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Solar Powered Battery Charging with Reverse Current Protection System

Mr. B. Kaviraj, Assistant Professor

Info Institute of Engineering

Mr. K. Kishore, Third Year Student

Sri Ramakrishna Engineering College

Ms. D. Subaranjani, Third Year Student

Bannari Amman Institute of Technology

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Abstract - This paper describes a solar-powered battery charging system that uses the BY127 diode to provide reverse current safety. The technology is sustainable and eco-friendly since photovoltaic (PV) panels use solar energy to charge a rechargeable battery. A BY127 diode is used as a blocking diode to stop the batteries from draining back into the solar panel when there isn't much sunshine. Because of its ability to handle high voltages and currents and its low forward voltage drop, which guarantees less power loss during charging, the BY127 diode was selected. The system is appropriate for off-grid applications, remote areas, or backup power systems since it is built for efficient power conversion and optimal charging performance. The main design factors are covered in this paper, along with the importance of reverse current protection, battery management, and solar panel choices. By avoiding energy loss, particularly at night conditions, the suggested method improves battery life, battery efficiency and system reliability.

Key Words: Photovoltaic (PV) panels, blocking diode, BY127 diode, solar-powered charging, renewable energy, off-grid power systems, and battery management.

1. INTRODUCTION

Solar energy is radiant light and heat from the Sun that is harnessed using a range of ever-evolving technologies such as solar heating, photovoltaic, solar thermal energy, solar architecture, molten salt power plants and artificial photosynthesis. It is an essential source of renewable energy, and its technologies are broadly characterized as either passive solar or active solar depending on how they capture and distribute solar energy or convert it into solar power. Active solar techniques include the use of photovoltaic systems, concentrated solar power, and solar water heating to harness the energy. A solar charge controller is a voltage and current regulator that prevents a battery bank from overcharging due to solar arrays. To prevent a deep cycle battery from overcharging during the day, the voltage and current from the solar panel are controlled before they reach the batteries. Moreover, when there is no sun energy to recharge the solar panel throughout the night, no electricity returns to the panels, which would drain the battery. There are numerous charge regulators that are equipped with extra features like lighting and load management. Their main responsibility is to regulate the voltages and currents. In order to avoid overcharging the batteries, a solar charge regulator is essential. The majority of 12-volt panels consistently provide 17 volts since, in the event that the voltage is 12 volts, it indicates that the panel is operating under ideal conditions, which are not usually reach.

2. OBJECTIVES

Reverse current protection is a method of preventing unwanted current flow from the battery to the photovoltaic solar array (usually at night). It is generally done by a blocking diode.

Solar energy is a very efficient source of green energy that is available for free at everywhere. However, it needs to be coupled with proper storage for best use. Also, to store it, we need to use charge-controlling

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circuit to protect the panel from reverse current and charge the battery efficiently. So we demonstrate this concept by using a mini solar panel to charge a rechargeable battery. Also, we use a charge control circuit designed to stop reverse current flow and charge the battery effectively using the solar panel. Thus, this allows us to effectively provide solar battery charging with reverse current protection.

3. METHODOLOGY

To design a solar-powered battery charger with reverse current protection, start by defining the system requirements, including the type of battery, its specifications, and the appropriate solar panel. Selection of solar panel and charge controller that are appropriate for the battery's requirements, making sure the latter can manage the panel's output and has essential functions like overcharge prevention. Put a Schottky diode in series between the solar panel and the charge controller to stop reverse current flow from the battery to the solar panel during low light. Put in a circuit breaker or fuse to guard against overcurrent. Assemble the circuit by attaching the battery to the charge controller's output and the solar panel to the charge controller's input, making sure all connections are tight and properly polarized. Test the system after it has been assembled to make sure it is operating and calibrating properly. Check voltage and current to make sure the battery is charging properly and that the reverse current protection is working. Reliability depends on routine maintenance, which includes keeping an eye on the system and looking for wear indicators.

4. BLOCK DIAGRAM

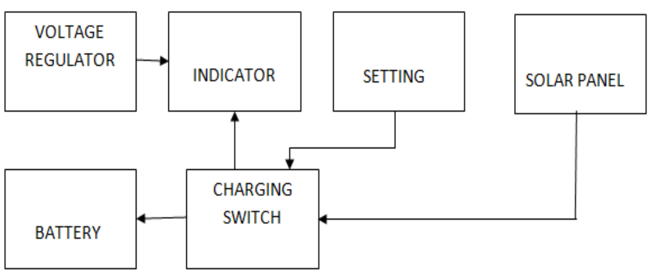

Fig. 1: Block Diagram

5. HARDWARE DESCRIPTION

Building a solar-powered battery charger with reverse current protection is a great project that combines renewable energy with practical electronics. Here's a step-by-step guide to help you design and construct your own solar-powered battery charger:

5.1 Solar Panel

An arrangement of photovoltaic solar cells installed on a (often rectangular) frame is called a solar cell panel, solar electric panel, or solar panel. It is also referred to as a photovoltaic (PV) module or PV panel. Radiant energy from sunlight is captured by solar panels and transformed into electric energy in the form of direct current (DC) electricity. Fig. 2 shows the construction of a solar panel, A photovoltaic system, often known as a solar array, is a well-organized grouping of solar panels. Photovoltaic system arrays can produce solar electricity directly for electrical equipment or require an inverter system to feed power back into the alternative current (AC) grid.

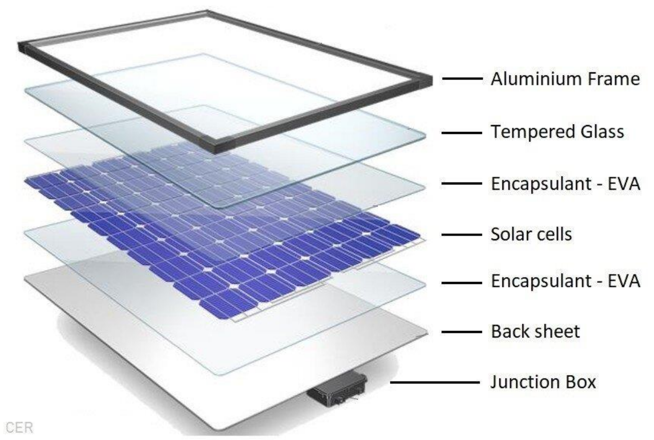

Fig. 2: Solar Panel

5.2 Rechargeable Lead Acid Battery

Fig. 3: Rechargeable battery

Fig. 3 shows the **lead–acid battery** is a type of rechargeable battery first invented in 1859 by French physicist Gaston Plant. It is the first type of rechargeable battery ever created. Compared to modern rechargeable

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batteries, lead-acid batteries have relatively low energy density. Despite this, their ability to supply high surge currents means that the cells have a relatively large power-to-weight ratio. These features, along with their low cost, make them attractive for use in motor vehicles to provide the high current required by starter motors. Lead-acid batteries suffer from relatively short cycle lifespan (usually less than 500 deep cycles) and overall lifespan (due to the "double sulfation" in the discharged state).

5.3 Diode

IN4007

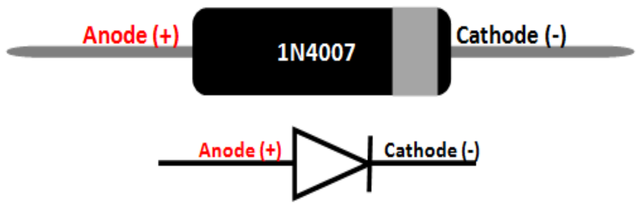

Fig. 4: Diode IN4007

A diode is a device which allows current flow through only one direction. That is the current should always flow from the Anode to cathode. The cathode terminal can be identified by using a grey bar as shown in the picture above (Fig. 4). For **IN4007 Diode**, the maximum current carrying capacity is 1A it withstand peaks up to 30A. Hence we can use this in circuits that are designed for less than 1A. The reverse current is 5uA which is negligible. The power dissipation of this diode is 3W.
An electronic component made of semiconductor material that allows conduction of current in only one direction is termed as a Diode. It is a **two-terminal device** normally formed by fusing p and n-type semiconductor materials each having majority and minority carriers.

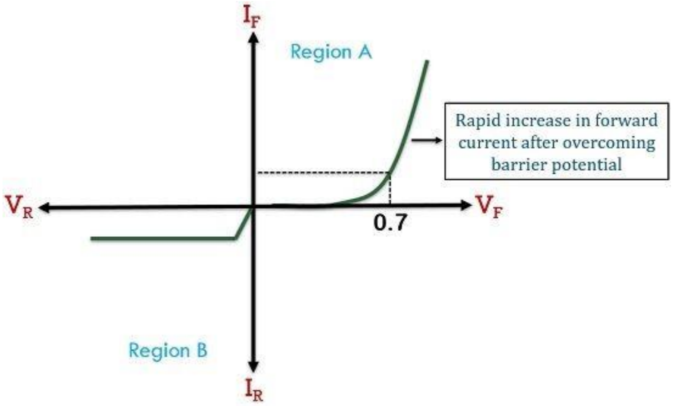

Fig. 5: V-I Characteristics Curve (IN4007)

DIODE BY127

Fig. 6: BY127

A diode is a two-terminal electronic component that conducts current primarily in one direction it has low (ideally zero) resistance in one direction, and high (ideally infinite) resistance in the other.

A semiconductor diode, the most commonly used type today, is a crystalline piece of semiconductor material with a p–n junction connected to two electrical terminals. It has an exponential current–voltage characteristic. Semiconductor diodes were the first semiconductor electronic devices. The discovery of asymmetric electrical conduction across the contact between a crystalline mineral and a metal was made by German physicist Ferdinand Braun in 1874. Today, most diodes are made of silicon, but other semiconducting materials such as gallium arsenide and germanium are also used.

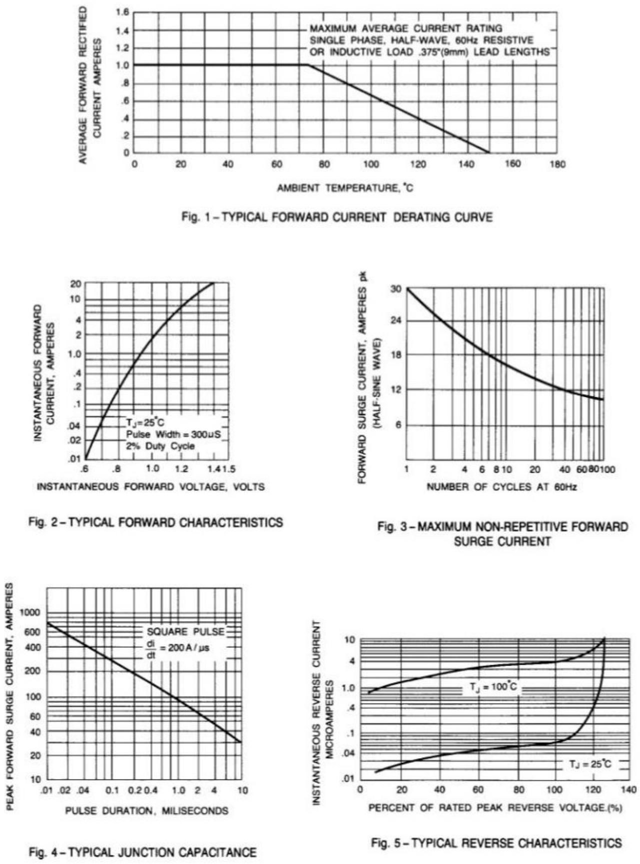

Fig. 7: Characteristics Curve (BY127)

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Among many uses, diodes are found in rectifiers to convert AC power to DC, demodulation in radio receivers, and can even be used for logic or as temperature sensors. A common variant of a diode is a light emitting diode, which is used as electric lighting and status indicators on electronic devices.

5.4 Digital Meter

Fig. 8: Digital Meter

This voltmeter can be used to measure the storage battery's voltage upto 100Volts in motorcycles and cars and also can grasp the storage battery's status. It can also be used to measure other DC voltage. This voltmeter can operate on versatile 4.5V to 30VDC range is the voltmeter's maximum operating limited voltage, because of an electrical spark, power supply ripple, or other too high abrupt change of voltage. A very bight and decent LED Display is ready to measure the dc voltages in the range of 0V to 100V. Depending on the power supply and the load used, you can measure current from 0 to 1.5A. However, the present circuit is designed for voltage up to 15V and current up to 1A only.

5.5 Bridge Rectifier

A bridge rectifier using **BY127 diodes** is a common setup in power supply circuits, converting alternating current (AC) to direct current (DC). The BY127 is a silicon rectifier diode, capable of handling high voltages and moderate current levels. Here's how the bridge rectifier works with BY127:

Components: The bridge rectifier consists of four BY127 diodes, arranged in a specific configuration to convert AC to DC.

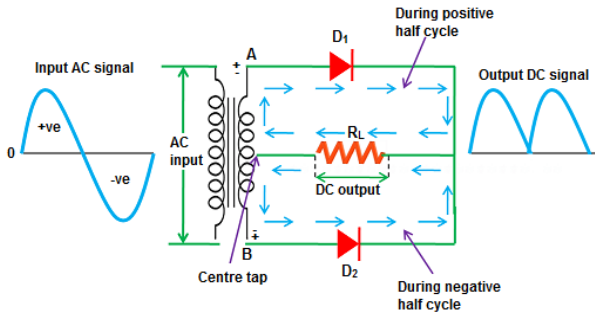

Fig. 9: Diagram of Bridge Rectifier

Fig. 9 shows the diagram of the Bridge rectifier, Each BY127 diode can handle reverse voltages up to 1250V and currents up to 1A, making it suitable for many power supply applications.

1. Operation:

When four diodes are connected as shown in figure, the circuit is called as bridge rectifier. The input to the circuit is applied to the diagonally opposite corners of the network, and the output is taken from the remaining two corners.

Let us assume that the transformer is working properly and there is a positive potential, at point A and a negative potential at point B. the positive potential at point A will forward bias D3 and reverse bias D4.

The negative potential at point B will forward bias D1 and reverse D2. At this time D3 and D1 are forward biased and will allow current flow to pass through them; D4 and D2 are reverse biased and will block current flow. The path for current flow is from point B through D1, up through RL, through D3, through the secondary of the transformer back to point B. this path is indicated by the solid arrows. Waveforms (1) and (2) can be observed across D1 and D3.

One-half cycle later the polarity across the secondary of the transformer reverse, forward biasing D2 and D4 and reverse biasing D1 and D3. Current flow will now be from point A through D4, up through RL, through D2, through the secondary of T1, and back to point A. This path is indicated by the broken arrows. Waveforms (3) and (4) can be observed across D2 and D4. The current flow through RL is always in the same direction. In flowing through RL this current develops a voltage corresponding to that shown waveform (5). Since current flows through the load (RL) during both half cycles of the applied voltage, this bridge rectifier is a full-wave rectifier.

2. Filtering: After rectification, the output is pulsating DC. To smooth this, a capacitor is often added across the load. The capacitor charges during the peaks and discharges between them, providing a more stable DC output.

5.6 Capacitor

Fig. 10 Capacitors

Electrolytic Capacitors are generally used when very large capacitance values are required. Here instead of using a very thin metallic film layer for one of the electrodes, a semi-liquid electrolyte solution in the form of a jelly or paste is used which serves as the second electrode (usually the cathode).

The dielectric is a very thin layer of oxide which is grown electro-chemically in production with the thickness of the film being less than ten microns. This insulating layer is so thin that it is possible to make capacitors with a large value of capacitance for a small physical size as the distance between the plates, d is very small.

The majority of electrolytic types of capacitors are **Polarized**, that is the DC voltage applied to the capacitor terminals must be of the correct polarity, i.e. positive to the positive terminal and negative to the negative terminal as an incorrect polarization will break down the insulating oxide layer and permanent damage may result.

Electrolytic Capacitors are generally used in DC power supply circuits due to their large capacitance's and small size to help reduce the ripple voltage or for coupling and decoupling applications. One main disadvantage of electrolytic capacitors is their relatively low voltage rating and due to the polarization of electrolytic capacitors, it follows then that they must not be used on AC supplies.

5.7 IC Voltage Regulator

Voltage regulators comprise a class of widely used ICs. Regulator IC units contain the circuitry for reference source, comparator amplifier, control device, and overload protection all in a single IC. IC units provide regulation of either a fixed positive voltage, a fixed negative voltage, or an adjustably set voltage. The regulators can be selected for operation with load currents from hundreds of milli amperes to tens of amperes, corresponding to power ratings from milli watts to tens of watts.

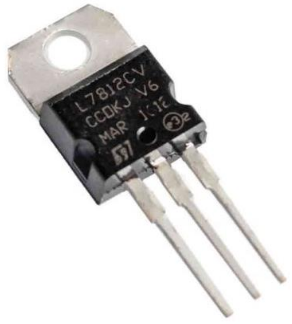

Fig. 11: Pinout of IC

A fixed three-terminal voltage regulator has an unregulated dc input voltage, Vi, applied to one input terminal, a regulated dc output voltage, Vo, from a second terminal, with the third terminal connected to ground are shown in Fig. 11
The series 78 regulators provide fixed positive regulated voltages from 5 to 24 volts. Similarly, the series 79 regulators provide fixed negative regulated voltages from 5 to 24 volts.

5.8 Transformer

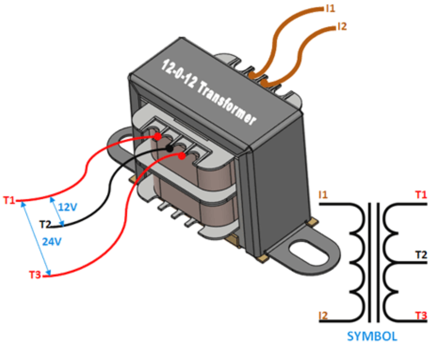

Fig. 12: Transformer

The potential transformer will step down the power supply voltage (0-230V) to (15-0-15V) level. Then the secondary of the potential transformer will be connected to the precision rectifier, which is constructed with the help of op–amp. The advantages of using precision rectifier are it will give peak voltage output as DC, rest of the circuits will give only RMS output.

15-0-15 Centre Tapped Transformer Specifications

- Step-down Centre tapped Transformer
- Input Voltage: 220V AC at 50Hz
- Output Voltage: 24V, 15V or 0V

- Output Current: 1A
- Vertical mount type

6. CIRCUIT DIAGRAM

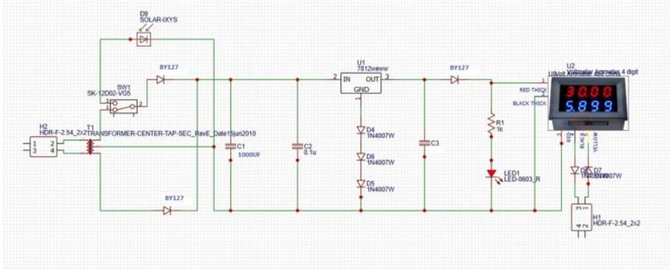

Fig. 13: Circuit Diagram

Fig. 13 shows the circuit diagram of the project

7. WORKING PRINCIPLE

A **solar-powered battery charging system** with **reverse current protection** is designed to efficiently charge a battery using solar energy, while preventing reverse current flow from the battery to the solar panel during non-sunny conditions, such as at night. Here's how the system works:

7.1. Solar Panel Generates Power:
The solar panel produces DC electricity when exposed to sunlight. The amount of current and voltage generated depends on the size of the panel and the intensity of sunlight.

7.2. Charging the Battery:
The solar panel's positive output is connected to the positive terminal of the battery, and the negative output is connected to the negative terminal.

BY127 diode is placed in series between the solar panel and the battery to prevent reverse current flow.

7.3. Reverse Current Protection Using BY127:
The BY127 diode allows current to flow only in one direction from the solar panel to the battery.

During the day, when the solar panel is producing power, the forward voltage drop across the BY127 diode (typically around 1.1V) allows current to flow into the battery, charging it.

At night or when the solar panel isn't generating power, the battery could potentially discharge back into the panel, but the BY127 diode blocks this reverse current due to its one-way conduction property. This prevents power loss and protects both the solar panel and the battery.

7.4. Charge Regulation:
A **charge controller** may be added to the system for more sophisticated charge management. It ensures that the battery is charged optimally and prevents overcharging by cutting off or regulating the current once the battery reaches full capacity.

Step-by-Step Operation:

1. Daytime (Charging Mode):

- The solar panel produces electricity.
- Current flows through the BY127 diode, which allows it to charge the battery.
- The diode's forward voltage drop is minimal (about 1.1V), ensuring efficient charging with only a small voltage loss.

2. Nighttime (Protection Mode):

- When the solar panel stops generating power, the potential difference across the diode is reversed.
- The BY127 diode blocks any reverse current that might otherwise discharge the battery through the solar panel.
- This prevents battery drain and increases overall system efficiency.

8. HARDWARE SNAPSHOT

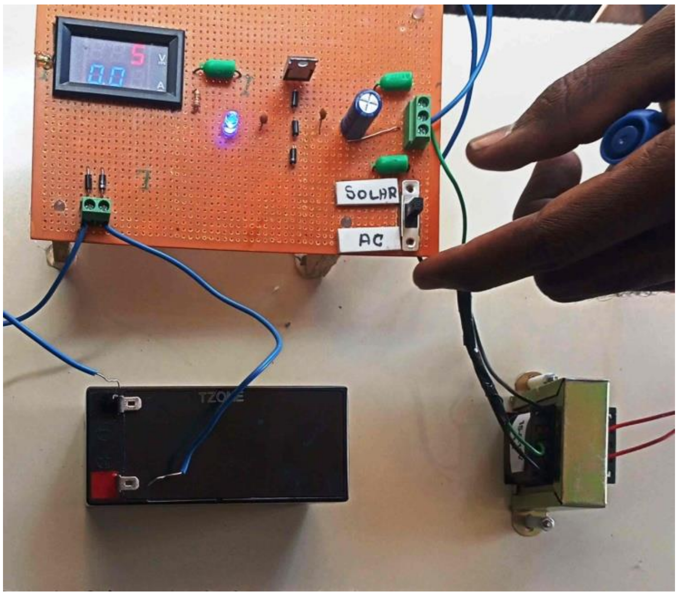

Fig. 14: Hardware Snapshot

9. IMPORTANT CHARACTERISTICS

Protection from Reverse Current: The BY127 diode prevents reverse current from flowing from the battery to the solar panel, thereby safeguarding both parts.

High Voltage Handling: Suitable for solar installations with fluctuating output, the BY127 can withstand high reverse voltages of up to 1250V.

Cost-Effective Solution: Protecting the system from reverse current without the need for sophisticated electronics can be done at a reasonable cost by using a basic diode like the BY127.

10. EFFICIENCY CONSIDERATION

The BY127 diode marginally lowers charging efficiency by introducing a minor voltage drop (around 1.1V) in the charging circuit.

In contemporary solar charging systems, Schottky diodes which have a reduced forward voltage drop or MOSFET-based protective circuits are frequently employed for increased efficiency.

For many solar applications, where the voltage drop isn't critical—the BY127 is dependable and sturdy.

11. CONCLUSION

In Conclusion, a **solar-powered battery charging system with reverse current protection** using a **BY127 diode** offers a simple, reliable, and cost-effective solution to ensure efficient energy storage and system protection. The BY127 diode effectively blocks reverse current flow, preventing the battery from discharging back into the solar panel when it is not generating power, such as during nighttime or cloudy conditions. This protection extends the life of both the battery and the solar panel while maintaining system efficiency. Although the diode introduces a small voltage drop, it remains an excellent choice for many low to medium power solar applications, ensuring robust operation and protecting the system from unwanted power loss.

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AUTHORS

KAVIRAJ B who has received Master Degree of Power Electronics and Drives at **United Institute of Technology**. He is the former lecture at **Nanjiah Lingammal Polytechnic college, Mettupalayam** and currently working in Assistant Professor at **Info Institute of Engineering, Coimbatore**
kaviinfoengg@gmail.com

KISHORE K is a Pre-Final year student at the Department of Electrical and Electronics Engineering from **Sri Ramakrishna Engineering College**, **Coimbatore** and received the Diploma at First Class With Distinction in the Department of Electrical and Electronics Engineering at **Nanjiah Lingammal Polytechnic college, Mettupalayam**
eeekishorek@gmail.com

SUBARANJANI D is a Pre-Final year student at the Department of Electrical and Electronics Engineering from **Bannari Amman Institute of Technology**, **Sathyamangalam** and received the Diploma at First Class With Distinction in the Department of Electrical and Electronics Engineering at **Nanjiah Lingammal Polytechnic college, Mettupalayam**
subaranjan2004@gmail.com