Engineering" by Roger A. Messenger and Jerry Ventre - This book focuses on the engineering aspects of photovoltaic systems, including monitoring and optimization.

3."Arduino: A Technical Reference" by J. M. Hughes - If you plan to use Arduino for your project, this reference book provides detailed information on Arduino hardware and programming.

4."Raspberry Pi Cookbook" by Simon Monk - If you're using a Raspberry Pi, this book offers practical recipes for various Raspberry Pi projects, including data logging and web development.

5."Data Science for Business" by Foster Provost and Tom Fawcett - This book can help you understand the data analysis and visualization aspects of your project, which are crucial for monitoring and interpreting solar data.

Websites and Online Resources:

1.National Renewable Energy Laboratory (NREL) - PVWatts:The NREL's PVWatts calculator and website provide valuable information and tools for estimating solar energy production and monitoring systems: https://pvwatts.nrel.gov/

2.EnergySage: EnergySage offers a variety of resources on solar energy, including articles on monitoring and optimizing solar systems: https://www.energysage.com/

3.SolarPowerWorld: The Solar Power World website provides news, articles, and resources related to solar power, including monitoring and control systems: https://www.solarpowerworldonline.com/

4.OpenEnergyMonitor: The OpenEnergyMonitor website offers open-source tools and resources for energy monitoring, including detailed documentation and guides: https://learn.openenergymonitor.org/

5.Adafruit Learning System: Adafruit's learning system includes tutorials and guides on using sensors and microcontrollers in various projects, which can be helpful for your solar monitoring system: https://learn.adafruit.com/

6.Raspberry Pi Foundation - Projects: The Raspberry Pi Foundation's website has a section dedicated to projects, including those related to data logging and monitoring: https://projects.raspberrypi.org/

7.InfluxData Documentation: If you plan to use Influx DB for data storage, the Influx Data website provides comprehensive documentation and guides: https://docs.influxdata.com/influxdb/

8.Grafana Documentation: For data visualization and dashboard creation, the Grafana documentation offers detailed information on using the Grafana platform: https://grafana.com/docs/

9.Coursera and edX: These online learning platforms offer courses in topics related to solar energy, data analysis, and IoT that can enhance your project knowledge and skills.