# Development of Charging System for Electric Chair by using Renewable Energy

A thesis submitted in partial fulfilment of the requirements for the degree of

**Bachelors of Science in Electrical Engineering**

By


Muhammad Talha Bashir ELEN19111055
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Session: 2019-2023

**Supervisor**
Engr. Arslan Hassan


Department of Electrical and Biomedical Engineering

Khwaja Fareed
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# Declaration

We **Muhammad Talha Bashir, Muhammad Faisal Qureshi and Muhammad Aqib** declare that the BS thesis entitled "Development of Electric Seat Charging System Using Renewable Energy" is his own work and has not been previously submitted for a degree from Khawaja Fareed University of Engineering and Information Technology, RahimYar Khan or elsewhere. country / world.

Even after graduation, if our statements are found to be incorrect, the university has the right to award a BS degree.

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# Certificate of Approval

This is to certify that the research work presented in this thesis, entitled ”Development of Charging System of Electric Chair by using Renewable Energy” was conducted **Muhammad Talha Bashir, Muhammad Faisal Qureshi and Muhammad Aqib** under the supervision of **Engr. Arslan Hassan**.

Any part of this thesis has not been submitted anywhere else for any other degree.

This thesis is submitted to Department of Electrical Engineering, Khwaja Fareed University of Engineering and Information Technology, Rahim Yar Khan in partial fulfilment of the requirements for the degree of BS Electrical Engineering.

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# Acknowledgments

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# Abstract

Transportation by battery-powered electric vehicles can help reduce fuel costs and reduce greenhouse gas emissions. Electric transport requires the creation of a large charging network in an ecological environment. A smart charging station is a different technology for charging electric vehicles. Photovoltaic (PV) cells in solar panels are used to convert solar energy into uncontrolled electrical energy. The efficiency of this nonlinear photovoltaic solar cell is very low. Consequently, it becomes necessary to increase the production of photovoltaic solar cells by tracking the maximum power point (MPPT). One of these MPPT schemes is a more efficient and consistent voltage method than the others due to its easy implementation and low losses. The purpose of this paper is to discuss the behavior of the conventional constant voltage method under solar surge and variable load conditions. The modified MPPT method is implemented in the DC-DC converter control circuit. Proetus simulation software was used to perform the analysis. The prototype unit is being tested using sunlight to accurately measure the position of the changing sunlight in the photovoltaic solar panel. The smart charging station deploys quickly and provides superior results when the solar radiation changes.

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# Chapter 1 Introduction

## 1.1 Introduction of Project

Solar energy has become the dominant source of energy in recent years. Solar energy is widely available these days. Energy given by the sun in a single day is enough energy to power the entire year. Solar energy has little impact on our environment. The process of converting solar energy into electrical energy can be perform in different ways. Here, solar energy is converted into electrical energy, solar thermal energy, and solar voltaic energy in two distinct ways. Steam turbines will be used instead of fossil fuels to produce energy from solar thermal sources and traditional AC. Steam is produced using the heat from solar rays, and some of this steam is kept in insulated tanks for use at time of night when there is no sun. Solar photovoltaic systems employ silicon cells or specific types of semiconductor materials to convert solar radiation-absorbed light energy into direct current (D.C.). Batteries are used to store the generated power for usage at night or when there is no sunlight. For the generation of low-cost solar energy in the future, concentrated systems should have been deployed in recent years through a combination of teamwork and innovative research concepts. We have illustrated the operation of photovoltaic panels in this project. Using the MPPT (Voltage constant technique) we may boost the efficiency of solar panels. Therefore, efficiency can be boosted by employing MPPT-designated electronic equipment. This Device will function at maximum power point and it will consume the highest amount of energy. It will also generate more output power. Thus, MPPT boosted system efficiency and decreased system costs.

A converter that can convert 220V AC to 24V DC is commonly known as a power supply or a voltage converter. These devices are used to provide a steady and reliable source of DC voltage to power various electronic devices such as computers, televisions, audio equipment, and more. The conversion process involves several stages. First, the AC voltage is stepped down from 220V to a lower voltage using a transformer. Then, the rectifier circuitry converts the AC voltage to DC voltage. Finally, a smoothing circuit filters the DC voltage to remove any ripples or fluctuations, providing a steady DC voltage output of 24V. There are different types of power supplies which are easily available in the market, such as linear power supplies, switch-mode power supplies, and more. Each type of power supply has its own advantages and disadvantages in terms of expenses, size, and efficiency. When selecting a power supply, it is essential to ensure that it can provide enough power for the device it is intended to power. The power supply's output current rating should be equal to or greater than the device's current requirement. Overloading a power supply can damage both the power supply and the device it powers

**1.2 Need for Renewable Energy**

In the majority of developing nations like Pakistan, the industry of renewable energy sources is relatively new. The advancement in this field is urgently needed. The main resources covered below are renewable energy sources, which are unlimited. These resources, which are often known as “green energy sources” do not have any hygienic or negative effects on the environment means these resources are environment friendly. These things have compelled human beings to think about them. Researchers and Engineers from all corners of the world are working on it to make them more reliable and advanced. The need to use these resources effectively is that fossil fuels which are still the major source of energy like electricity production and fuel for vehicles are increasing global warming because the burning of fossil fuels causes an increase in the ratio of CO2 and other harmful gases. These gases cause a greenhouse effect and also damage the Ozone layer. On the other

hand, green energy resources are less harmful and do not produce such poisonous

gases Major Renewable energy sources.

### 1.3 Problem Statement

The problem statement for a Solar MPPT and Converter for charging batteries is to efficiently convert the variable voltage and current output of a solar panel into a stable and appropriate voltage and current for charging a battery.

Solar panels generate DC voltage that varies with the amount of sunlight they receive. To charge a battery, the current and voltage must be regulated to match the battery's specific charging requirements. Additionally, the amount of power that a solar panel generates can be maximized by tracking its Maximum Power Point (MPP), is define as point at which the panel generates/produce the most power for given of conditions.

Therefore, the problem statement is to design and implement a solar MPPT and converter system that can:

- Efficiently track the MPP of the solar panel to maximize power output.
- Convert the variable current and voltage output of solar panel to a stable and appropriate voltage and current for charging a battery.
- Ensure the safety of the battery by preventing overcharging or undercharging.
- Operate efficiently and reliably over range of environmental conditions, including changes in temperature, light intensity, and load demand.
- Be cost-effective and scalable for different battery sizes and types.

## 1.4 Solar MPPT Boost Converter

The solar MPPT (Maximum Power Point Tracking) boost converter is known as a device used to get the maximum power from a solar panel by regulating the current and voltage output. The MPPT algorithm used in this device helps to find the maximum power point of the solar panel and adjusts the output current and voltage accordingly. It is used to increase the voltage of the solar panel to a level that is sufficient to charge the batteries in series. The efficiency of MPPT boost converter is crucial as it directly affects the power output of the solar panel.

## 1.5 Power Supply for AC to DC Charging

To charge the batteries in series using the solar MPPT boost converter, an AC to DC power supply is required. The power supply converts the alternating current (AC) into direct current (DC) to charge the batteries. Output voltage and current of power supply should match the requirements of the batteries to ensure efficient charging. The power supply also be able to handle the voltage and current fluctuations caused by the MPPT boost converter.

## 1.6 Charging of Batteries in Series

Charging batteries in series is a common practice in many applications, especially in renewable energy systems. When we connect batteries in series, voltage of each battery adds up, while current remains the same. This arrangement is commonly used in solar energy systems to increase the voltage output of the batteries to the suitable level for powering various devices. The charging process of batteries in series requires precise control of the charging current and voltage to ensure the safety and longevity of the batteries

## 1.7 State of Charge Controller

The control system is the heart of the charging system, and it ensures the efficient and safe charging of the batteries. The control system regulates the charging current and voltage, monitors the temperature and state of charge of the batteries, and protects the batteries from overcharging and over-discharging. The control system also provides feedback to the MPPT boost converter to ensure maximum efficiency of solar panel. The control system can be implemented using various techniques, including microcontrollers, programmable logic controllers, and analog circuits.

## 1.8 Applications

- The charging control system using a solar MPPT boost converter and power supply for AC to DC charging of batteries in series has many applications, including solar street lighting, solar water pumps, solar-powered homes, and solar-powered vehicles.
- These applications require a reliable and efficient charging system to ensure the continuous operation of the devices.
- The charging control system can also be integrated with other renewable energy sources, such as wind turbines and hydropower, to provide a sustainable and reliable source of energy.

# Chapter 2 Literature Review

This chapter presents a literature review on the development of charging systems for electric wheelchairs. Renewable energy sources are becoming increasingly important in recent years as a strategy to reduce the dependence on fossil fuels to gain energy.

## 2.1 History of Batteries

Luigi Galvani in 1780 dissected a frog on a bronze hook. When he touched his paw with the iron head, his paw trembled. Galvani believed that the energy that caused these contractions came from the legs themselves and called it "animal electricity".

Alessandro Volta did not believe that this phenomenon was caused by two similar metals kept together in a humid environment, and began to conduct experiments to test his hypothesis. In 1800, Volta invented the first true battery, called the Voltaic Pile. The voltage array consists of copper and zinc discs stacked on top of each other and separated by a layer of fabric or cardboard and a salt (or electrolyte) layer. Unlike the Leyden jar, the voltaic cell produced a steady, continuous current and lost some charge over time when not in use, but early models could not produce a voltage high enough to produce a spark.

Figure 2.1 Voltaic Pile

Volta's original stack/pile model had several technical flaws, one of which was electrolyte leakage and short circuits due to the weight of the disk compressing the salt-damp cloth. An Englishman named William Cruickshank solved this problem by putting it in a box instead of a glass. This is called a channel battery. Volta himself developed a variant consisting of a chain of cups filled with salt solution connected to an iron arc immersed in the liquid. This is called Crown Cup. This bracket is made of two different metals (for example, zinc and copper) welded together. This model has proven to be more effective than the original.

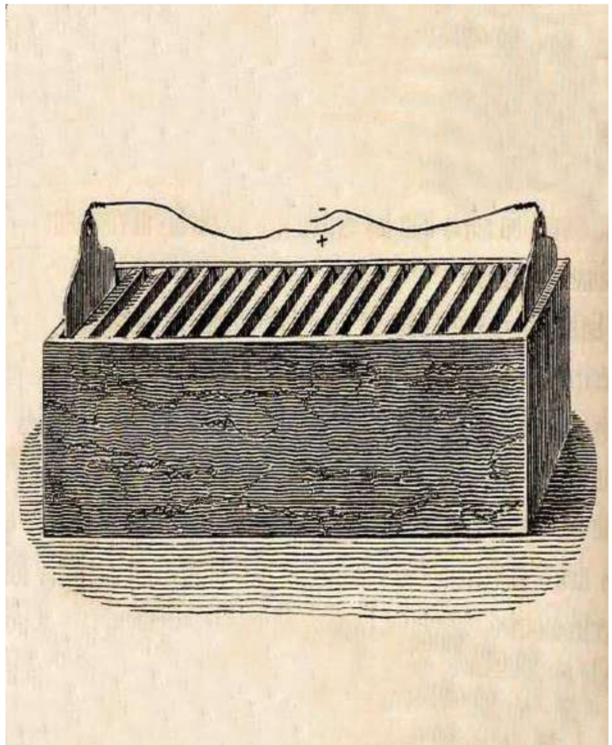


Figure 2.2 Trough Batteries

Lithium-ion polymer battery was released in 1996. These batteries stores the electrolyte in a solid polymer compound rather than in a liquid solvent, and the electrodes and separators are combined together. The final difference allows for flexible battery packaging instead of a rigid metal housing, which allows such batteries to be built to fit specific devices. It also has a higher energy density than conventional lithium-ion batteries. This advantage makes the battery of choice for portable electronics such as mobile phones and PDAs, as it allows for a more flexible and compact design. *[1]*

## 2.2 History and Development of PV Panels

### 2.2.1 Solar Energy in the 1800s

Edmond Becquerel discovered the photovoltaic effect in 1839 at the age of 19. He realized that when electrons are excited in the conduction band, they can move freely through the material, thus creating a current. But it was not widely known until Einstein wrote a paper on the Sun's energy in 1922 that won him the Nobel Prize. The first solar panel was invented in 1883 by Charles Fritts by coating a thin layer of selenium and layer of gold. The resulting cell has only 1% electrical conversion. This discovery led to the beginning of the movement to produce solar energy.

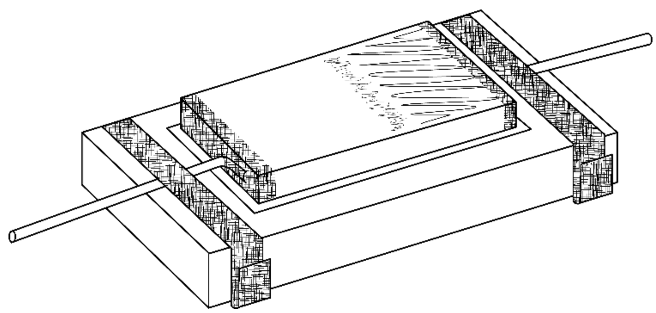


Figure 2.3 Silicon P-N photo-EMF

### 2.2.2 Solar Energy in the 1900s

Conventional photovoltaic cells were first developed in the late 1950s and early 1960s to power satellites orbiting the Earth. Improvements in manufacturing, performance, and quality of PV modules in the 1970s helped reduce costs and open up several opportunities for charging batteries, signaling, telecommunications equipment, and other critical, low-energy needs.

In the 1980s, it became a popular power source for photovoltaic devices and other small battery charging applications. The energy crisis of the 1970s led to significant efforts to develop residential and commercial PV power systems. During that time, international applications for PV systems to power rural health clinics, telecommunications and grid households have increased significantly. Currently, industrial production of PV modules is growing at about 25 percent per year, and major programs in the US, Japan and Europe are accelerating the deployment of PV systems in cities and residential areas and interconnection with utility networks.

### 2.2.3 Solar Energy in the 2000s

The world had less than one watt of solar energy running electrical appliances till 1950. Fast forward to the 21st century, 50 years of development and innovation in silicon and other PV materials, and today solar panels power millions of homes around the world, power buildings and satellites, and provide clean energy worldwide.

Figure 2.4 PV Panels

Global solar installed capacity is approximately 728 GW and is expected to increase to 1,645 GW by 2026. Solar energy has shown the fastest cost reduction among energy technologies. In the 1950s, the cost of silicon PV cells was US$76/Watt, and it has dropped significantly to $0.20/Watt in 2021. The price dropped significantly between 2000 and 2019, but the decline has slowed. The picture. [1]

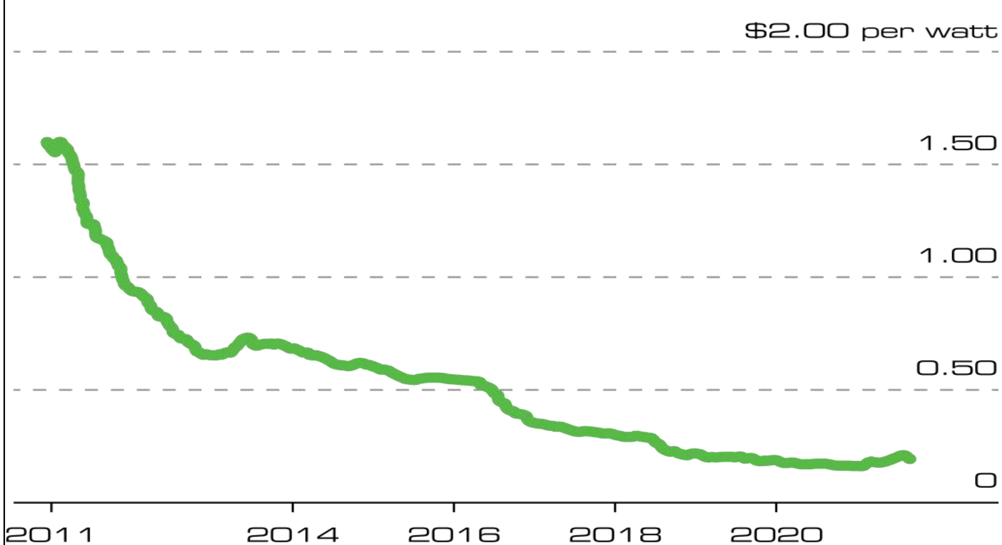



Figure 2.5 cost of PV panels

**2.3 Introduction to MPPT**

Global energy demand has increased dramatically over the past decade. This leads to an increase in energy demand as a result of socio-economic development in general. Photovoltaic cells (PV solar) are at the forefront of popular renewable energy sources, but they are not enough to increase the efficiency of solar PV systems; it must be driven at a point where it can demand the greatest power from it. Today's literature shows that there are research efforts to improve module output in the context of MPPT. The characteristics of the SPV module are non-linear and the power and voltage characteristics indicate that there is a single point (Pm) where the module delivers maximum power. The Pm point cools due to temperature and/or insulation changes. Consequently, the mismatch between the source and load characteristics reduces the maximum power available to be delivered to the load and causes a large power loss. To reduce power loss, the MPPT algorithm ensures that the source impedance is equal or close to the load impedance performed by the DC-DC converter. Classification and comparison of MPPT methods are also available in the literature. The MPPT method is also compared in a solar photovoltaic system under the same isolation conditions and partial shade conditions. [2]


Figure 2.6 MPPT

# Chapter 3 Methodology and Design of MPPT

## 3.1 Functionality and Design of MPPT

Main objectives of project is to design a stand-alone Photovoltaic charging system with the following specifications:

Stand-alone system

Output Power of 30 Watt

Maximum PowerPoint Tracker

Batteries of 24 Volts

Charger of 24 Volts output for batteries

Modules of the project are shown in the block diagram below

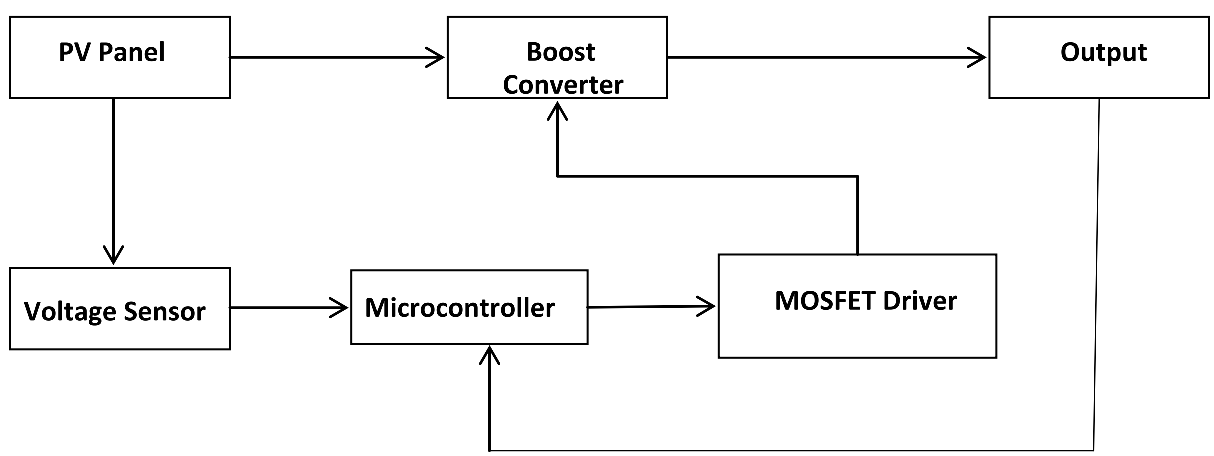



Figure 3.1: Block diagram of modules

**Components of MPPT**

1. Solar panel

2. Battery

3. Sensor

4. Boost Converter

5. Control Circuit

## 3.2 Solar Panel

The characteristics of solar panels are discussed in detail in previous chapters. The model and specifications of the solar panel used for this project are listed below

### 3.2.1 Model

BCT30-12

### 3.2.2 Specification:

Table 3.1: Solar panel specifications

| **Solar Panel**<br><br>BCT30-12 | |
|---|---|
| Power | 30W |
| Vmax | 16V |
| Imax | 1.83 |
| Vocct | 21.6V |
| Is | 1.98A |

here,

Vmax is the Maximum Voltage

Imax is the Maximum Current

Vocct is the Open circuit voltage

Is is the short circuit current

### 3.3 Battery

The battery used in this project is a deep-discharge battery. This battery is capable of supplying current to load even when its terminal voltage is less than its nominal voltage.

Its specifications are

#### 3.3.1 Specification

Table 3.2: Battery specification

| Lead Acid Battery<br><br>LP12-24 (12Volts24AH) | |
|---|---|
| Nominal Voltages | 12Volt |
| Standby Usage | 13.5-13.8 Volt |
| Cycle Usage | 14.4-15.0 Volt |
| Initial Current of batteries | <7.2 Ampere |

**NOTE:** We use two batteries connected in series to fulfill our load requirement

### 3.4 Sensor circuit

It consists of two sensors

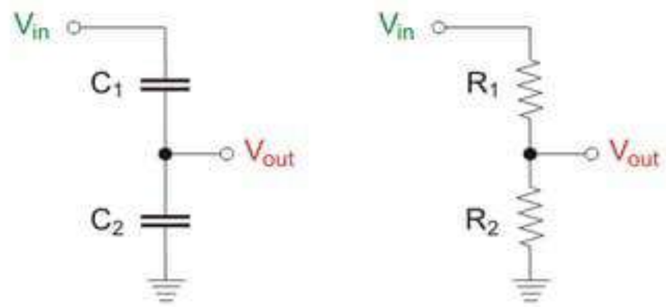
Voltage sensor

Current sensor

Due to the implementation of the MPPT technique, the voltage and current of the solar panels must be monitored continuously. Thus, this sensor is used to sense voltage and current. The operation and design of voltage and current sensors are described below

#### 3.4.1 Voltage Sensor

It will be used to measure the output voltage of the solar panel and then feed it to the microcontroller. The maximum voltage of the solar panel is about 20V, and the analog to digital converter (ADC) of the microcontroller can measure a maximum of 5V. So, the voltage divider circuit will be used to limit the voltage supplied to the microcontroller to 5V. It consists of a combination of two resistors and two capacitors on the other side as shown below




$$V_{out} = \frac{C_1}{C_1 + C_2} \times V_{in}$$

$$V_{out} = \frac{R_2}{R_1 + R_2} \times V_{in}$$

Figure 3.2 Circuit of a voltage sensor

Output voltage of solar panel is provided across series combination of R1 and R2. The voltage drop across R2 is fed to the microcontroller.

$$v_{R_1} = \frac{v_P \times R_2}{R_1 + R_2}$$

$$\frac{v_p}{v_R} = \frac{R_1 + R_2}{R_2}$$

Vp is the panel voltage and its maximum value is 20V.

For Vp =20V ; VR1 =5V

Putting these values in the above equation

$$4 = \frac{R_1 + R_2}{R_2}$$

Let R1=100KΩ

Then R2= 33KΩ

So R2=33KΩ and R1=100KΩ were used for making the voltage sensor.

### 3.4.2 Current Sensor

The current sensor in the MPPT system measures the output current of the PV array. Provides information on the amount of current produced by the PV panels. Similar to the voltage sensor, the current sensor plays an important role in determining the MPP. By continuously monitoring the output current, the MPPT controller can adjust the load or input parameters to keep the system operating near the MPP. Current sensors help optimize the power conversion process by accurately tracking changes in array current and making the necessary adjustments to output power.

By combining measurements from voltage and current sensors, the dynamic MPPT controller can adjust the operating conditions of the PV array, such as load impedance, to ensure the system operates at MPP. This allows the MPPT system to increase the efficiency and capacity of solar panels, resulting in increased energy harvesting from sunlight. [3].

To design the current sensor for this project six resistors were used in parallel each having a value of .1 ohm and a power rating of 3 watts. The equivalent resistance is .0167 ohms. Since the maximum output current of a solar panel is 6.35A. So maximum voltage drop across the resistor is

$$V = I \times R$$

$$= 6.35 \times 0.0167$$

$$= 0.106V$$

will be the maximum voltage drop across the current sensor resistor. So, there is a need to amplify this voltage drop to 5V. To amplify 0.106V to 5V a differential amplifier is used. The circuit diagram of a differential amplifier is given below.

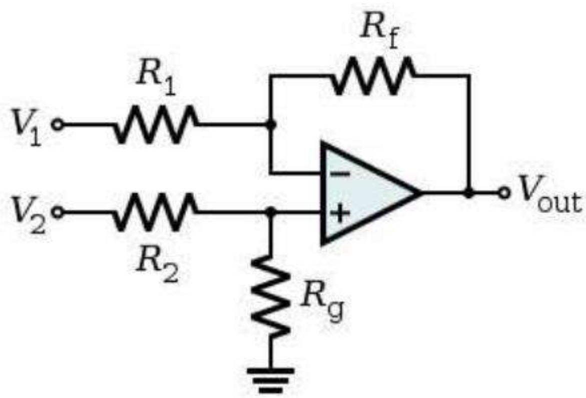



Figure 3.3 Differential amplifier

The output voltage expression of an above given differential amplifier is given as

$$v_{out} = \frac{(R_f + R_1)R_g}{(R_g + R_2)R_1} - \frac{R_f}{R} v_1$$

This expression for output voltage is a little bit complicated. It can be simplified by imposing different conditions. Such as under the condition that the

$$\frac{R_f}{R_1} = \frac{R_g}{R_2}$$

the output expression becomes:

$$V_{out} = A(v_2 - v_1)$$

Where $A = \frac{R_f}{R_1}$

For this purpose, we select the values of the resistor such that

$$R_f = R_g \ \& \ R_1 = R_2$$

To amplify 0.106V to 5V the gain of the amplifier can be calculated from the above given equation.

$$A = \frac{v_{out}}{v_2 - v_1}$$

$$A = \frac{5}{0.106}$$

$$\approx 47$$

We also know that

$$A = \frac{R_f}{R_1}$$

When $R_f = R_g$ & $R_1 = R_2$

So, to obtain the gain of 47 we select

$$R_f = R_g = 47K\Omega$$

$$R_f = R_2 = 1K\Omega$$

To design the current sensor the OPAM used is LM741 shown below

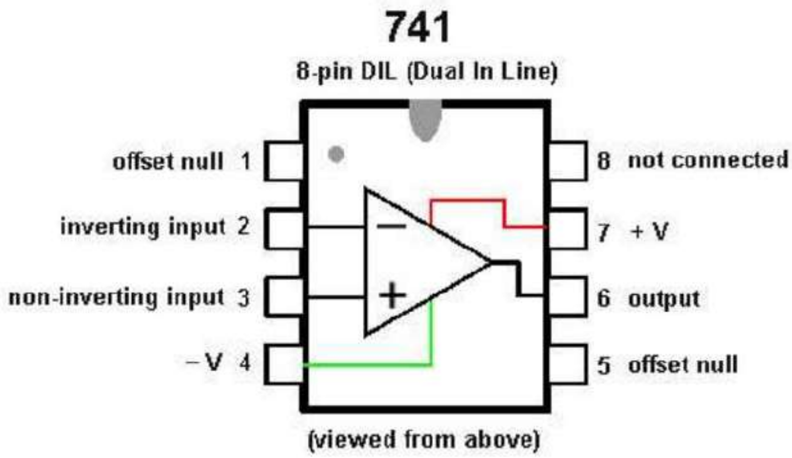



Figure 3.4 LM741 IC

The Schematic circuit diagram of the current sensor is given below

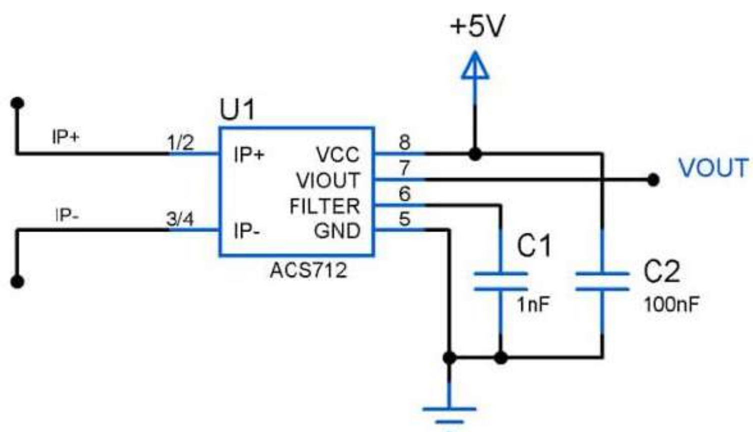



Figure 3.5 Schematic Circuit of Current

### 3.5 Boost Converter

The boost converter is a key component in the MPPT (Maximum PowerPoint Tracking) system design. A type of DC-DC converter is used to increase the voltage from the PV (photoelectric) array allowing the MPPT system to operate at its peak power point. [4].

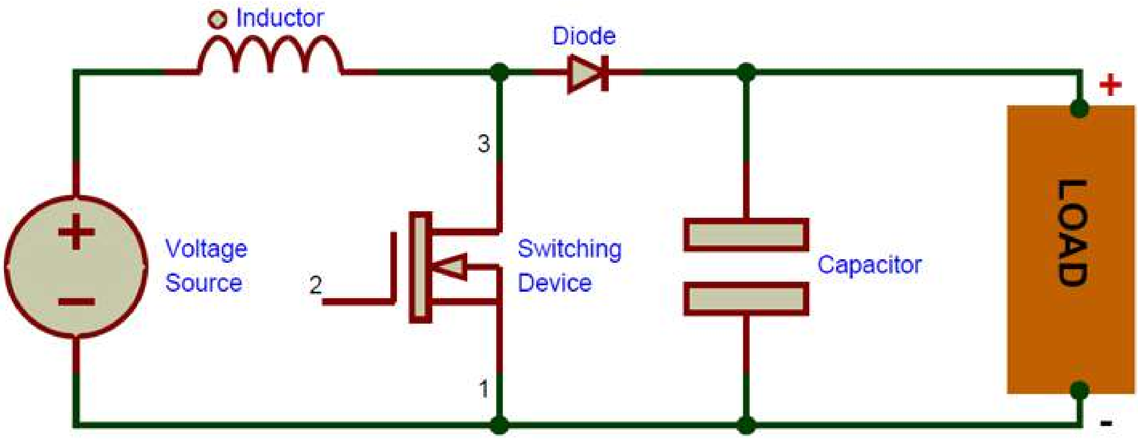



Figure 3.6 Circuit diagram of Boost Converter

The boost converter operates by storing energy in an inductor during one portion of the switching cycle and then transferring that energy to the output during another portion of the cycle. It consists of an inductor, a switch (typically a MOSFET), a diode, and a capacitor as shown in above figure 3.7.

Here's a simplified explanation of how a boost converter works within an MPPT system:

- **Voltage Sensing:** The MPPT controller measures the output voltage of the PV array using a voltage sensor.
- **Comparison:** Measured voltage is compared to a reference voltage indicating the desired operating point (MPP). If the voltage is measured below the reference, this indicates that the array is not operating at MPP.
- **Duty Cycle Adjustment:** Bring the set closer to the MPP, the MPPT controller adjusts the duty cycle of the switch in the boost converter. Duty cycle refers to the ratio of switch open time to the total switching period. With various control cycles, the controller controls the amount of energy sent to the output.
- **Energy Transfer:** When the switch is open, current flows through the inductor, storing energy. When the switch is turned off, the energy stored in the inductor is transferred to the output through the diode and capacitor, causing the output voltage to increase.
- **Feedback Loop:** The MPPT controller continuously monitors the output voltage and adjusts the duty cycle to maintain the output voltage at a level consistent with the MPP.

By using of boost converter, the MPPT system can efficiently increase the voltage from the solar array to match the requirements of the load or the energy storage system. This allows utilization of the available solar energy in better way and enhances the efficiency of the MPPT system. The two working modes of boost-converter operation are defined below

### 3.5.1 Working of Mode 1 of Boost Converter

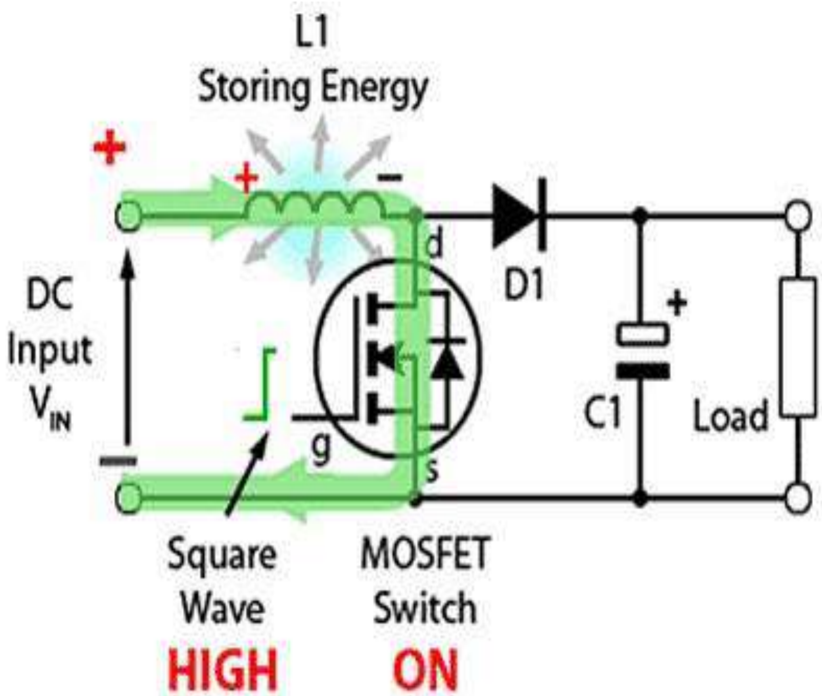



Figure 3.7 Mode 1 of a boost converter

Figure 3.7 shows the behavior of the circuit during the initial high phase of a high frequency square wave applied to the MOSFET gate at start-up. During this period, the right side of MOSFET L1 puts a short circuit to the negative input supply terminal. Therefore, current flows between the positive and negative supply terminals through L1, which stores energy in the magnetic field. There is almost no current flowing through the rest of the circuit because the combination of D1, C1, and the load presents a higher impedance than the path through the heavy MOSFET.

### 3.5.2 Working of Mode 2 of Boost Converter

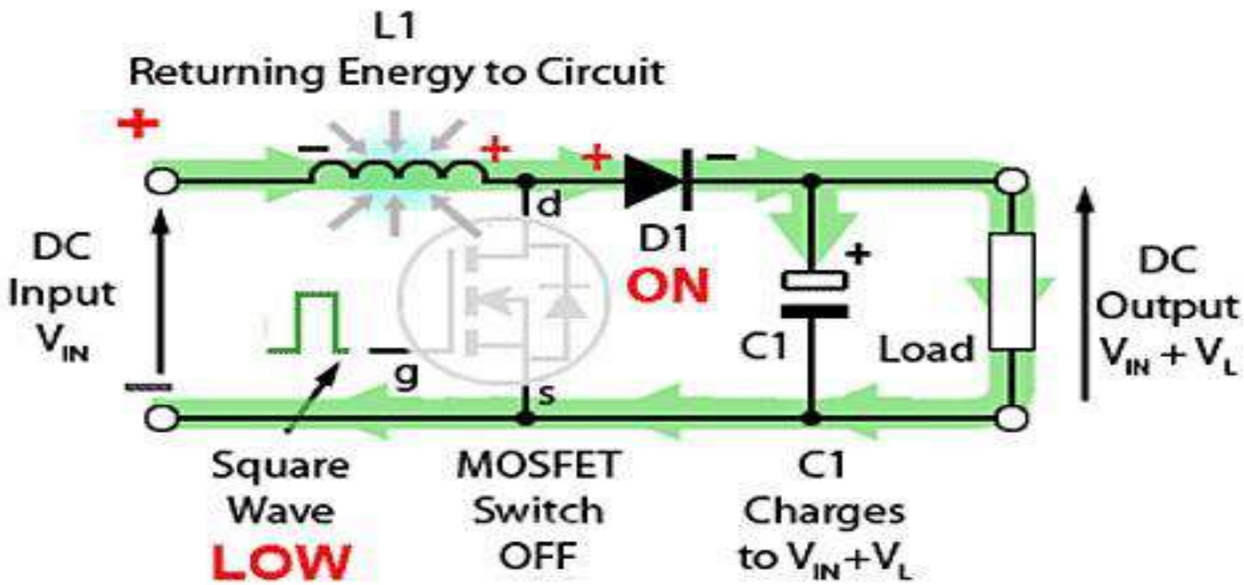



Figure 3.8 Mode 2 of boost converter

Figure 3.8 shows the current path during the low phase of an alternating square wave cycle. As the MOSFET quickly turns off, the sudden drop in current causes L1 to generate an emf again in the opposite polarity to the voltage across L1 at that time. These two voltages, supply voltage VIN and back e.m.f (VL) are in series with each other. This high voltage (VIN + VL) now has no path through the MOSFET, D1 is forward biased. The current generated through D1 charges C1 to VIN + VL and also charges the small voltage drop across D1.

### 3.6 Maximum Power Point Tracking

MPPT or Maximum Power Point Tracking is used to extract the maximum power from the PV module under certain conditions. The voltage at which the PV module can produce the most power is called the "peak power point" (or peak voltage). Peak power varies depending on solar radiation, ambient temperature, and solar cell temperature.

For any given set of operating conditions, the cell has a single operating point, the value of current (I) and voltage (V) in the cell at which it produces maximum power. This value corresponds to the same specific load resistance V/I as described by Ohm's law. Power P is given by P = V * I. Photovoltaic cells have an exponential relationship between current and voltage. From the basic circuit theory, the result (graph, slope) of the I-V curve is equal to the ratio dI/dV I/V and dP/dV = 0 This is known as the maximum power point (MPP) and corresponds to the "knee" of the curve. [5].

Fig 3.9 illustrates the V-I and P-V characteristics of a 16V solar panel and the maximum power point at the bend of the V-I curve.

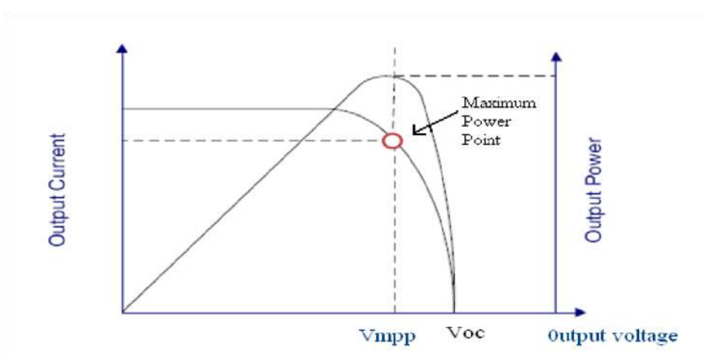



Figure 3.9Maximum power of solar panel

### 3.6.1 MPPT Techniques

There are many MPPT technique but some of them are as follow:

- Perturbation and Observation (P&O) method.
- Incremental Conductance (InC) method.
- Constant Voltage method.

NOTE: We are using the Perturbation and Observation Technique.

**Perturbation and Observation (P&O) method**

The concept of the "Disruption and Review" method is to change the operating voltage or current of the photovoltaic panel until it receives maximum power. This is often called the slope method because it depends on the curve rising to the left of the MPP ($dP/dV > 0$) and the curve falling to the right of the MPP ($dP/dV < 0$). Then we use only one sensor with voltage sensor to measure PV voltage and low performance cost. This process works by increasing or decreasing the duty cycle of a single phase or step up DC to DC converter.

One of the main disadvantages of the perturbation and monitoring method is that the output power at steady state oscillates around the peak power point. This algorithm is able to track incorrectly under rapidly changing beam conditions. The time complexity of this algorithm is high, but when it is too close to the MPP, it does not stop at the MPP and continues to disturb in both directions [6].

**Incremental Conductance (InC) method**

The boost converter method uses two voltage and current sensors to measure the output voltage and current of the PV array. This method uses the increasing conductance of the photovoltaic array (dI/dV) to calculate the magnitude of the power change in relation to the voltage (dP/dV). InC calculates the peak power point by comparing the increased conductance (V) and conductance (I/V). When the increase in transmittance is zero, the output voltage is defined as the MPP voltage and remains at this voltage until the MPP undergoes a change due to a change in the radiation conditions. The process is then repeated until the point of maximum strength is reached.

The disadvantage of this method is that it can cause oscillations and perform incorrectly in rapidly changing atmospheric conditions. The computational time is increased due to the slower frequency of the algorithm compared to the P&O method.

**Constant Voltage Method**

In the constant voltage method, the power to the load is temporarily interrupted and the zero voltage of the open circuit is measured. The controller then begins to operate with a control voltage at a fixed ratio of 0.76 of the open-circuit voltage, which is empirically determined as an approximation of the maximum power point. The operating point of the PV array is maintained near the MPP by adjusting the array voltage and comparing it to a fixed voltage Vref. The Vref value is equal to the peak power point voltage of a typical PV module or the best rated voltage.

One of the limitations of this method is that it does not consider changes in individual panels. The continuous reference voltage can be calculated as the maximum input voltage. Data for this method varies with geographic location and should be processed differently for different geographic locations. The CV method does not require any input. It is important to observe that the CV technique is more efficient than the P&O method or other methods when the PV panel is in a low insulation condition. CV is sometimes combined with other MPPT methods. [7]

## 3.7Control Circuit

### 3.7.1 Microcontroller PIC16F887:

The PIC16F887 is a popular microcontroller from the PIC (Peripheral Interface Controller) family developed by Microchip Technology. It is widely used in various applications that require a low-power, high-performance microcontroller.

Key features of the PIC16F887 controller include:

- **Architecture:** The PIC16F887 is based on a Harvard architecture with an 8-bit RISC (Reduced Instruction Set Computer) core. It operates at a maximum frequency of 20 MHz and has a pipelined instruction execution capability, allowing for efficient and fast operation.
- **Flash Memory**: It has a 14 KB Flash program memory for storing the user's code, which can be electrically erased and reprogrammed. This feature allows for easy updates and flexibility in application development.
- **RAM and EEPROM:** The controller offers 368 bytes of RAM (Random Access Memory) for data storage during program execution. Additionally, it has 256 bytes

of EEPROM (Electrically Erasable Programmable Read-Only Memory) for non-volatile data storage.

- **I/O Ports:** The PIC16F887 has a total of 33 I/O pins that can be individually configured as inputs or outputs. These pins provide interface capabilities for connecting peripheral devices such as sensors, displays, actuators, and communication modules.
- **Analog-to-Digital Converter (ADC):** It includes an 8-channel, 10-bit ADC with selectable voltage references. This ADC allows the microcontroller to measure analog signals from sensors or other analog sources, enabling it to interface with the real world.
- **Timers/Counters:** The controller features three 8-bit timers/counters and one 16-bit timer/counter. These timers can be used for various timing and counting applications, such as generating accurate delays, measuring time intervals, or generating PWM signals.
- **Communication Interfaces:** The PIC16F887 supports various communication protocols, including USART (Universal Synchronous/Asynchronous Receiver/Transmitter), SPI (Serial Peripheral Interface), and I2C (Inter-Integrated Circuit). These interfaces facilitate communication with other devices, such as external sensors, displays, or microcontroller networks.
- **Interrupts**: It has several interrupt sources that can trigger an interrupt routine, allowing the microcontroller to respond to external events in real time.

- **Low-Power Features:** The controller incorporates power-saving features, including different sleep modes and a low-power watchdog timer, to optimize energy consumption in battery-powered applications.
- **Development Tools:** Microchip provides a comprehensive set of development tools, including an integrated development environment (IDE), compilers, programmers, and debuggers, to facilitate software development for the PIC16F887.

Overall, the PIC16F887 controller offers a wide range of features and capabilities, making it suitable for various embedded system applications, including industrial control, home automation, consumer electronics, and more.

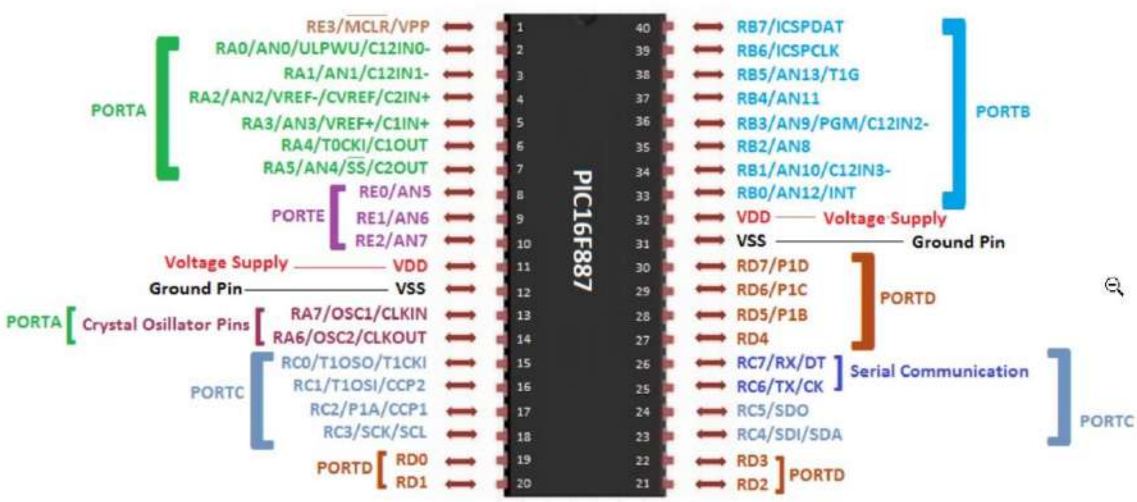



Figure 3.10 Pin Diagram of PIC16F887

### 3.7.2 Working of PIC16F887 as a Controller

The PIC16F887 is a microcontroller that can be used in various applications, including control circuits for maximum power point tracking (MPPT) in boost converters. MPPT is a technique used in solar power systems to extract the maximum power available from a photovoltaic (PV) panel.

In a boost converter, the output voltage is increased from the input voltage by controlling the duty cycle of a switching element, typically a power MOSFET. The MPPT algorithm continuously adjusts the duty cycle to maintain the PV panel operating at its maximum power point, which can vary depending on environmental conditions such as sunlight intensity and temperature.

The PIC16F887 microcontroller can be employed to implement the control circuit for MPPT in a boost converter. It offers several features that make it suitable for this application, including analog-to-digital converters (ADCs) to measure the PV panel voltage and current, digital input/output (I/O) pins for controlling the switching element, and a timer for generating the necessary timing signals.

Here's a brief explanation of the control circuit's functioning:

- **PV Panel Measurements:** The microcontroller's ADCs are used to measure the voltage and current of the PV panel. These measurements provide the necessary information to calculate the power output of the panel.
- **Power Calculation:** The microcontroller calculates the power output of the PV panel by multiplying the measured voltage and current values.
- **MPPT Algorithm**: Based on the calculated power and previously obtained values, the MPPT algorithm determines the optimal duty cycle for the boost converter. The algorithm adjusts the duty cycle in small increments or decrements to track the maximum power point.

- **PWM Generation:** The microcontroller generates a pulse-width modulation (PWM) signal using its timer and sets the duty cycle according to the MPPT algorithm's output. The PWM signal controls the switching element (power MOSFET) in the boost converter.
- **Feedback Control:** The output voltage of the boost converter is monitored using the microcontroller's ADC. The microcontroller compares the actual output voltage with the desired voltage and adjusts the duty cycle accordingly to maintain the output at the desired level.
- **Iterative Process:** The control circuit continuously repeats the above steps to track the maximum power point. The microcontroller regularly samples the PV panel's voltage and current, calculates the power, adjusts the duty cycle, and monitors the output voltage to maintain efficient operation.

By implementing the MPPT control circuit using the PIC16F887 microcontroller, the boost converter can optimize the power output from the PV panel, maximizing the energy harvested from solar sources.

# Chapter 4 Design and Methodology of Charging System

There are 4 portions of our charging system:

- Design of a Transformer
- Design of a Bridge Circuit
- Cutoff Circuit
- Current Limiting Circuit

## 4.1 Design of a Transformer

To design a transformer that converts 220V AC to 24V AC with a current rating of 7A, we need to determine the required specifications of the transformer, such as the number of windings and the core size. Here's a general procedure for designing such a transformer [8]:

- **Determine the turns ratio:** The turns ratio of a transformer determines the voltage conversion. In this case, we want to step down the voltage from 220V to 24V. The turns ratio (N) can be calculated using the formula:

  $N = Vout / Vin$

  where Vout is the desired output voltage (24V) and Vin is the input voltage (220V).

  $N = 24V / 220V \approx 0.1091$

  The turn ratio should be approximately 0.1091.

- **Determine the primary current:** The primary current (Ip) can be calculated using the formula:

Ip = Pout / Vin

where Pout is the desired output power. In this case, the output power is the product of the output voltage and current:

Pout = Vout × Iout = 24V × 7A = 168W

Ip = 168W / 220V ≈ 0.7636A

The primary current should be approximately 0.7636A.

- **Determine the secondary current**: The secondary current (Is) is equal to the primary current multiplied by the turn's ratio
- Is = Ip / N = 0.7636A / 0.1091 ≈ 7A

  The secondary current should be approximately 7A, which matches our desired rating.
- **Choose a suitable core size:** The core size depends on various factors such as power handling capability, core material, and efficiency. The core size selection involves complex calculations based on specific design requirements, including factors like core material, frequency, and efficiency. Detailed calculations and consideration of losses, such as copper losses and core losses, are required. These calculations are beyond the scope of a simple response [9].

### 4.1.1. Working on Transformer

Figure 4.1 Winding of Transformer

Figure 4.2 Output of a Transformer

## 4.2 Design a Bridge Circuit

To design a bridge rectifier circuit that converts 24V AC to DC with a specific current rating of 7A, you can use a combination of diodes and smoothing capacitors. Here's a step-by-step guide to designing the circuit:

### 4.2.1. Determine the peak voltage

The peak voltage (Vp) of the AC input can be calculated as the square root of 2 times the RMS voltage. For a 24V RMS AC input, the peak voltage can be calculated as follows:

$$Vp = \sqrt{2} \times Vrms = \sqrt{2} \times 24V \approx 33.94V$$

The peak voltage is approximately 33.94V.

### 4.2.2. Select diodes

Choose diodes that can handle the desired current and voltage ratings. Since we want a current rating of 7A, select diodes that can handle this current or higher. For example, you could use diodes rated for 10A or more.

### 4.2.3. Determine the ripple current

The ripple current (I ripple) is the maximum current variation that occurs in the output due to the rectification process. It depends on the load, smoothing capacitors, and desired ripple voltage. Let's assume a desired ripple voltage of 1% of the DC voltage [10].

$$V\ ripple = Vdc \times 0.01$$

For a 24V DC output, the desired ripple voltage is $0.01 \times 24V = 0.24V$.

I ripple =I out / (2 × π × f × C)

where I out is the desired output current (7A), f is the frequency of the AC input (50Hz or 60Hz), and C is the value of the smoothing capacitor.

Let's assume a frequency of 50Hz and solve for C:

0.24V = 7A / (2 × π × 50Hz × C)

C = 7A / (2 × π × 50Hz × 0.24V)

≈ 0.0185F (or 18,500μF)

The required value for the smoothing capacitor (C) is approximately 18,500μF.

Add the positive DC output and the negative terminal of the capacitor to the negative DC output. The capacitor value should be 18,500μF.

**4.2.4 PCB Layout of Bridge Rectifier Circuit**

Once the circuit is assembled, verify that the diodes and capacitors used can handle the desired current and voltage ratings. Ensure proper heat sinking for the diodes and follow safety guidelines.

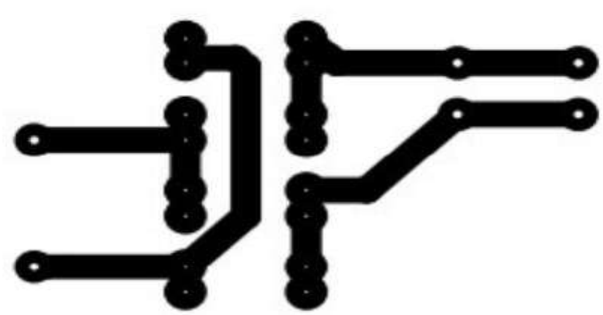


Figure 4.3 PCB Layout of the Bridge

## 4.3 Cutoff Circuit

Designing a cutoff circuit for a 24V power supply involves implementing a voltage monitoring mechanism that detects when the voltage exceeds or falls below a certain threshold. Here's a general approach to designing such a circuit [11].

**Specification**

- Transformer (0-16V)
- Diode (1N4007)
- 12V Battery
- Zener Diode 12v/1w
- Voltage Regulator IC (LM317)
- NPN Power Transistor (BD139)
- LED
- Potentiometer 10K
- Electrolysis Capacitor (1000uf)
- Ceramic Capacitor (0.1uf)
- Resistor (1K, 2K, 10 Ohm, 230 Ohm)

**Components needed**

Zener diode: Choose a Zener diode with a breakdown voltage slightly higher than the desired cutoff voltage. For example, you can use a 24V Zener diode.

**Transistor:** Select an NPN transistor with sufficient voltage and current ratings to handle the load connected to the power supply.

**Resistors:** You'll need a few resistors to set up the biasing and voltage divider circuits.

**Circuit design steps**

Determine the desired cutoff voltage. Let's assume it's 21V for this example.

1. Set up a voltage divider circuit using resistors to create a reference voltage. Choose the resistor values to divide the 24V supply by the desired reference voltage. For example, if you want a reference voltage of 21V, you can use a voltage divider with resistors R1 and R2 [12].
2. Connect the Zener diode in reverse bias across the base-emitter junction of the transistor. This helps protect the transistor from excessive voltage.
3. Connect the emitter of the transistor to the ground, and the collector to the load.
4. Connect the reference voltage from the voltage divider to the base of the transistor through a current-limiting resistor.
5. Add a pull-up resistor between the collector and the positive supply voltage to maintain stability.
6. Finally, connect the load between the collector and the positive supply voltage.

### 4.3.1Circuit Diagram

The Circuit Diagram of the cutoff circuit is shown as follows:-

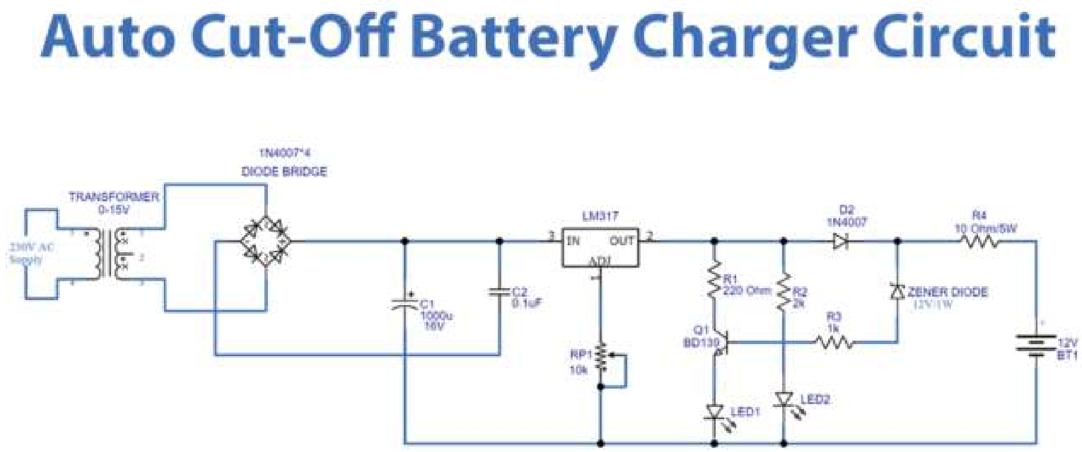



Figure 4.4 Auto Cut-off circuit

### 4.3.2. Working principle

When the supply voltage is below the cutoff voltage, the voltage at the base of the transistor will be lower than the reference voltage, keeping the transistor off. As a result, no current flows through the load. However, when the supply voltage rises above the cutoff voltage, the reference voltage at the base of the transistor becomes higher than the reference voltage, causing the transistor to turn on. This allows current to flow through the load, providing power. The Zener diode protects the base-emitter junction of the transistor from excessive voltage [13].

Please note that the specific resistor values and transistor choice may vary based on the load requirements and the characteristics of the components available. It's important to double-check component datasheets and make appropriate adjustments to suit your specific application.

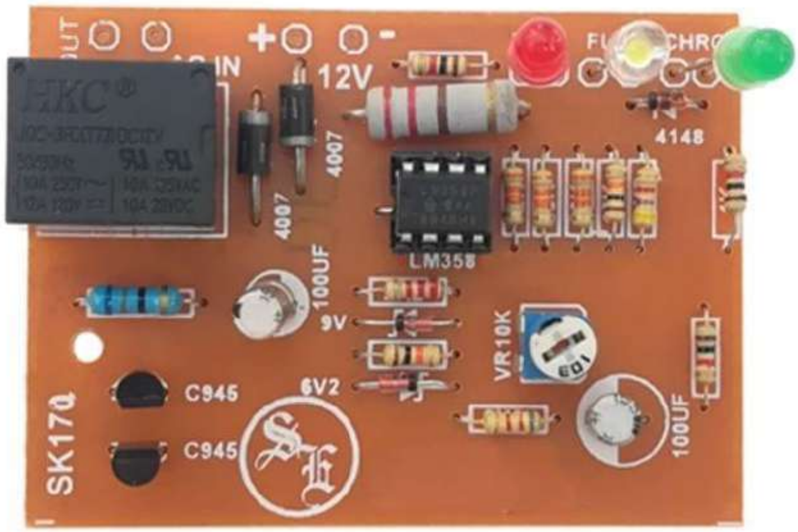



Figure4.5 Designed of Auto cutoff Circuit

### 4.4 Voltage and Current Regulator

A current-limiting circuit is a circuit designed to control or limit the amount of current flowing through a load or component [14]. It is commonly used to protect electronic devices or components from excessive currents that could potentially damage them.

#### 4.4.1 Equipment’s

- LM317
- BD139
- D1047
- Potentiometer (50K & 5K)

- Resistor 220Ω
- Capacitor 0.1uF
- Heat Sink

- **LM317**

  The LM317 is a widely used adjustable voltage regulator IC that can be utilized to create a voltage regulator circuit capable of regulating voltage in the range of 0-30V. However, the LM317 alone cannot provide current limiting functionality up to 10A. To achieve both voltage and current regulation, you will need to combine the LM317 with additional circuitry.

- **BD139**

  The BD139 is a popular NPN bipolar junction transistor (BJT) commonly used in low-power applications. While it can handle moderate currents (up to a few amperes) and voltages (up to 80V), it may not be suitable for providing the full current limiting capability up to 10A in your circuit.

- **D1047**

  The D1047 is a high-power NPN bipolar junction transistor (BJT) commonly used in power amplifiers and switching applications. It has a higher current and voltage rating compared to the BD139, making it more suitable for applications requiring higher power levels. If you want to incorporate the D1047 in your voltage and current regulator circuit, you can replace the BD139 transistor in the circuit diagram I provided earlier with the D1047

**4.4.2. Circuit Diagram** The circuit diagram is shown as follows:

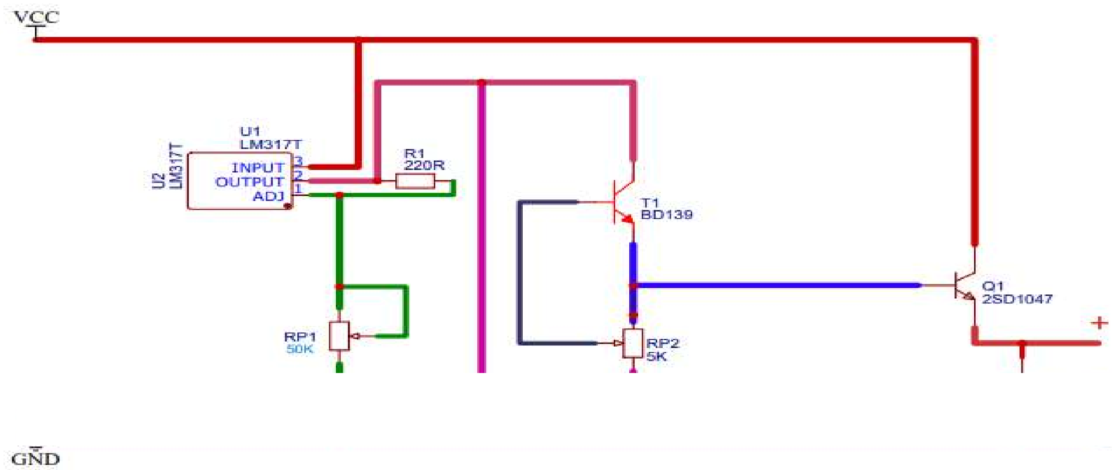



Figure 4.6 Voltage and Current Regulator

**How did the circuit operate?**

**Voltage Source:** This represents a variable DC power supply capable of providing a voltage range of 0-30V.

**Voltage Regulator:** This portion of the circuit regulates the output voltage. It includes a voltage reference, error amplifier, and pass transistor (Q1). By adjusting the reference voltage and providing appropriate feedback, the voltage regulator maintains a stable output voltage across the load [15].

**Current Limiting Circuit:** The current-limiting section consists of a sense resistor (R1) and a current-sensing circuit. The sense resistor is connected in series with the load, and the current flowing through it is monitored. An error amplifier compares the voltage across the sense resistor with a reference voltage representing the desired current limit.

**Transistors (T1 and Q1):** T1 acts as the voltage regulator's pass transistor, controlling the output voltage. Q1 is a current-controlling transistor that limits the current flowing through the load. The base voltage of Q1 is regulated by the current-sensing circuit.

By adjusting the reference voltages for the voltage regulator and current limiting circuit, you can set the desired output voltage and current limits. The circuit will regulate both parameters within the specified ranges.

# Chapter 5 Results and Conclusion

## 5.1 Results of Transformer

A Transformer is a step-down transformer that is designed for 220V AC to step-down 24V AC

Here are some key considerations and results for such a transformer:

- **Voltage Conversion:** The transformer will convert the input voltage of 220V to the desired output voltage of 24V.
- **Turns Ratio:** The turn ratio of the transformer can be calculated by dividing the primary voltage by the secondary voltage. In this case, the turn ratio would be 9.17:1 (220/24). This means that for every 9.17 turns on the primary side (220V), there is 1 turn on the secondary side (24V).
- **Power Capacity:** The power capacity of the transformer can be calculated by multiplying the output voltage by the current rating. In this case, the power capacity would be approximately 168VA (24V * 7A). This means that the transformer can handle a maximum power of 168 watts.
- **Current Capacity**: The current capacity of the transformer is determined by its current rating. In this case, the transformer is rated for a maximum current of 7A on the secondary side.
- **Efficiency:** The efficiency of the transformer can vary depending on its design and construction. Typically, transformers have efficiencies in the range of 90-95%. However, the specific efficiency of this transformer would depend on its design and manufacturer specifications.

- **Isolation:** Transformers provide electrical isolation between the input and output circuits. This isolation helps protect connected devices from electrical faults and improves safety.

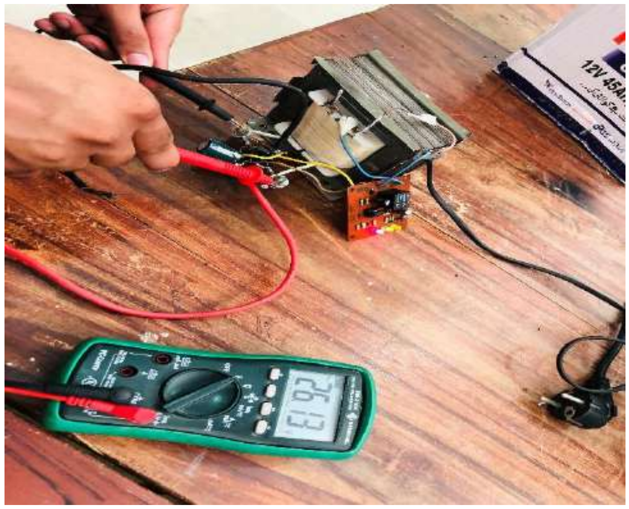


Figure 5.1 Output Voltage of Transformer

Figure 5.2 Sinewave of transformer

### 5.2 Results of Bridge Circuit

A 24 V to 24 V DC bridge using 10A diodes suggests that you are trying to rectify a 24V AC voltage and obtain a 24V DC output using diodes with a current rating of 10A. However, it's important to note that a bridge rectifier typically converts AC voltage to DC voltage, so in this specific scenario, the voltage level remains the same.

Here are the main points regarding the results of a 24V AC-to-24V DC bridge using 10A diodes:

- **Voltage Conversion:** The voltage level remains the same in this setup. Since the input and output voltage are both 24V, the bridge rectifier does not change the voltage magnitude. It primarily converts the AC waveform to a DC waveform.
- **Rectification:** The bridge rectifier configuration, consisting of four diodes, allows for full-wave rectification. It ensures that both the positive and negative halves of the input AC waveform are utilized to generate a DC output.

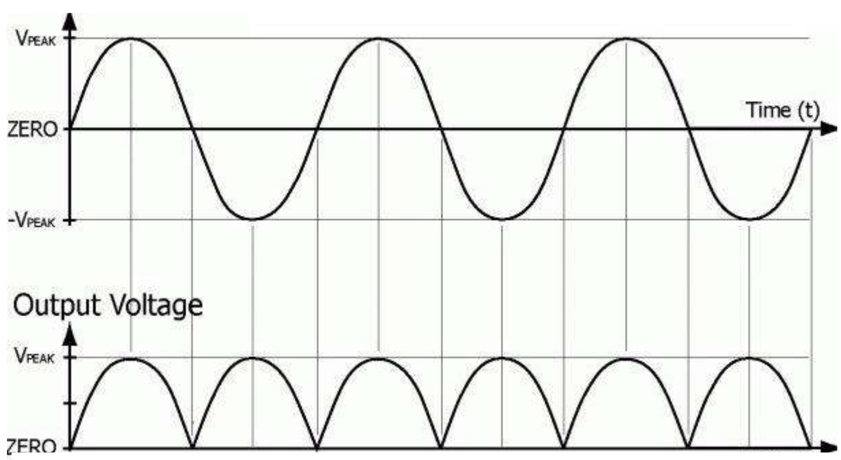



Figure 5.3 Full Wave Rectification

- **Diode Current Rating:** The diodes used in the bridge rectifier have a current rating of 10A. This means they can handle a maximum continuous current of 10A without experiencing excessive heat or damage.
- **Ripple Voltage**: The output of the bridge rectifier produces a pulsating DC waveform with ripple voltage. The magnitude of the ripple voltage depends on various factors such as the load current, capacitor filtering, and the frequency of the input AC waveform. The diodes' current rating does not directly affect the ripple voltage.
- **Output Current:** The output current of the rectifier is determined by the load connected to it. The load resistance or impedance determines the current flowing through the circuit. The diodes' current rating of 10A suggests that the rectifier can handle a load current of up to 10A without exceeding the diodes' maximum current rating.
- **Efficiency:** The efficiency of the bridge rectifier depends on various factors such as the diode characteristics, circuit design, and load conditions. Generally, bridge rectifiers can achieve efficiencies ranging from 80% to 90% or higher. The diodes' current rating does not directly impact the rectifier's efficiency.

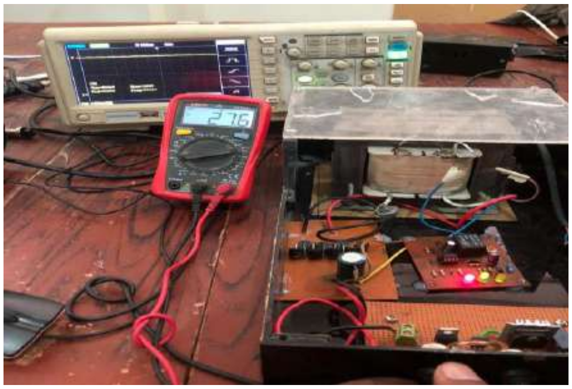


Figure 5.4 Output of the Bridge Circuit

### 5.3 Conclusion of Charging System

In conclusion, transitioning from a 220VAC charging system to a 24V DC charging system can offer several advantages in terms of efficiency, safety, and compatibility.

By adopting a 24V DC charging system, the following benefits can be realized:

- **Improved Efficiency**: DC systems have inherently higher efficiency compared to AC systems due to reduced energy losses during conversion. With a 24V DC charging system, there are fewer conversions between AC and DC, resulting in improved overall efficiency and reduced energy waste.
- **Enhanced Safety**: Direct current systems at lower voltage levels, such as 24V, present a lower electrical hazard compared to higher voltage AC systems. This is particularly important in mobile or off-grid applications where the risk of electrical shock must be minimized.
- **Compatibility with DC Loads**: Many devices and appliances, especially those used in off-grid or mobile applications, operate on DC power. By utilizing a 24V DC charging system, the need for additional DC-AC inverters to power these loads is eliminated, resulting in increased compatibility and reduced equipment costs.
- **Simplified System Design:** A 24V DC charging system allows for a simplified system design, with fewer components and reduced complexity. This can lead to easier installation, maintenance, and troubleshooting, making it a more user-friendly option.
- **Future Extension with Renewable Energy Sources:** The 24V DC charging system can be easily expanded and integrated with various renewable energy

sources, such as solar panels and wind turbines. This enables the system to harness clean energy and further reduce reliance on the grid, promoting sustainability and energy independence.

### 5.4 Future Extensions

Advanced Battery Management: Implementing advanced battery management systems (BMS) can optimize charging and discharging cycles, extend battery life, and ensure efficient use of stored energy. These systems can include features like battery monitoring, equalization charging, and state-of-charge estimation algorithms.

- **Integration of Energy Storage:** Adding energy storage, such as lithium-ion batteries, to the 24V DC charging system can provide backup power and allow for load-shifting capabilities. This integration enhances system resilience, enabling continuous power supply during grid outages or periods of low renewable energy generation.
- **Smart DC Microgrids:** Building intelligent DC microgrids can enable better energy management, load balancing, and coordination between multiple energy sources and loads. Smart grid technologies, such as advanced control algorithms and communication protocols, can be implemented to optimize the performance and reliability of the DC charging system.
- **Vehicle-to-DC Charging:** Exploring the potential for vehicle-to-DC charging can enable electric vehicles (EVs) to directly charge from the 24V DC system. This integration can provide an additional source of power and promote energy sharing and flexibility between EVs and the charging system.

- **Energy Management and Automation:** Implementing energy management and automation systems can optimize overall energy usage, prioritize loads, and minimize waste. This can include features such as load scheduling, intelligent power distribution, and integration with smart home or building energy management systems.

Overall, transitioning to a 24V DC charging system offers several advantages, including improved efficiency, enhanced safety, and compatibility with DC loads. Future extensions can focus on advanced battery management, energy storage integration, smart DC microgrids, vehicle-to-DC charging, and energy management and automation. These advancements will contribute to a more efficient, sustainable, and resilient charging system for various applications.

### 5.5 Results of MPPT

MPPT stands for Maximum Power Point Tracking, which is a technique used in solar power systems to optimize the power output of photovoltaic (PV) panels. MPPT algorithms continuously track the maximum power point (MPP) of the PV panels by adjusting the operating voltage and current to ensure that the panels operate at their maximum power output.

The results of using MPPT in a solar power system can be significant. Here are some of the benefits and outcomes:

- **Increased Efficiency:** MPPT algorithms help extract the maximum available power from the PV panels, leading to improved overall system efficiency. By dynamically adjusting the operating point, MPPT ensures that the panels are always operating at the MPP, even under varying environmental conditions.

- **Enhanced Energy Harvesting:** MPPT helps capture more energy from the PV panels, especially in situations where the panels are subject to shading, temperature variations, or partial cloud cover. By continuously optimizing the operating point, MPPT ensures that the system extracts as much energy as possible from the available sunlight.
- **Faster ROI:** By maximizing the energy production of solar panels, MPPT can help accelerate the return on investment (ROI) for solar power systems. The increased energy yield translates into higher savings on electricity bills or increased revenue for commercial installations, making the investment more financially attractive.
- **Improved System Performance:** MPPT algorithms provide stability and robustness to the solar power system, allowing it to maintain optimal performance even in challenging conditions. By tracking the MPP, MPPT helps prevent overcharging or undercharging of batteries in off-grid or hybrid systems, ensuring reliable operation.

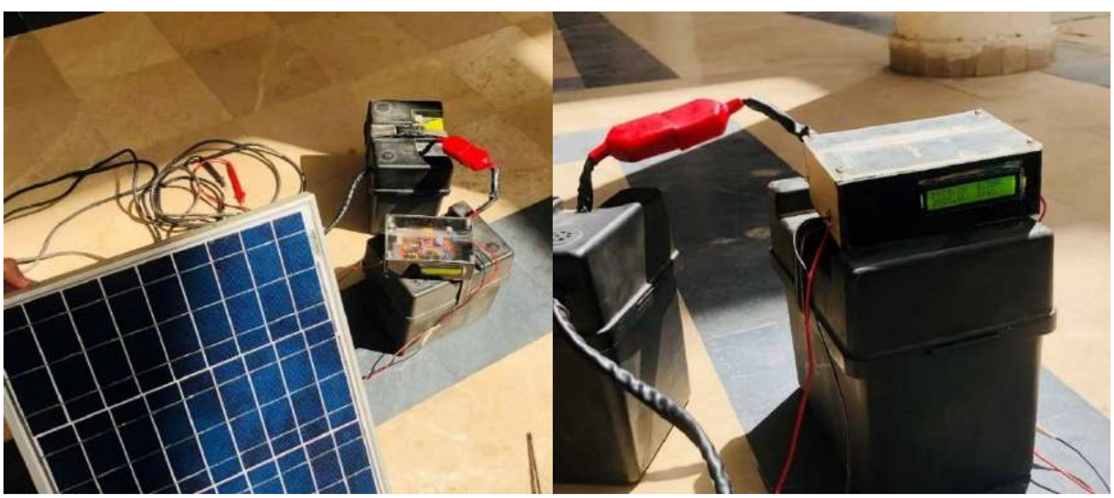


Figure 5.5 Final Readings of MPPT

- **Flexibility in Panel Configuration:** MPPT can accommodate various PV panel configurations, including different types, sizes, and orientations. This flexibility allows system designers to optimize the system for specific applications and locations, ensuring maximum power output from the available panels. It is important to note that the exact results of using MPPT may vary depending on factors such as the quality of the MPPT controller, the efficiency of the PV panels, and the environmental conditions because of the movement of the vehicle [16].

## 5.6 Conclusion of MPPT

In conclusion, the implementation of MPPT (Maximum Power Point Tracking) algorithms in solar power systems has proven to be highly beneficial. MPPT allows for the optimization of power output from photovoltaic panels, resulting in increased system efficiency and improved energy harvesting. The continuous tracking of the maximum power point ensures that the solar panels operate at their highest possible output, even under varying environmental conditions

## 5.7 Future Extensions

Future extensions and advancements that can be explored with MPPT technology:

- **Advanced MPPT Algorithms:** Developing more sophisticated MPPT algorithms can further enhance the efficiency and performance of solar power systems. This includes the utilization of advanced control techniques, artificial intelligence, and machine learning algorithms to adapt and optimize MPPT operation based on real-time data and environmental conditions.

- **Integration with Energy Storage:** Combining MPPT with energy storage systems, such as batteries, allows for the efficient storage of excess energy produced during peak sunlight hours and its utilization during periods of low sunlight or high demand. Integrating MPPT with energy storage enhances system reliability, flexibility, and the ability to provide a continuous power supply.
- **Internet of Things (IoT) Integration**: Connecting MPPT systems to IoT platforms allows for remote monitoring, control, and data analysis. IoT integration can provide real-time performance monitoring, predictive maintenance, and the ability to adjust MPPT parameters based on changing conditions or user preferences.
- **Grid Integration and Energy Management:** Integrating MPPT systems with the electrical grid enables bidirectional power flow, allowing excess solar power to be fed back into the grid. This integration can facilitate net metering, grid stabilization, and demand response programs, maximizing the benefits of renewable energy generation.
- **MPPT for Other Energy Sources:** Exploring the application of MPPT beyond solar power, such as in other renewable energy sources like wind or hydroelectric power, can contribute to more efficient and optimized energy generation.

Overall, the future extension of MPPT technology lies in the development of advanced algorithms, integration with energy storage and IoT platforms, hybrid systems, EV charging, grid integration, and exploring applications in other renewable energy sources. These advancements will continue to improve the efficiency, reliability, and effectiveness of MPPT systems, further promoting the adoption and utilization of renewable energy

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# Appendix A Sustainable Development Goals (SDGs)

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United Nations Policy and Pakistan's Priority


SDGs - an ambitious and universal agenda

• On 25 September 2015, the UN General Assembly adopted the 2030 Agenda for Sustainable Development (UN, 2015)

• At the core of the 2030 Agenda are 17 Sustainable Development Goals (SDGs

• The universal, transformational, and inclusive SDGs describe major development challenges for humanity.

- The aim of the 17 SDGs (Annex. 1) is to secure a sustainable, peaceful, prosperous, and equitable life on earth for everyone now and in the future.

- For the goals to be reached, everyone needs to do their part: governments, the private sector, civil society, and every human being across the world

- The Sustainable Development Goals achieved in our project Unmanned Ground robot

**A1Good Health and Well-Being**

We ensure that our project hit the level of healthy lives and promotes well-being for all. As we know the disable person in the society will suffer more than a simple person. Our project prove to be very helpful for their health and reducing mental stress. They Utilize the benefits of our fast-charging system and solar charger (MPPT) to do their daily work easily.

**A2 Affordable and Green Energy**

This project is affordable for everyone specially for disable persons because we used solar energy for charging purpose. Which decrease our dependency on conventional energy sources.

**A3 Decent Work and Economic Growth**

This project promotes sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all by our project. It reduces the use of petroleum vehicles and energy from fossil fuels which causes pollution. It is beneficial for economic growth as discussed in article 2.2.

### A4 Sustainable Cities and Communities

After application of this project, it makes cities and human settlements inclusive, resilient, and sustainable. It provides healthy transportation and reduces traffic congestion to make the cities sustainable. Prove to be helpful for the people of different communities in different ways like for fast charging of electrical equipment.

### A5 Climate Action

We ensure that our project does not take part to combat climate change and its impacts. It helps in reducing pollution with usage of solar panel we reduce our dependency on conventional energy resources. Today world is moving towards green energy resources.

# Appendix B Complex Engineering Problem Attributes

The Maximum Power Point Tracking (MPPT) algorithm is commonly used in photovoltaic (PV) systems to optimize the power output from solar panels. By continuously adjusting the operating point of the PV system to the maximum power point (MPP), MPPT ensures efficient power conversion and improved energy harvesting.

To implement an MPPT algorithm using the PIC16F887 microcontroller and a boost converter, you will need to consider several aspects and tackle various engineering challenges. Here's an overview of the complex engineering problem involved:

**B1 Range of Conflicting Requirements**

During Selection process of algorithm multiple issues arises like choosing an appropriate MPPT algorithm for your application. Commonly used algorithms include Perturb and Observe (P&O), Incremental Conductance (IncCond), and Fractional Open-Circuit Voltage (FOCV).

Understand the algorithm's requirements, limitations, and stability characteristics to implement it effectively.

**B2 Depth of Analysis Required**

Design the PCB layout carefully, paying attention to trace routing, grounding, and EMI considerations.

Minimize noise coupling between different components and reduce electromagnetic emissions to comply with regulatory standards.

**B3 Depth of Knowledge Required**

Development of the MPPT algorithm in firmware using the PIC16F887 microcontroller and performing calculations, control logic, and decision-making based on the measured panel voltage, current, and environmental sensor data. During development of algorithm, we have to consider the limited processing power and memory resources of the PIC16F887.

During design of transformer for AC to DC charging we read articles and research paper for understanding all the parameters of transformer to meet our required values.

**B4 Familiarities of Issues**

Most of the time after programming in microcontroller PIC16F887, the program did not work accurately or some time it seems like program holds different type of errors.

**B5 Extent of Applicable Code**

Sometimes due to mechanical issues of solar panel and loosing of connection from solar panel MPPT disconnect from solar panel. It also seems that it is due to loosing of some wire connectors while electric wheel chair is in running condition.

**B6 Consequences**

By the development of charging system for electric chair many benefits arises for the disable person like charging through renewable energy. Major thing is that it reduce liability of patient on conventional energy sources.

**B7 Interdependence**

During testing process due to movement of electric chair and mechanical instability of solar panel mostly connection loses and disconnect MPPT or sometimes it disconnects the battery

# Development of Smart Control of Electric Chair

A thesis submitted in partial fulfilment of the requirement for degree of

**BS Electrical Engineering**


**By**

Kashif Anwar ELEN19111099

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Session: 2019-2023


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June 2023

# Development of Smart Control of Electric Chair

By

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Bachelors of Science in Electrical Engineering

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Rahim Yar Khan

June, 2023

## Declaration

We hereby state that my BS thesis titled" Development of Smart Control of Electric Chair" is our own work and has not been submitted previously by us for taking any degree from Khwaja Fareed University of Engineering and Information Technology, Rahim Yar Khan or anywhere else in the country/world.

At any time if our statement is found to be incorrect even after my graduation the university has the right to withdraw my BS degree.

Rahim Yar Khan, on June, 2023

Kashif Anwar (ELEN19111099): Signature: ____________

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I solemnly declare that research work presented in the thesis titled *" Development of Smart Control of Electric Chair"* is solely my research work with no significant contribution from any other person. Small contribution/help wherever taken has been duly acknowledged and that complete thesis has been written by me.

I understand the zero tolerance policy of the HEC and Khwaja Fareed University of Engineering and Information Technology, Rahim Yar Khan towards plagiarism. Therefore, I as an Author of the above titled thesis declare that no portion of my thesis has been plagiarized and any material used as reference is properly referred/cited. I undertake that if I am found guilty of any formal plagiarism in the above titled thesis even after award of BS degree, the University reserves the rights to withdraw/revoke my BS degree and that HEC and the University has the right topublish my name on the HEC/University Website on which names of students areplaced who submitted plagiarized thesis.

Rahim Yar Khan, on june 2023

Kashif Anwar (ELEN19111099): Signature: ____________________

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# Certificate of Approval

This is to certify that the research work presented in this thesis, entitled *" Development of Smart Control of Electric Chair"* was conducted by **Abdul Wasay Kashif Anwar and Rubait Sani** under the supervision of **Engr. Arslan Hassan**.

Any part of this thesis has not been submitted anywhere else for any other degree.

HOD: Engr. Dr. Shahid Atiq External Examiner: Supervisor: Engr. Arslan Hassan Signature

This thesis is submitted to Department of Electrical Engineering, Khwaja Fareed University of Engineering and Information Technology, Rahim Yar Khan in partial fulfilment of the requirements for the degree of BS Electrical Engineering.

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Supervisor: Engr. Arslan Hassan Signature Signature: ________________

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## Abstract

With the advancement of technology assisted robots for disable humans have been designed in the world to enhance their confidence for spending life like nor-mal humans. The project is developed to help those who are facing difficulties in movement such as people who met with accidents and end up with paralyzed legs, physically disabled or injured people, Project is designed to develop a smart wheelchair to facilitate the people with disabilities. Micro-controller is the main controlling component that controls the whole wheelchair. The designed project is multi-mode offering control interfaces of app control, voice control, gesture control and joystick control to control the wheelchair movement. A patient health care system is also designed in this wheelchair which allows the patient to measure hisheart rate and also contain a system that helps the caretakers to understand the needs of the person. Another feature of the designed system is the live streaming and location tracing. Using live streaming feature, a real time activity/video of a wheelchair can be monitored by the caretaker and its location can also be traced. This product not only allows the handicapped people to control the wheelchair by themselves without help from others but also allows other people to use the android phone (remote control) to control the wheelchair. Obstacle detection system is incorporated in the smart wheelchair which works if an emergency condition occurs. Qibla direction finder is also available in the smart wheelchair. The designedwheelchair system will pay more attention to the health safety of the disabled person.

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# 1 Introduction

A smart electric wheelchair is a type of mobility device that offers increased independence and convenience to individuals who have difficulty walking or standing. These wheelchairs are powered by electricity and can be controlled by either a joystick or a touchpad, depending on the model. Unlike traditional manual wheelchairs, smart electric wheelchairs do not require the user to exert physical effort to move themselves around. The modern technology integrated into smart electric wheelchairs has transformed the traditional mobility device into a high-tech, advanced device that can perform multiple functions. For example, some models are equipped with obstacle detection sensors, which help to avoid obstacles in the user's path making it easier for users to access different environments. One of the key benefits of smart electric wheelchairs is the level of customization that they offer. For example, users can adjust the speed. Additionally, many smart electric wheelchairs come with adjustable seating, allowing users to find the most comfortable position for their needs. Another advantage of smart electric wheelchairs is their safety features. Many models come equipped with anti-tip wheels, seatbelts, and other safety features that help to prevent accidents. In addition, smart electric wheelchairs are often designed with ergonomic features, such as armrests, footrests, and headrests, which can help to prevent pain and discomfort for the user. Smart electric wheelchairs also have several advantages over traditional manual wheelchairs. For example, they are much easier to operate, making them a good option for individuals who have limited mobility. Additionally, they are generally faster and more efficient than manual wheelchairs, allowing users to get to their destination more quickly and with less effort. Smart electric wheelchairs are also a good option for those who want to remain as independent as possible. Users are able to access more areas on their own, without the need for assistance from a caregiver or family member.

In conclusion, smart electric wheelchairs are a valuable tool for individuals with mobility issues, offering increased independence, convenience, and safety. With a wide and advanced technology, these wheelchairs have transformed the traditional mobility device into a high-tech, user-friendly device that can help individuals to live their lives more fully and with greater ease. Whether you are looking for a wheelchair for personal use or for a loved one, a smart electric wheelchair is a great option that can provide the support and independence that you need

## 1.2 Project Background

The development of smart electric wheelchairs can be traced back to the increasing need for mobility devices that can provide greater independence and convenience for individuals with mobility issues. As technology advanced, the demand for wheelchairs that could be controlled using electronics and sensors grew. This led to the creation of the first smart electric wheelchair prototypes in the early 2000s.

Wheelchair demand has increased as a result of physical limitations, whether temporary or permanent. The smart wheelchair has seen significant technical advancements over the past few decades and has become extremely popular. The World Report on Disability estimates that there are roughly 1 Billion disabled people worldwide. These people require help in getting their everyday requirements. An intelligent wheelchair system that will be useful for individuals with any kind of impairment is required for this aim. A hand-driven wheelchair was invented in the past, but it took a lot of energy and physical effort to operate. Wheelchairs with motors or power assistance have been created recently to make mobility easier.

## 1.3 Project Objectives

Here are ten potential objectives for a smart electric wheelchair project:

- To design and develop a smart electric wheelchair that is safe and easy to use for individuals with mobility issues.

- To incorporate advanced technology, such as obstacle detection sensors and Patient care system to improve the user experience.
- To create a wheelchair that offers a high level of customization, allowing users to adjust the speed to their individual needs.
- To develop a wheelchair that is conveniently designed, with features such as armrests, footrests, and headrests, to help prevent pain and discomfort for the user.
- To design a wheelchair that is lightweight and compact, making it easy to transport and store.
- To create a wheelchair that is easy to maintain, with replaceable parts and a simple battery replacement system
- To develop a wheelchair that is accessible and affordable for a wide range of individuals with mobility issues.
- To develop a wheelchair that integrates with other technology, such as smartphones or wearable devices, to provide a seamless user experience.
- To create a wheelchair that is aesthetically pleasing and has a modern design, making it appealing for users of all ages.

## 1.4 Applications

- **Indoor spaces:** Smart electric chairs can be used in indoor spaces like shopping malls, airports, and office buildings to provide mobility assistance to individuals who need it. The chairs can be used to navigate through crowded areas or to move from one location to another.

- **Outdoor spaces:** Smart electric chairs can also be used in outdoor spaces like parks. They can help individuals explore the outdoors without having to worry about mobility limitations

- **Hospitals:** Smart electric chairs can be used in hospitals to transport patients who are unable to walk or who have limited mobility. The chairs can also be equipped with sensors and other IoT devices to monitor patients' vital signs and other health-related information.

- **During transportation:** Smart electric chairs can be used during transportation, such as on buses or trains, to provide mobility assistance to individuals who need it. This can help make public transportation more accessible and inclusive

- **Sports and recreational activities:** Smart electric chairs can be used in sports and recreational activities to provide mobility assistance to individuals who have difficulty walking or standing. For example, they could be used in golf or tennis tournaments to help individuals move around the course or court.

- **Workplaces:** Smart electric chairs can be used in workplaces, such as factories or warehouses, to help workers move heavy loads with ease. This can improve productivity and reduce the risk of workplace injuries.

## 1.5 Limitations

- **Cost:** The cost of developing and producing smart electric wheelchairs can be high, making it difficult for some individuals to afford them.

- **Battery Life:** The battery life of smart electric wheelchairs is a limiting factor, as users may need to recharge their chairs frequently or replace the batteries over time.

- **Durability:** The mechanical and electrical components of smart electric wheelchairs are subject to wear and tear over time, which can reduce their durability and lifespan.

# 2 Literature Review

This chapter presents literature review on the development of smart wheelchair. The advancement of the multi-mode smart wheelchair that aim to help disable people to move freely is discussed.

## 2.1 Wheelchair History

The history of the wheelchair dates back thousands of years, with evidence of early versions of the device found in ancient Greece and China. However, it wasn't until the 19th century that the modern wheelchair as we know it today began to emerge.

One of the first recorded wheelchair designs was created by John Dawson of Bath, England in 1783. Dawson's wheelchair featured large rear wheels and a small front wheel, making it easier to maneuver over rough terrain. However, the design was not widely adopted, and it would be several decades before significant improvements were made. In the mid-19th century, the first wheelchair with a collapsible frame was invented by James Heath of London, England. This design was much more portable than previous versions and made it possible for wheelchair users to travel more easily. In the early 20th century, the first motorized wheelchairs were invented, making it possible for people with limited upper body strength to travel greater distances. These early electric wheelchairs were heavy and cumbersome, but they paved the way for the development of more advanced designs in the decades that followed [1].

During World War II, the need for lightweight, portable wheelchairs for injured soldiers led to the development of the folding wheelchair. This design, which allowed the wheelchair to be easily stored and transported, quickly became the most popular type of wheelchair in use. In the latter half of the 20th century, significant improvements were made to wheelchair design, including the development of power-assisted and fully electric wheelchairs. These designs offered even greater independence and mobility for people with disabilities, allowing them to navigate challenging environments and travel longer distances than ever before. Today, the wheelchair continues to evolve, with new materials, technologies, and designs constantly being developed. From lightweight carbon fiber frames to sophisticated control systems, modern wheelchairs offer users unprecedented freedom and mobility, improving their quality of life and enabling them to participate fully in society. Despite its long and complex history, the wheelchair remains an essential tool for people with disabilities, providing them with the means to move, explore, and achieve their goals [2].

## 2.2 Wheelchair Technology Previous Development

The modern wheelchair as we know it today began to emerge in the 19th century, with early versions featuring large rear wheels and small front wheels to make them easier to maneuver over rough terrain. The first collapsible wheelchair was invented in the mid-19th century, making it easier for users to travel more easily. Motorized wheelchairs were invented in the early 20th century, followed by the development of the folding wheelchair during World War II. In the latter half of the 20th century, power-assisted and fully electric wheelchairs were developed, providing users with even greater mobility and independence.

### 2.2.1 Voice Activated Wheelchair Controller

The history of voice-activated wheelchair controllers can be traced back to the early 2000s, when the first experimental systems were developed. These early systems were often clunky and unreliable, but they demonstrated the potential of the technology and paved the way for more sophisticated designs. In 2007, researchers at Georgia Tech developed a system that used voice recognition software to allow users to control their wheelchair through spoken commands. The system, known as the "Brain-Computer Interface Wheelchair," was the first to demonstrate reliable voice control of a motorized wheelchair.

Since then, a number of companies and researchers have continued to develop voice-activated wheelchair controllers, with the goal of improving the accuracy, reliability, and ease of use of the technology. Today, voice-activated wheelchair controllers are becoming more sophisticated, incorporating machine learning algorithms and other advanced technologies to improve their performance. As the technology continues to advance, it has the potential to become an important tool for improving the mobility and independence of wheelchair users, enabling them to navigate their environment with greater ease [3].

### 2.2.2 Smart Wheel-Chair with Touch Control

Smart wheelchairs with touch control have a relatively short history compared to other types of wheelchair controls. The technology behind touch control was first developed in the early 2000s, with the first touch-sensitive wheelchair control systems appearing on the market in the mid-2000s. These early systems used sensors embedded in the armrests of the wheelchair to detect the user's touch and translate it into movement commands. Since then, touch control technology has continued to evolve, with newer systems incorporating more sophisticated sensors and algorithms to improve accuracy and responsiveness [4].

### 2.2.3 Smart wheelchair with joystick controller

The smart wheelchair with joystick control has been in development since the mid-20th century. Early designs were often large and cumbersome, with limited maneuverability and control. However, advances in technology and materials led to the development of more sophisticated designs, incorporating features such as lightweight materials, power-assisted steering, and advanced control systems. In the 1990s, the first smart wheelchairs with joystick control were introduced, using sensors and computer algorithms to improve maneuverability and safety. Today, smart wheelchairs with joystick control continue to evolve, incorporating advanced features such as obstacle detection, automated braking, and integrated communication systems.

These innovations have made it possible for wheelchair users to navigate their environment with greater ease and autonomy, improving their quality of life and enabling them to participate fully in society [5].

### 2.2.4 Smart wheelchair with head motion controller

Smart wheelchairs with head motion controllers have been in development since the early 2000s. The first systems used sensors mounted on the user's headrest to detect movements of the head and translate them into movement commands for the wheelchair. These early systems were often clunky and unreliable, but they demonstrated the potential of the technology and paved the way for more sophisticated designs. Since then, head motion controllers have become more accurate and responsive, incorporating advanced sensors and algorithms to improve performance. Today, head motion control is a popular option for wheelchair users with limited upper body mobility or who may prefer a control system that is hands-free and easy to use [6].

### 2.2.5 Smart wheelchair with Bluetooth controller

The use of Bluetooth technology in smart wheelchairs is a relatively recent development, with the first Bluetooth-enabled wheelchair controllers appearing on the market in the late 2000s. These systems use Bluetooth wireless technology to connect the user's smartphone or other mobile device to the wheelchair, allowing them to control the movement of the chair using a custom app or software program [7]. Bluetooth-enabled smart wheelchairs offer several advantages over traditional control systems, including the ability to customize control settings, access to real-time diagnostic information, and the ability to remotely adjust the chair's settings. As Bluetooth technology continues to evolve, it is likely that we will see even more advanced and sophisticated smart wheelchair control systems in the future [8].

### 2.2.6 Mind Controlled Wheelchair

The history of mind-controlled wheelchairs dates back to the early 1970s when the first experiments were conducted using EEG signals to control simple devices. In the 1980s, the development of more sophisticated brain-computer interfaces (BCIs) led to the creation of the first mind-controlled wheelchairs. In 2005, the first commercially available mind-controlled wheelchair was introduced, using electroencephalography (EEG) to detect brain signals and a computer to translate them into commands for the wheelchair [9]. In recent years, advances in machine learning and neural decoding algorithms have improved the accuracy and speed of mind-controlled wheelchairs, making them more practical and accessible for individuals with disabilities [10].

# 3 Project Design

## 3.1 Project Description

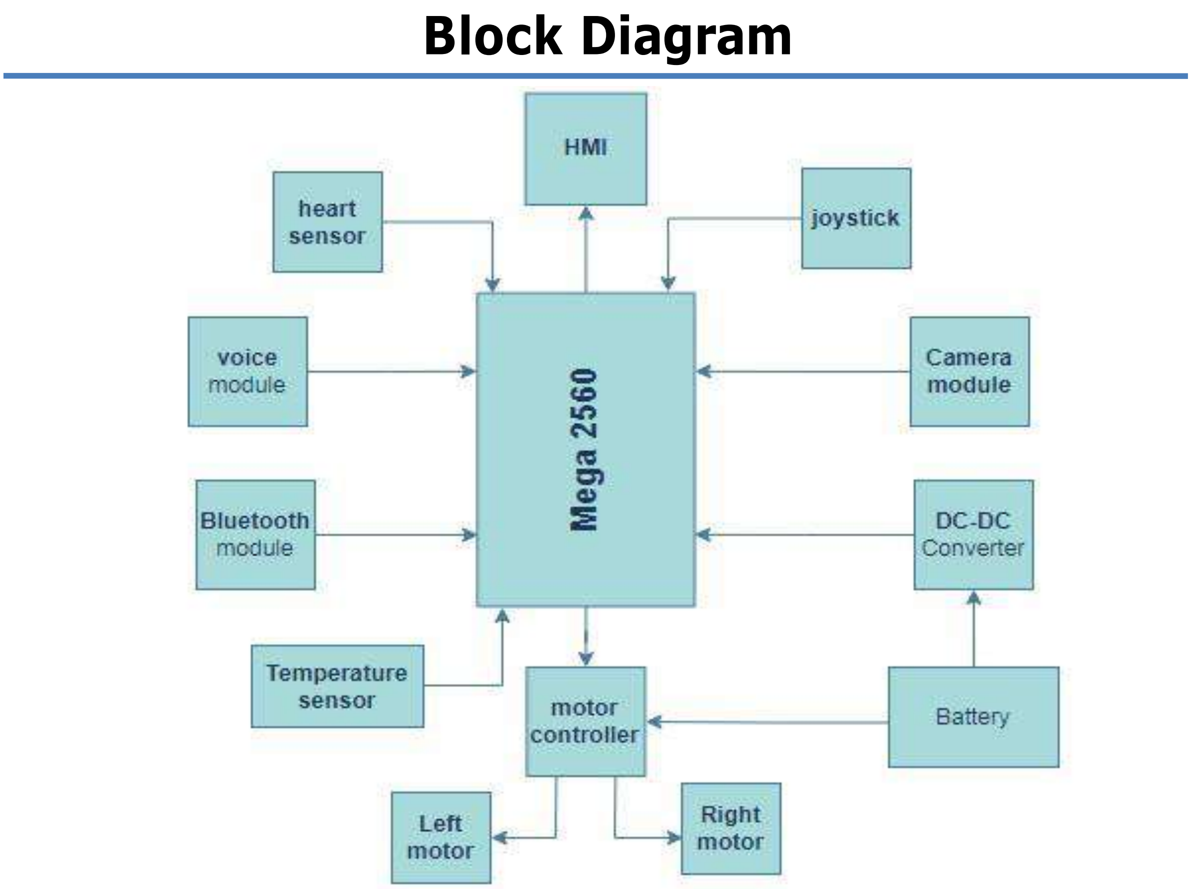
A smart electric wheelchair is a technological advancement in the field of mobility and assistive devices. It is a motorized wheelchair equipped with sensors, processors, and connectivity features that allow the user to operate it more efficiently and safely. The smart electric wheelchair project aims to design and develop a wheelchair that is intuitive, user-friendly, and intelligent enough to assist the user in navigating through different environments. The smart electric wheelchair will be equipped with various sensors such as ultrasonic sensors. These sensors will detect obstacles. which will help in providing an optimal driving experience. The ultrasonic sensors will detect obstacles in the path of the wheelchair and send signals to the motor control system to slow down or stop the wheelchair to avoid collisions. The wheelchair will also be equipped with a Wi-Fi module, which will enable it to connect to the internet and communicate with other smart devices.

The smart electric wheelchair will be operated using a joystick or a touchpad. The joystick will be designed to be more ergonomic and user-friendly, while the touchpad will be more intuitive and responsive. The user will be able to customize the wheelchair's settings and preferences using a mobile application that will be available for both iOS and Android platforms. The smart electric wheelchair will be powered by lithium-ion batteries, which will provide longer battery life and faster charging times. The batteries will be easily removable, allowing the user to replace them without the need for any technical assistance.

Overall, the smart electric wheelchair project aims to provide a revolutionary solution for people with mobility impairments, providing them with more autonomy, safety and comfort.

### 3.2 Block Diagram

Figure 3.1 shows the block diagram of the smart wheelchair system.




3.1: Block Diagram of Smart Wheelchair

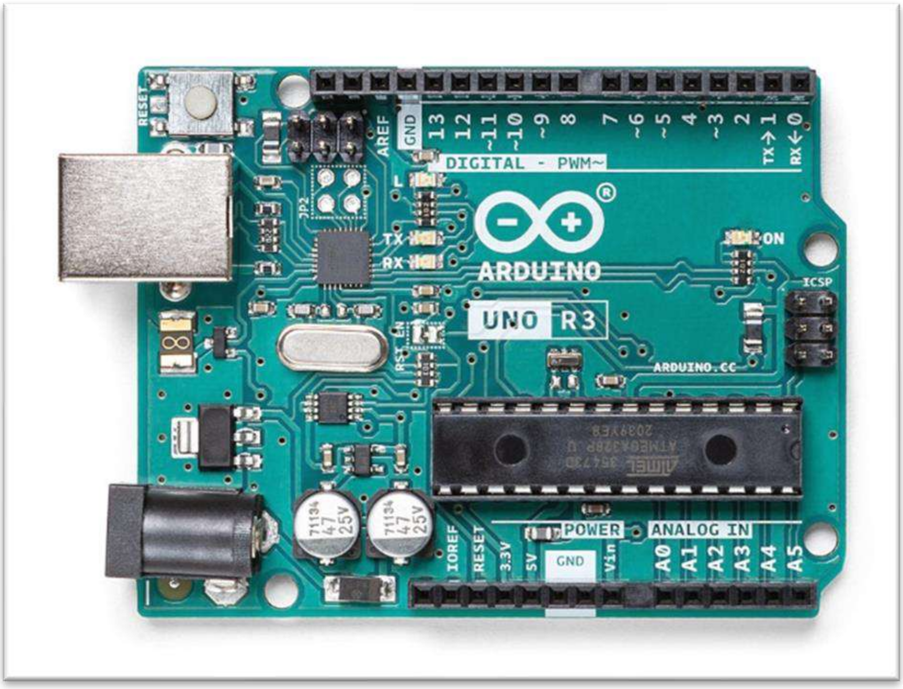
## 3.3 Hardware Description

The primary component of the project's implementation is hardware. The following provides a detailed list of the project's components:

- Arduino Uno
- ESP 32 cam module
- Bluetooth module
- Heart beat sensor
- HMI
- Motor driver Shield
- Brushed Dc motors
- Ultrasonic sensor
- Joystick
- Battery
- DC-DC convertor
- Temperature sensor
- Horn
- Push Buttons
- DC Relay

### 3.3.1 Arduino Uno

The ATmega328P-based Arduino Uno is a microcontroller board with 14 digital input/output pins, 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It has everything the microcontroller needs to be supported; To get started, simply connect it to a computer using a USB cable, power it with an AC-to-DC adapter, or use a battery.




3.2 Arduino Uno

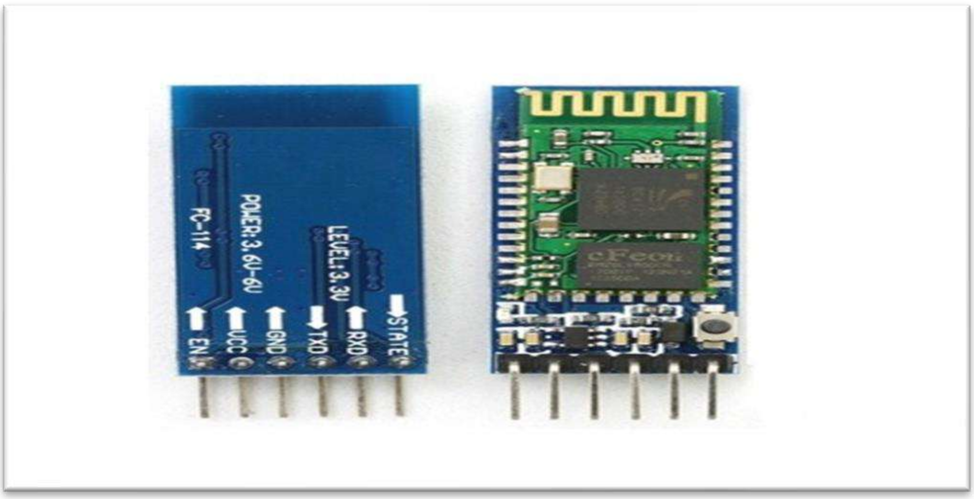
### 3.3.2 ESP32 CAM Module

The ESP32-CAM module is a small size, low power consumption camera module based on ESP32 that comes with an OV2640 camera and provides onboard TF card slot. It can work independently as a minimum system with a footprint of only 2740.54.5mm and can be widely used in intelligent IoT applications such as wireless video monitoring, WiFi image upload, QR identification, and so on. The module also features onboard ESP32-S module that supports WiFi + Bluetooth, and its control interface is accessible via pinheader, making it easy to be integrated and embedded into user products.

3.3. ESP32 CAM Module

### 3.3.3 Bluetooth Module

The Bluetooth wireless technology is one of the wireless technology fields that is expanding at the fastest rate and has gained a lot of popularity in communication.The wireless component's communication channel is managed by Bluetooth technology.Two devices can be used to wirelessly send and receive data from the Bluetooth modules.With the help of the host controller interface (HCI), the Bluetooth module can receive and transmit data from a host system. HC 05 Bluetooth is a wireless communication protocol;It is used to send and receive information in two devices.Because it has a shorter range than other wireless communication protocols like WiFi, Bluetooth can be used in the wireless communication protocol for free.Bluetooth operates at a frequency of 2.41 GHz and is utilized in numerous applications with small ranges.




3.4: Bluetooth module

### 3.3.4 Heart Rate Sensor

Heart rate sensor is such type of sensor which is used to measures heart rate per minute by using the LED light sensor and optical LED. When user hold the sensor the light of sensor shines through skin, and the reflected back light is being measured by sensor in the form of Beats. As light passed by blood pulses under the skin the reflected light changes. These variations of the reflected light are considered as heartbeats. Change of the intensity of light is based on the change of volume of blood in an organ so changed the heartbeats which is monitored by heart rate sensor.

### 3.3.5 Human Machine Interface ( HMI )

A dashboard or user interface that links a person to a machine, system, or device is called a Human-Machine Interface (HMI). Technically, the term can be used to describe any screen that lets a user interact with a device. In order to obtain and display information for users to view, HMIs communicate with input/output sensors and Programmable Logic Controllers (PLCs). Depending upon how they are implemented, HMI screens can be used for a single function, like monitoring and tracking, or for more complex operations, like turning off machines or increasing production speed. The most common application of HMI is in an industrial process. Fundamental HMI models incorporate inherent screens on machines, PC screens, and tablets, yet no matter what their arrangement or which term you use to allude to them, their motivation is to give knowledge into mechanical execution and progress. Most industrial organizations use HMI technology, as do many other businesses like oil and gas, food and beverage, and others.


3.5: Human Machine Interface

### 3.3.6 Motor Drive Shield

The Motor Shield is a driver module for motors that allows you to use Arduino to control the working speed and direction of the motor. We use the BTS7960B for motor control. It is a full-bridge motor drive module with high current. It contains high- and low-side MOSFET having p and n networks, etc. It is a part of a Novalith ICTM family and contains a driver IC as well. Operating at 24v and a maximum continuous current of 43A, with a maximum PWM frequency of 25 kHz, and with active freewheeling. The BTS7960B can be used for a variety of things, including sun roofs, seat positioning, power windows, and door lock etc.

3.6. Motor Drive Shield

### 3.3.7 Brushed DC Motor

It is an electric motor that is made and designed with precision speed output and high torque in mind. This motor has the ability to deliver from three to four times the amount of torque that it is rated for. According the consumer demand, it can also supply up to five times as much as its rated value without pausing. It is made up of a variety of parts, including an axle, rotor, commutator, magnet, stator, and brushes. This motor uses rings to deliver continuous current so that a magnetic drive may work the armature. Probably because it can adjust the speed-to-torque ratio, brushed DC motors are frequently employed

*3.7. Brushed Dc motor*

### 3.3.8 Ultrasonic  Sensor

It is a sensor that is mostly used to find obstacles. It measures the distance between the closest object and the sensor, which can be anywhere from 3 cm to 400 cm. It works by conveying an eruption of ultrasound and tuning in for the reverberation when it skips off of an item. It uses ultrasound to ping the obstructions. The Arduino board sends a brief pulse to start the detection, and then it uses the pulseln()  function to listen for a pulse on the same pin. This second pulse lasts for the same amount of time that the ultrasound takes to travel to the object and back to the sensor. This time can be converted to distance by using sound speed.


*3.8. Ultrasonic sensor*

### 3.3.9 Joystick

The wheelchair's direction of travel is controlled with a joystick. The joystick is known as corresponding control. The most widely used kind of control is this one. The wheelchair moves in the direction that the user points it with the joystick. The wheel-chair typically moves at a faster rate the further the joystick is pushed. The brakes are applied automatically when you release the joystick. The wheelchair will then stop.

Using the joystick instead of the keys on the keypad is much more effective.

3.9. joystick

To control the direction of wheelchair a joystick is used. Joysticks consist of two parts which are a base and a stick which help to move the wheelchair in any di- rection. User can move stick slowly and speedily and in different amount.

### 3.3.10 Battery

A lead-acid battery is a rechargeable battery that uses lead and sulfuric acid to function. The lead is submerged into the sulfuric acid to allow a controlled chemical reaction that produces electricity. When the battery is charged, sulfuric acid in the electrolyte keeps increasing, water gradually decreases, and the specific gravity of the electrolyte increases. The lead-acid battery was first invented in 1859 by French physicist Gaston Plante and is the first type of rechargeable battery ever created. Despite its relatively low energy density compared to modern rechargeable batteries, lead-acid batteries have a relatively large power-to-weight ratio, making them attractive for use in applications where surge current is important. Lead-acid batteries are the dominant market for lead, and the Advanced Lead-Acid Battery Consortium (ALABC) has been working on the development and promotion of lead-based batteries for sustainable markets such as hybrid electric vehicles(HEV), start-stop automotive systems, and grid-scale energy storage applications.


3.10. Battery

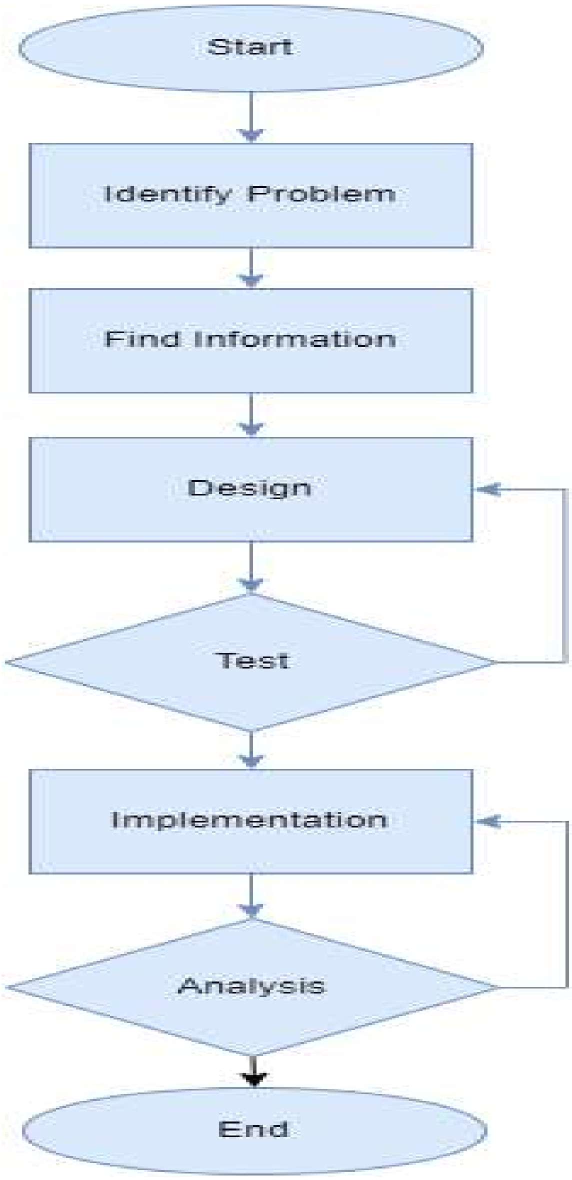
### 3.3.11 DC – DC Converter

A buck converter, also known as a step-down converter, is a type of DC-to-DC converter that steps down voltage (while stepping up current) from its input (supply) to its output (load). It is a class of switched-mode power supply that provides 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 basic operation of the buck converter has the current in an inductor controlled by two switches, which are realized by a transistor and a diode or two transistors. 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. The waveform of the buck converter is shown in the figure below. Buck converters are mostly used in applications where high DC voltage needs to be converted to low DC voltage, such as in battery charging, LED lighting, and power supplies for electronic devices.

*3.11. Buck Converter*

# 4 Methodology

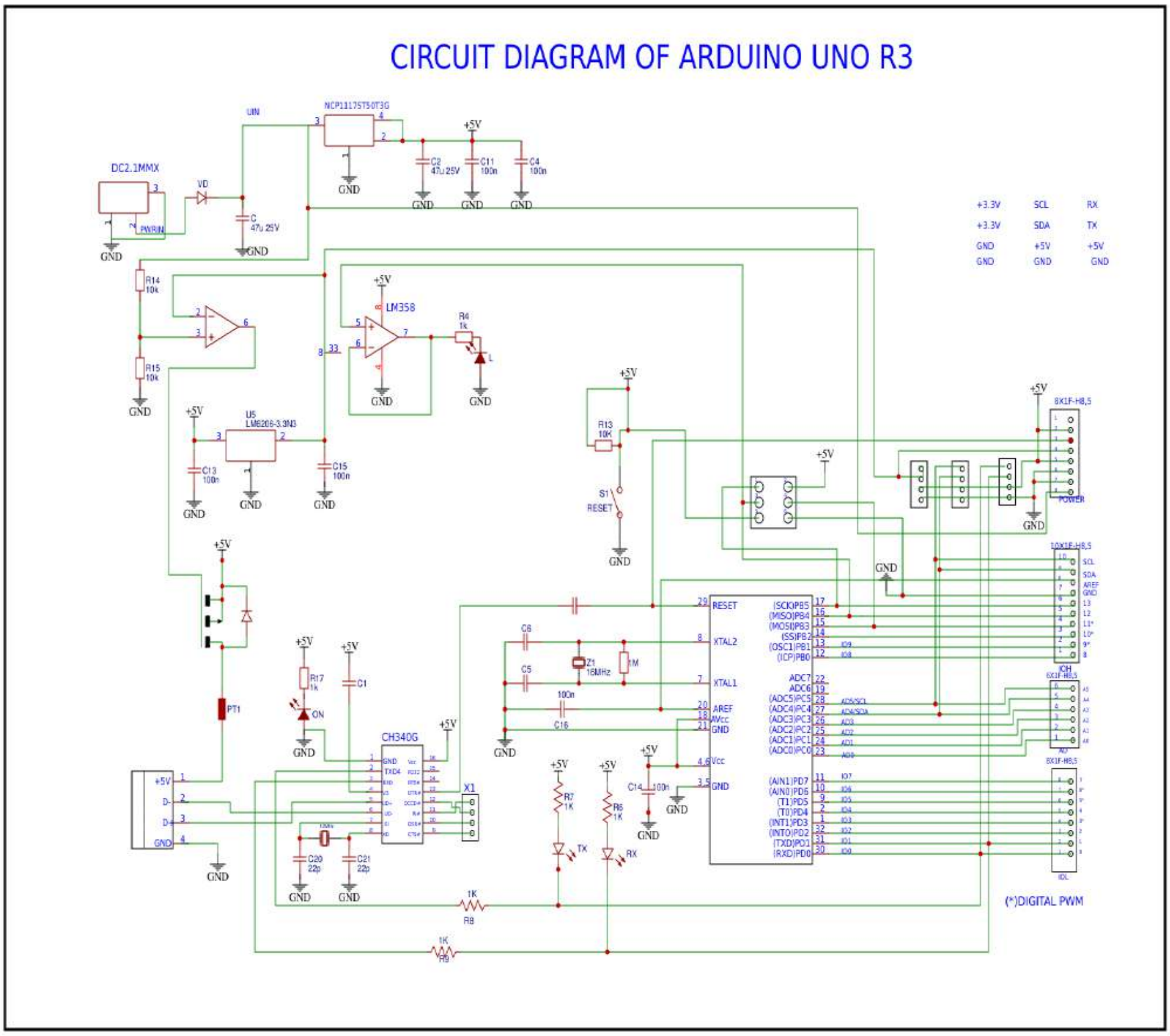
The flow of the designed project is shown in the flow chart in Figure 4.1 below.




*4.1. Flowchart of Overall Project*

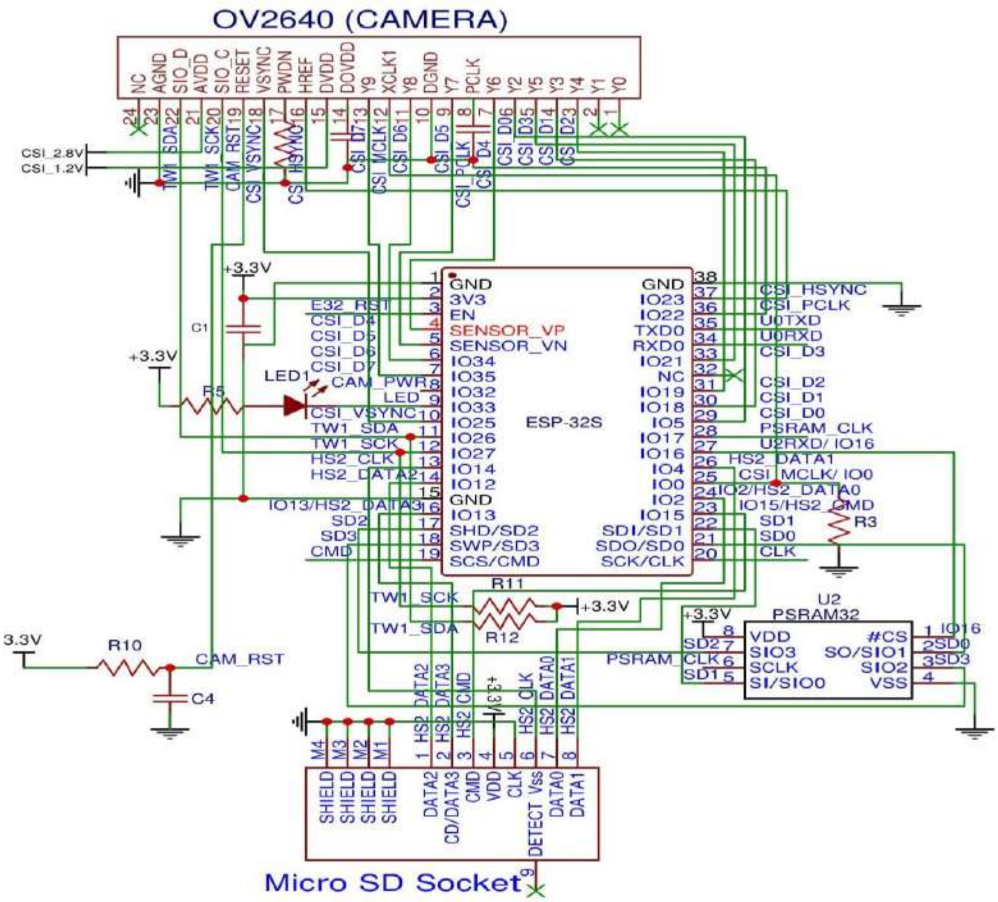
## 4.1 Circuit Design

The developed development board, which includes the I/O board, two motor driver modules (BTS 7960), Bluetooth module, joystick, ultrasonic sensor, heart rate sensor, HMI, camera module, and GPS module, is used to create the project circuit. Both motor drivers' PWM pins are linked to the microcontroller to configure the PWM output. In contrast to motor driver 2, which uses pins D10 and D13, motor driver 1's R-PWM and L-PWM are attached to D3 and D6, respectively.




4.2 Circuit diagram of arduino

With the use of R-EN and L-EN pins, the motors' direction can be changed. Motor driver 1's direction pins are connected to microcontroller pins D4 and D7, while motor driver 2 uses pins D11 and D14. Two dry batteries each of 12V are used for power supply for the DC motors. Pin D0 and D1 are used for Bluetooth module to transmit and receive data to and from micro-controller. Power supply for the Bluetooth module are from +5V and GND pins of the micro-controller. The X and Y coordinates of the joystick are connected to A4 and A5 of the I/O board respectively. The SDA and SCL pins of digital compass are attached to analog pins A6 and A7 of the microcontroller respectively. Ultrasonic sensors used for the obstacle detection are connected to D70 to D79 pins of the microcontroller. LCD display is connected to digital pins D26 to D31.



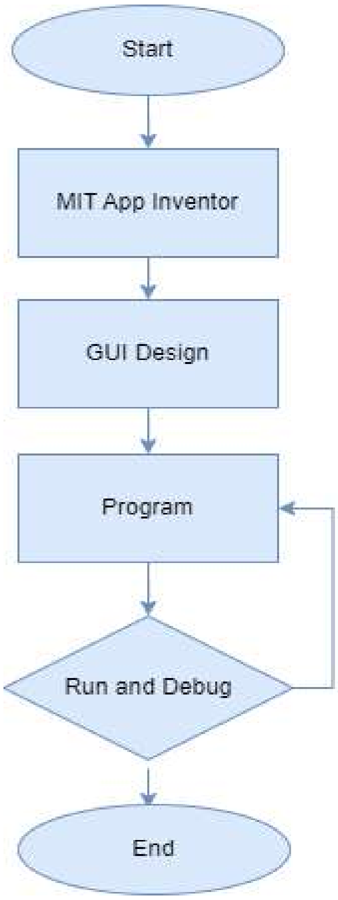

4.3. Circuit Diagram of the Live Stream

Figure 4.3 demonstrates the use of an ESP32 controller for a live streaming system. Pin CSI D0 a CSI D7 of the camera module is used to transmit live video.

Microcontroller Pins 8, 12, 16, 18, 19, 20, and 22 of the camera module are connected to the ESP32 microcontroller's PCLK, MCLK, HSYNC, VSYNC, RST, SCK, and SDA, respectively.

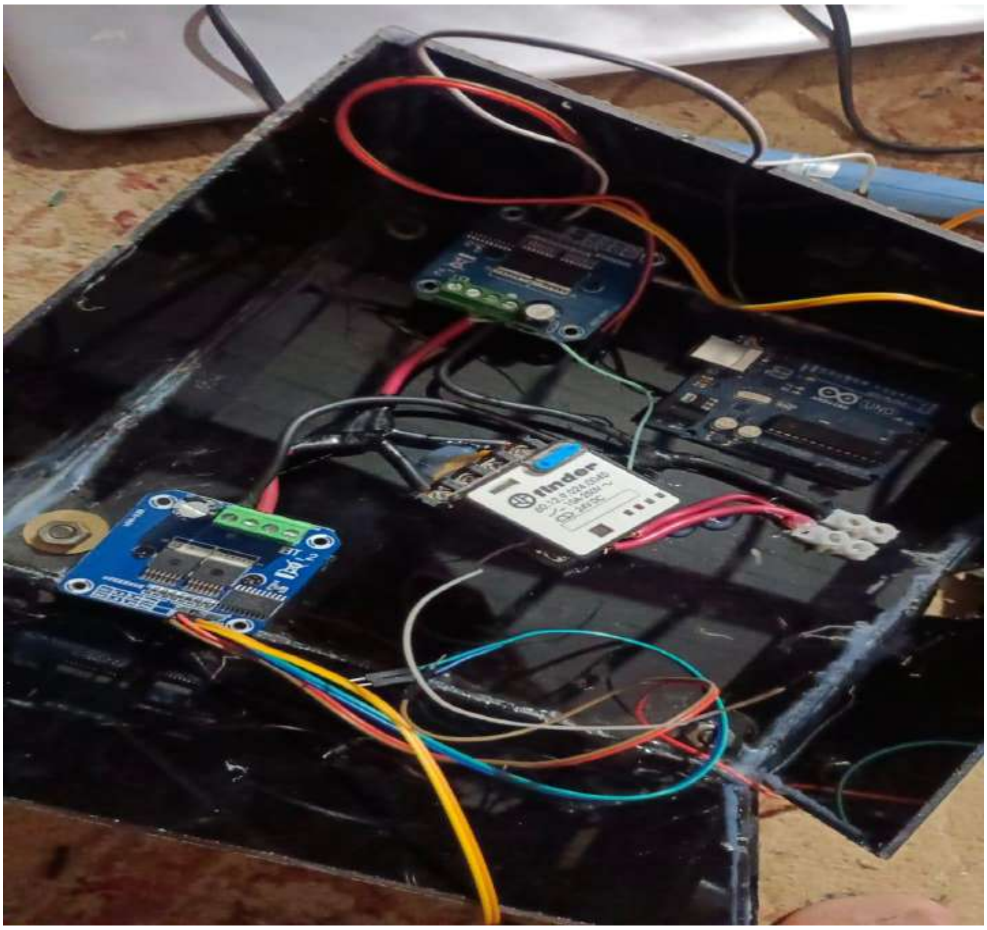
## 4.2 Software Implementation

Once the circuit design has been completed, the coding for the wheelchair is created using programming software such as MIT app inventor. MIT software that is utilized for software implementation and programming the wheelchair system design was installed. The following software implementation flowchart is shown below in Figure 4.4.




4.4. Software Implementation Flowchart

## 4.3 Hardware implementation



4.5. Control Box

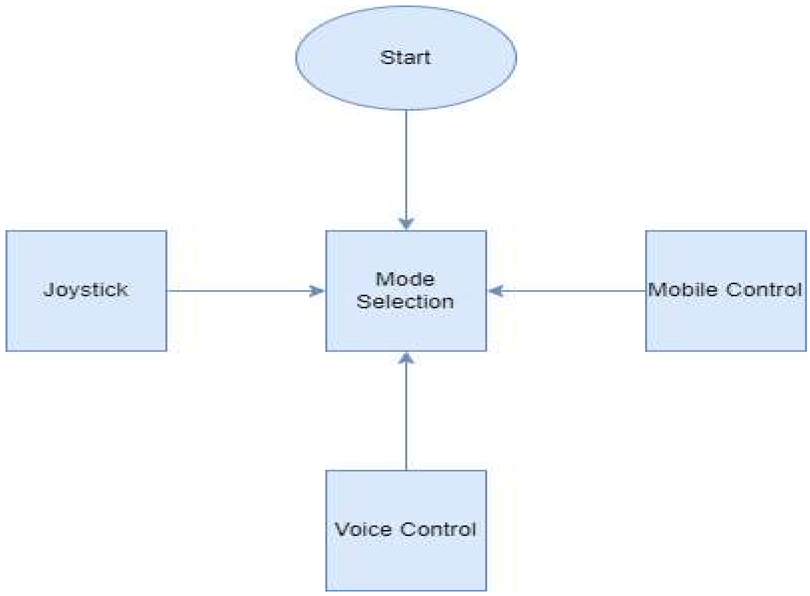
Electronics play a significant role in hardware implementation. In the electronic component, circuitry is created for the project's overall control box. The hardware circuitry, also known as the control box, contains all the parts required for the project, including the developer board and motor driver. A mode controller provides the user with the option to select the mode of operation for the wheelchair system. The user can choose the manner of operation that he prefers. To directly control the wheelchair from an Android phone, a Bluetooth module is used to interface with the wheelchair's primary microcontroller. The voice control function is operated through voice commands from the Android phone. Live streaming is done with camera.

# 5 Testing & Results

The designed wheelchair system is tested for all the implemented features. Wheelchairtesting steps are given below.

## 5.1 Testing of Wheelchair Movement

The developed wheelchair system includes several modes of operation, as shown in the block diagram in Figure 5.1. The wheelchair's movement is tested utilizing all of the designed modes of operation.



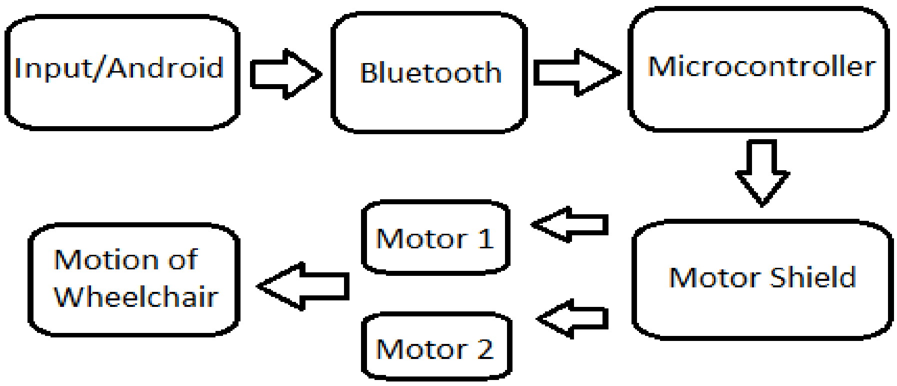

5.1. Block Diagram of Mode Selection

Movement of the wheelchair is according to the pin configuration at motor driver.There are four buttons in the android app. Which are used to control the direction of wheelchair in forward, reverse, left and right. The direction of motion is given below:

| Button Command | Left Wheel | Right Wheel | Condition of Wheelchair |
|---|---|---|---|
| ⇑ | Forward | Forward | Move Forward |
| ⇓ | Reverse | Reverse | Reverse |
| ⇒ | Forward | Reverse | Move Right |
| ⇐ | Reverse | Forward | Move Left |

Table for the Movement of Wheelchair

Controlling the wheelchair via a smartphone app is possible. The app is used to send Bluetooth commands to the Wheelchair. The code has predefined values for wheelchair motion. Bluetooth receives this signal and sends it to the microcontroller, which takes appropriate action. The flow diagram of the mobile app control is shown below.




5.2. Flow Diagram of App Control

## 5.2 Development Stages

### 5.2.1 Initial prototype Development

Our main goal for the initial effort was to test our components and get information on how to interface these pieces of equipment in our project. As a result, we created a project prototype. In this prototype, we controlled the direction and movement of the wheelchair using a microcontroller that communicates with the wheelchair. In this manner, the controller sends a signal to the system, which causes the system to follow the provided direction.

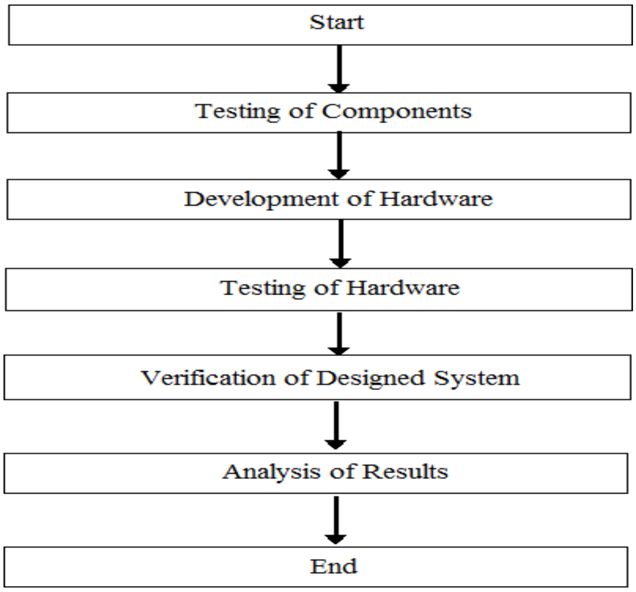
5.3: Initial Prototype

### 5.2.2 Hardware Development

The proposed feature is included in this phase of the project. The initial prototype is created to test the components; after testing all parameters, the components needs to be implemented. This stage contains features such as mobile app control, voice control, and joystick control. There is also a live streaming capability for monitoring the wheelchair's real-time action. Obstacle detection and patient health care system is included. This smart electric chair also has a front light and a study light.

### 5.2.2 Testing and Analysis of Hardware

Following the development of these features, the designed hardware must be tested. There is a time at which we can determine if we have met our proposed goal or not. As a result, verification is required before taking the analysis record. The diagram below illustrates the entire project development




5.4. Flow Diagram of Different Stages

.

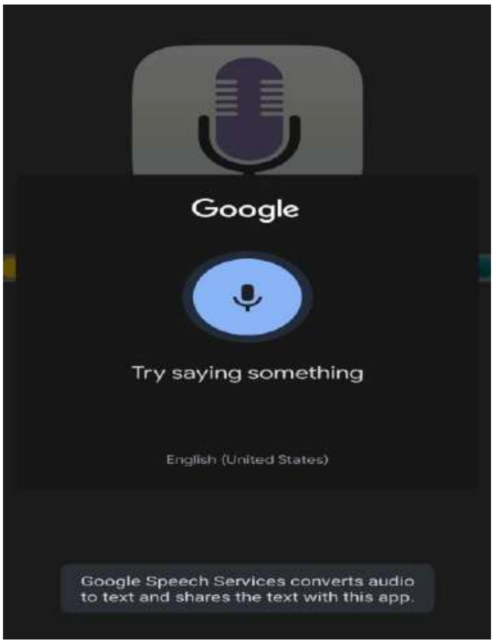
## 5.3 User Interface

As it is difficult for disabled persons to walk freely, there is a need for a gadget that assists them with daily workouts. To bring comfort to disabled persons, an app with an interface that provides access to all of the features required by the user to manage the wheelchair with the least amount of effort is chosen.

### 5.3.1 Mobile App Interface

The wheelchair is controlled using mobile application. Controlling the wheelchair via a smartphone app is possible. The project's electronic components and Android application must be properly communicated for the system to function properly. I put the chosen Android to test to control movements and


*5.5. Remote Control App Interface*




*5.6. Voice Control Interface*

direction of a wheelchair with this application. The app is used to control the wheelchair through Bluetooth. This method of interfacing is the finest because it is user pleasant and simple to use. The code has predefined values for wheelchair mobility. For example, the number 8 is utilized to advance. Bluetooth receives this signal and sends it to the microcontroller, which takes appropriate action. Speech recognition (voice control) is a major technology employed in the smart wheelchair system. The wheelchair is controlled by voice under voice control. When a user speaks specified commands, such as go, right, left, reverse, and stop, the micro-phone processes these commands and sends a signal to the micro-controller, which performs the appropriate functions. When a voice is received, the recognition process is initiated, and the recognition result is presented on the Android smartphone.

### 5.4 Results

The correct assembly of all the components utilized resulted in the hardware of the smart wheelchair.  The planned system is multi-mode, with app control, voice control, and joystick control as control capabilities. It also develops the hardware logic for live streaming, obstacle detection, and the patient health care system. The built wheelchair works correctly with voice commands and app commands. Hardware and software implementation were completed successfully. The designed programmed is uploaded to the microcontroller, and the wheelchair is tested with an app, voice, and joystick. The hardware works smoothly for live streaming and patient health care. The intended system worked properly in response to orders provided via mobile app; voice control was tested using Google Assistant, which is available on an Android phone. Rotating a joystick in each of the four directions also verifies the manual control. In short, the designated wheelchair operated correctly for all its required operations.

# 6 Conclusion & Future Extensions

## 6.1 Conclusion

We have implemented smart wheelchair system equipped with latest technology. This type of wheelchair system can be easily implemented on large scale. The designed wheelchair contributes to the self-dependency of handicapped people. It is operating in different modes i.e. mobile control mode, joystick mode and voice recognition mode. This Wheelchair is economical and affordable, that's why it is a bonus for common people. We have also add a new technology in this wheelchair. The system designed is highly effective for the disabled people. This type of multi-mode wheelchair can made person independent offering different modes of operation to the user. The running cost of this designed system is also lower making it efficient. It does not require any external help and is simple to operate. It is built to help the disabled become independent and is used for creating a connection between communication and hardware requiring less effort for controlling the wheelchair through specific mode, offering live streaming and location trace feature. An obstacle detection system is also designed in the wheelchair system which works if an emergency condition occurs. The designed wheelchair system is also equipped with patient health care system. This type of the wheelchair system will pay more attention to the health safety of the disabled people. The production of the designed wheelchair system will be beneficial for the hospitals to improve the comfort of the patient.

## 6.2 Future Extensions

Development possible for future improvements are mentioned below:

### 6.2.1 Artificial Intelligence and Machine Learning

Smart wheelchairs might leverage AI and machine learning algorithms to learn from user behavior and adapt to individual preferences. The wheelchair could optimize its performance based on the user's needs, anticipate movements, and adjust settings accordingly.

### 6.2.2 Environmental Adaption

Future wheelchairs might feature adaptive seating and suspension systems to provide a smoother ride over different terrains. They could also have the ability to adjust seat height, backrest angle, or footrest position to accommodate the user's comfort and posture needs.

### 6.2.3 Improved Battery Technology

Advancements in battery technology could lead to longer battery life and faster Charging for electric wheelchairs. This would provide user with increased independence and convenience

# Appendix A

## 1. 1 Pseudo code

```
#include <Motor Shield Library>

#include <Ultrasonic sensor Library>

#include <Motor Pins>


#define LeftMotor

#define Left-Motor-RPWM

#define Left-Motor-REN

#define Left-Motor-RIS

#define Left-Motor-LPWM

#define Left-Motor-LEN

#define Left-Motor-LIS


#define Right-Motor

#define Right-Motor-RPWM

#define Right-Motor-REN

#define Right-Motor-RIS

#define Right-Motor-LPWM

#define Right-Motor-LEN

#define Right-Motor-LIS

#define Motor-Rotation

#define Motor-Debug

Left-Motor (RPWM, REN, RIS, LPWM, LEN, LIS, Rotation, Debug)Right-Motor
```

(RPWM, REN, RIS, LPWM, LEN, LIS, Rotation, Debug)

#define Mode-selector

Store values from mode selector in integer

#define Bluetooth-Value

Store values from Bluetooth in integer

#define Speed-Controller

Store values from speed controller in integer

#define Joystick-pins

Store values from joystick in integer

#define Gesture-pins

Store values from gesture sensor in integer

#define Ultrasonic sensor-pins

#define Higher-pin

#define Lower-pin

#define Maximum-distance

Sensor (Higher-pin, Lower-pin, Maximum-distance)Store distance values in integer

Store duration values in integerStore

iteration values in integerSetup function ()

{

Set value of serial communication Set pins of mode selector as input Set pins of speed controller as inputSet pins of joystick as input

Set pins of ultrasonic sensor as input and outputSet motor pins

```
Activate motor pins

Main function ()
{
Read values from mode selector Read values from speed controllerRead values from Joystick
        Read values from Distance Sensor

        if (mode selector value is for manual mode)
        {
                Call Manual mode function
        }
          Else if (mode selector value is for Remote mode)
        {
               Call Remote control (Mobile control) function
        }
}
```

**Controlling Functions:**

```
Manual Mode function ()
{
        If (values for forward function)
          {
                Call forward function
```

```
        }
      Else If (values for left function)
        {
                Call left function
        }
      Else If (values for right function)
        {
                Call right function
        }
        Else If (values for stop function)
          {
                  Call stop function
          }
}

Remote Function ()
{
          If (values for forward function)
          {
                  Call forward function
          }
        Else If (values for left function)
```

```
            {
                    Call left function
            }
          Else If (values for right function)
            {
                    Call right function
            }
          Else If (values for stop function)
            {
                    Call stop function
            }
}
```

**Sub-controlling Functions**

```
 Forward ()
 {      Right motor (Value from speed controller, Rotation)

 Left motor (Value from speed controller, Rotation)
 }
 Left ()
```

```
{ Right motor (Value from speed controller, Rotation)
  Left motor (Value from speed controller, Rotation)

}
Right ()
{ Right motor (Value from speed controller, Rotation)
  Left motor (Value from speed controller, Rotation)

}
Stop ()
{
    Right motor ()
    Left motor ()

}
```

**Live Streaming**

```
#include ’camera module’
#include <camera module library>
#include <wifi library>
#include ’soc functions’
#include ’soc controlling function’
#include ’camera pins’
#define Camera AISet Wifi name Set wifi password
  Camera AI Server Function
```

#include ’esp server’

#include ’esp timer’

#include ’esp camera’ #include ’image converter’

#include ’camera index’

#define camera en-roller time

#define Face ID saver

#define Face-color- colors

#define camera index matrix []

Setup Function ()

{

Set serial communication valuesSet Serial debug output

Set serial print Configure camera functionConfigure channel Configure Timer Configure

GPIOs Configure Clock Configure synchronizationIf (found)

{

Configure frame size Configure image quality

}

Else

{

False

}

Wifi functions startIf (connected)

{

Pint wifi connected

```
call web server function ()
}
Else
{
Print wifi not connected
}
}
Main function ()
{
Delay of 10 seconds
  }
```

## 1.2 Schematics of developer board

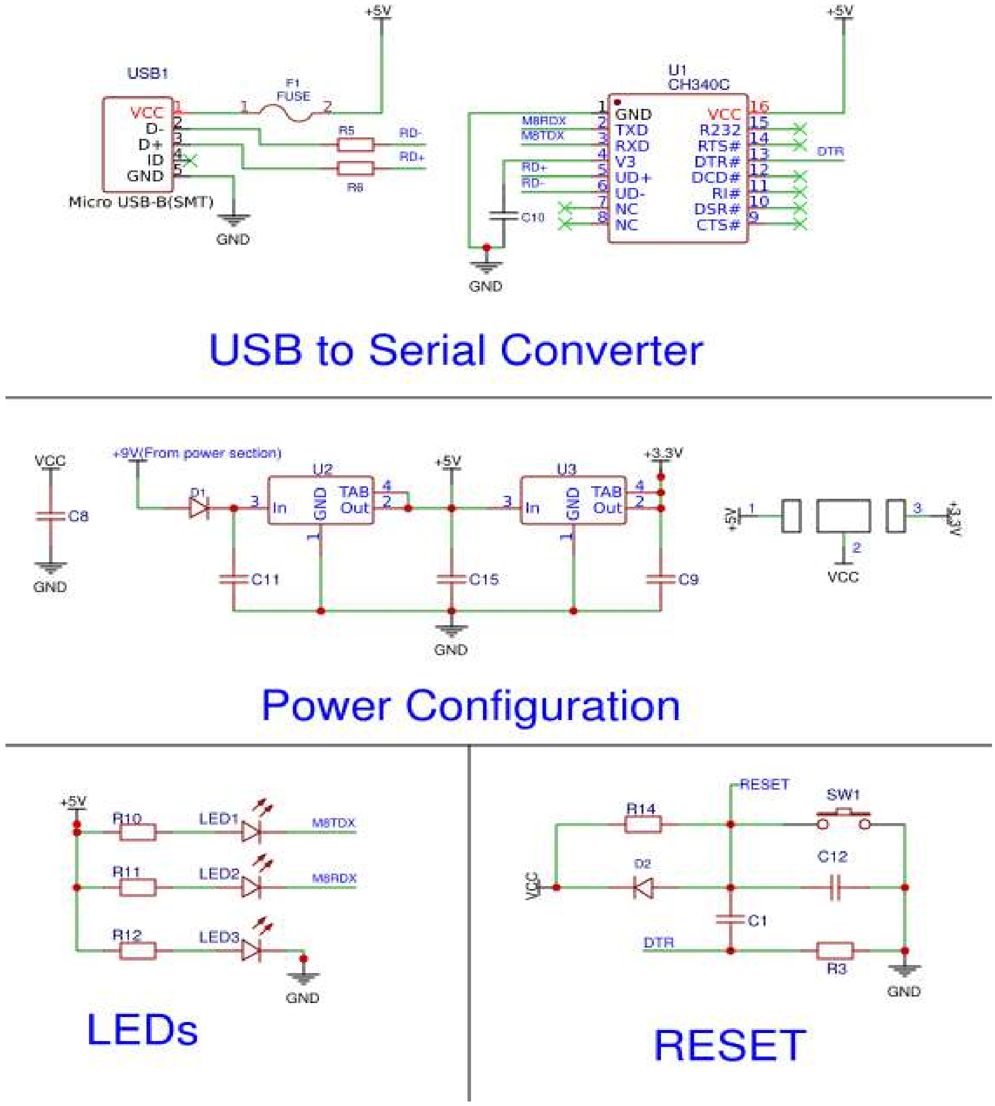



Figure 1. Schematics of Developer Board

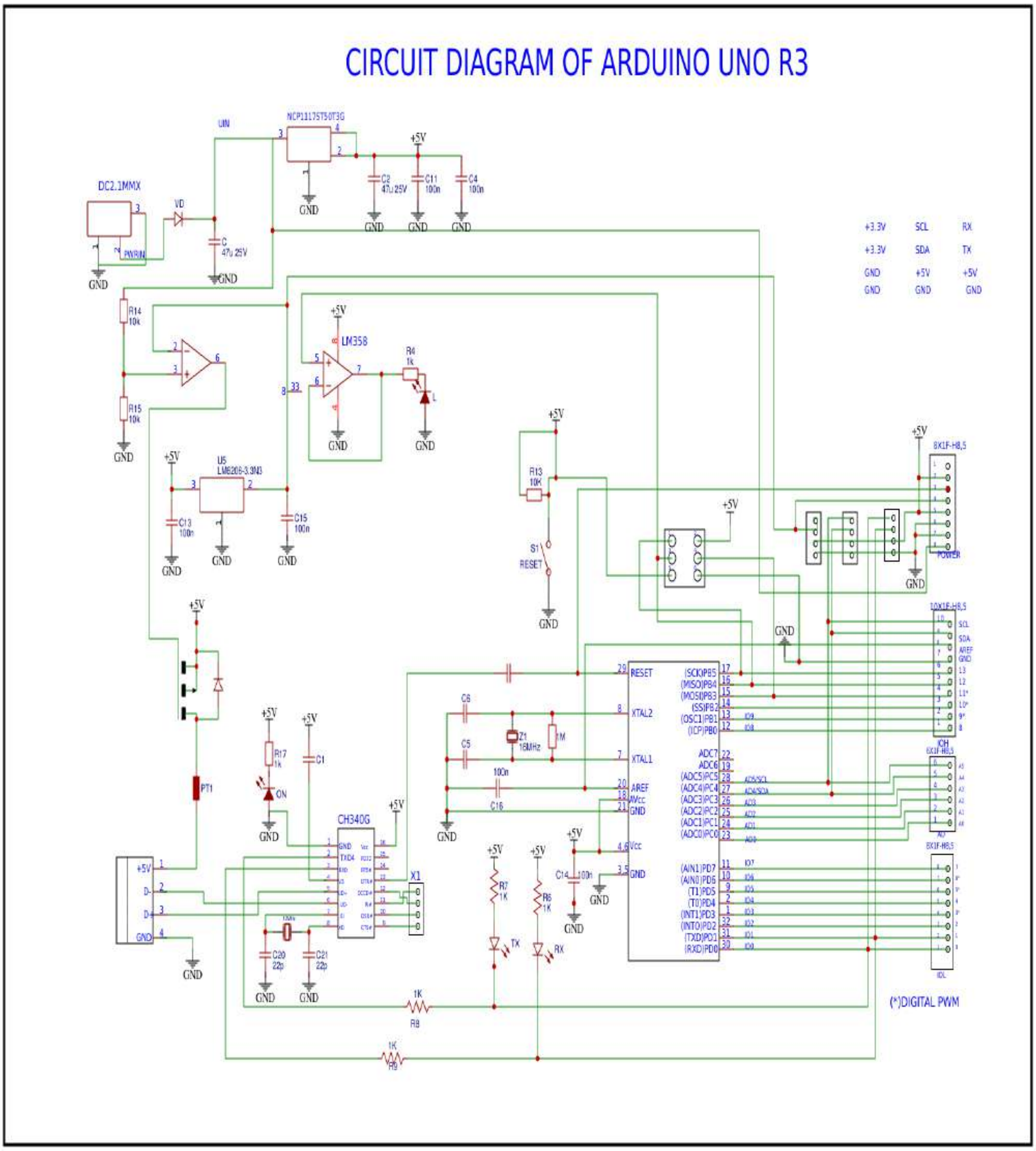


Figure 2. Schematics of Developer Board

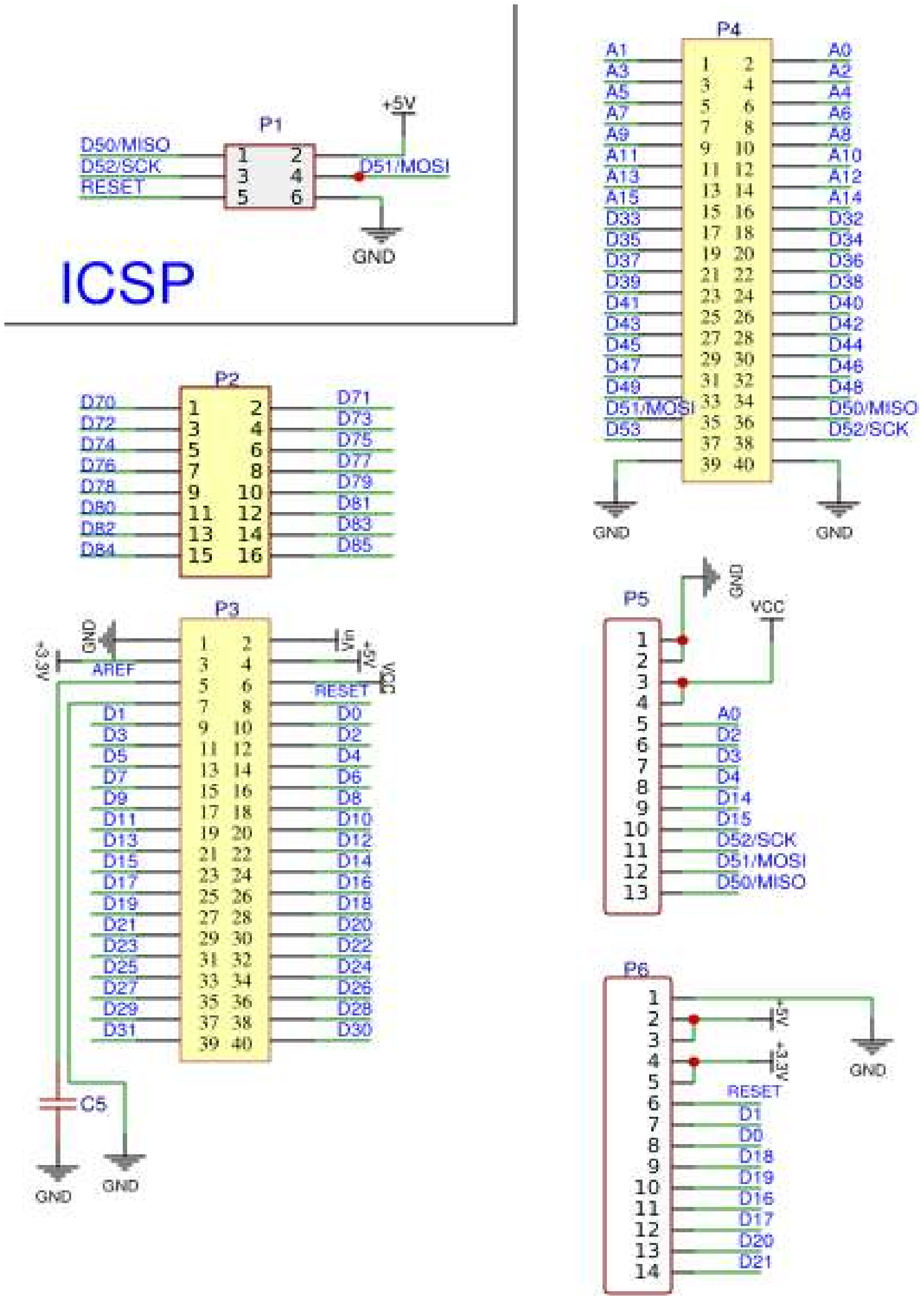



Figure 3. Schematics of Developer Board

## 2 Appendix B

### 2.1. Sustainable Development Goals (SDGs)

United Nation Policy and Pakistan’s Priority

SDGs - an ambitious and universal agend


*A.3. Sustainable Development Goals (SDGs)*

- On 25 September 2015, the UN General Assembly adopted the 2030 Agenda for Sustainable Development (UN, 2015)
- At the core of the 2030 Agenda are 17 Sustainable Development Goals (SDGs)
- The universal, transformational and inclusive SDGs describe major development challenges for humanity.
- The aim of the 17 SDGs (Annex. 1) is to secure a sustainable, peaceful, prosperous and equitable life on earth for everyone now and in the future.

- For the goals to be reached, everyone needs to do their part: governments, the private sector, civil society and every human being across the world
- The Sustainable Development Goals achieved in our project Unmanned ground robot

**Good Health and Well-Being**

We ensure that our project hit the level of healthy lives and promote well-being for all. As its main purpose to provide facilities for the patient that they can live like normal human being. It is thoroughly discussed in article 1.3.

**Industry Innovation and Infrastructure**

Our project is based on smart technologies and innovation, as we discuss in above articles. Our project provide assistance to disable person with help of application development and live streaming camera which help the patient to control and safety measures by other one. This project is overall on industrial revaluation make competent in industry.

**Sustainable Cities and Communities**

After application of this project, it makes cities and human settlements inclusive, resilient and sustainable. It provides a healthy transportation and reduces stress of disable person with convenient technology. It provides assistance for the normal need of like daily in use for the users. It is pollution free and depend on solar energy .

## 2.2 Complex Engineering Problem Attributes

A complex engineering problem in the context of a smart electric chair could be designing and implementing an intuitive Human-Machine Interface (HMI) that integrates seamlessly with a mobile app. This problem involves multiple facets, including hardware design, software development, and user experience considerations.

Let's break it down into key components and explore some challenges associated with each:

**Range of Conflicting Requirements:**

During development process multiple issues arises from the controller frequency management and synchronizing of motor shield controllers with main development board. The remote control and HMI control sometimes disrupt the controlling system.

**Depth of Analysis Required:**

The development process of schematic board with shield controllers showing revers current which cause the problem to burn the controllers by reverse current. There we required a lot to thing about the developer  and the reverse cycle of current.

**Depth of Knowledge Required:**

Programming part and the developer board with HMI designing required much effort to read research papers and past innovation and technologies that already tackle these problems.

**Familiarities of Issues:**

Most of the time after manual control, the smart control like HMI and App control did not work accurately or some time it seems like it disconnected from the system.

**Extent of Applicable Code:**

Sometimes due to mechanical issues of solar panel chair stability and vibration is uncontrolled. It also seems that due low air pressure of tires force the chair to move left or right instead of forward.

**Consequences:**

By the development of Smart chair many benefits arises for the disable person like multiple controlling features, safety measures and charging through renewable energy. Major thing is that it makes the patient independent.

**Interdependence:**

During testing process due to vibration and mechanical mostly connection lose and disconnect controllers or sometimes it disconnect the battery. This may cause sparking in the battery terminals and cause lower the efficiency of the solar.

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