Design and Implementation of an Efficient Charging System for Electrical Motor Cycle

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A Final Year Design Project (FYDP) submitted to the Department of Electrical and Electronic Engineering in partial fulfillment of the requirements for the degree of Bachelor of Science in Electrical and Electronic Engineering

Department of Electrical and Electronic Engineering
BRAC University
July 2024

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Declaration

This is our sincere declaration that the work in this project report was done by us and has not been sent to any other university or organization for the purpose of receiving a degree or certificate. We promise that the work that has been stopped here does not violate any copyrights that are already in place. We also promise to pay the university back for any loss or damage that happens because we broke the first commitment.

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Ethics Statement

This paper has a plagiarism score of 17%. The team members effectively accomplished the assignment by utilizing a range of research papers, journals, and publications. The materials were succinctly summarized in the literature review and accurately cited.

Abstract/Executive Summary

The broad adoption of electric vehicles is currently limited by the insufficient availability and convenience of charging infrastructure. To address this issue and actively contribute to the transition towards a more sustainable transportation system, this proposal advocates for the establishment of an electric vehicle charging station powered by renewable energy sources.

Through the utilization of solar panels, the charging station will offer an environmentally friendly and renewable source of electricity for electric vehicles (EVs). The objective of this project is to investigate the practicality, technical factors, and possible advantages of installing a charging station. This charging system could assist in decreasing our dependence on fossil fuels and alleviating the environmental consequences linked to conventional methods of generating electricity.

Dedication

This paper is dedicated to our family and friends who have consistently supported us during our journey. We extend our appreciation to our families for their steadfast belief in us and their ongoing assistance in our pursuit of our interests. Their steadfast love and support provided us with the essential resources and guidance to achieve our goals. We would like to thank our companions for their steadfast support and encouragement throughout our undertaking. Their tremendous efforts have been crucial for our development thus far. We are extremely grateful for the overwhelming love and support we have received during our journey. Expressing gratitude.

Acknowledgement

We express our profound gratitude to Md. Mosaddequr Rahman, PhD, who serves as the ATC Chair and is also a Professor and Chairperson in the Department of Electrical and Electronic Engineering at BRAC University. His excellent assistance has been instrumental in our Final Year Design Project. The consistent help and guidance he provided throughout the year in the domains of system design and implementation, data gathering, troubleshooting, and administrative matters were essential for the successful project completion. We express our gratitude for the assistance, encouragement, and mentorship offered by our ATC panel members, Aldrin Nippon Bobby and Mohaimenul Islam, esteemed senior teachers in the Department of Electrical and Electronic Engineering at BRAC University. Their support and comprehension facilitated our ability to operate with greater freedom and efficiency, ultimately resulting in the successful completion of this demanding one-year project.

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Chapter 1
Introduction

1.1 Introduction

Electric vehicles (EVs) possess the capacity to significantly diminish our reliance on fossil fuels and the release of greenhouse gas emissions. Nevertheless, the widespread accessibility and uncomplicated nature of charging infrastructure now impede the widespread acceptance and usage of electric vehicles. For this project, we propose creating a charging station for electric vehicles that runs on renewable energy as a solution to this problem. Our charging station will provide electric vehicles with a renewable and environmentally friendly source of power by harnessing solar energy via the use of solar panels. Utilizing renewable energy to charge electric cars not only reduces our reliance on fossil fuels but also helps mitigate the environmental issues linked to conventional power generation methods. This project aims to examine the practicality, technical factors, and possible advantages of establishing a charging station for electric vehicles that relies on renewable energy sources. Additionally, it aims to support the shift towards a more environmentally friendly transportation system and tackle the obstacles related to the widespread use of electric vehicles.

1.1.1 Problem Statement

The extensive adoption of electric vehicles has the capacity to significantly decrease greenhouse gas emissions and facilitate the shift towards a low-carbon transportation sector. However, the achievement of this change relies on the presence of reliable and durable charging infrastructure. The current electric vehicle charging infrastructure predominantly relies on fossil fuels, leading to elevated levels of greenhouse gas emissions and undermining the environmental advantages of electric vehicles. Therefore, it is necessary to conduct an investigation.

Renewable energy-based power sources for electric vehicle charging stations. The objective of our study is to tackle the limited utilization of renewable energy in electric vehicle charging infrastructure, while also exploring the capacity of this technology to facilitate the transportation sector's shift towards a low-carbon future.

1.1.2 Background Study

Given the environmental concerns associated with conventional automobiles, such as carbon emissions, air pollution, and noise pollution, it is advisable for the government to transition to electric vehicles, which are considered a sustainable and environmentally-friendly technology. A research conducted by the World Health Organization has revealed that air pollution in

Dhaka is accountable for more than 12,000 fatalities annually, therefore establishing it as a significant issue concerning public health. By transitioning to electric vehicles (EVs), the city has the potential to substantially decrease air pollution levels and enhance the well-being of its inhabitants. Consequently, the adoption of electric cars in our country will soon surge, leading to a substantial strain on the national power grid system.

Our work is trying to reduce this pressure as much as possible by implementing a smart charging system. Presently, the scarcity of public charging stations in Dhaka is a challenge for electric vehicle (EV) owners who need to recharge their vehicles. As of December 2020, the entire nation had a total of 14 EV charging stations, with a combined capacity of 278 kW. The government aims to achieve a minimum of 15% electric car penetration among all registered vehicles by 2030. Consequently, there will be a substantial rise in the demand placed on the national power grid. By deploying the intelligent charging system, we will be able to decrease the burden on the national power grid.

The paper "Solar Energy-based Net Metered Easy-Bike Charging Station in Bangladesh" [1] suggests utilizing a grid-tied net metering system for the creation of the charging station. The system would lack a battery energy storage system (BESS). Alternatively, the electricity produced by solar panels during daylight hours would be sent to the power grid. When the simple bikes require power for charging, it is obtained from the electrical grid. The researchers conducted simulations of their system using PVsyst at various azimuth angles and determined that the southern direction yielded the most power output. Without a Battery Energy Storage System (BESS), the scientists predicted that their system would require 45 months to recoup its costs. Implementing a BESS would more than double the cost of the system. The greenhouse gas (GHG) emissions for this system would amount to 89.63 kg CO2-eq/MWh, which is considerably lower than Bangladesh's grid emission factor of 670 kg CO2-eq/MWh [1].

The study paper titled "Bangladesh Power System Peak Demand Shaving through Demand Side Management of the Battery-Operated Easy Bike Load" [2] suggests using Demand Side Management (DSM) as a strategy to reduce peak load demand. According to the report, most electric vehicles (EVs) are plugged into the power grid within the time frame of 9 to 10 p.m. Conventional bicycles often possess a battery capacity ranging from 8 to 11 kilowatt-hours (kWh). According to the authors' estimation, if 70% of the regular bicycles are charged during non-peak hours, it would result in a decrease in demand of 700 MW. To achieve this, a timer-based charging mechanism would be implemented to prohibit charging during periods of high demand. Due to the low demand at night, the simple bikes are charged after midnight when they are not being used often [2].

In their publication titled "Designing a Solar Powered DC Charging Station for Easy Bikes: Bangladesh Perspective" [3], the authors suggested the integration of a solar-powered charging system with a Battery Energy Storage System (BESS). The Battery Energy Storage System (BESS) would store the solar energy produced during daylight hours. The electric bicycles would be powered by the Battery Energy Storage System (BESS). The writers maintained the grid as a contingency plan in the event of adverse weather conditions. In addition, they incorporated a grid-tied bidirectional inverter to facilitate the transmission of surplus energy produced by the solar panels back into the power system. This technique allows for the convenient charging of bicycles using renewable energy, regardless of the demand on the power grid [3].

There has been a global increase in the concentration of greenhouse gases in the atmosphere in recent years [1]. The energy industry is responsible for almost 75% of global greenhouse gas (GHG) emissions [1]. In response to this issue, the European Union (EU) has proposed a prohibition on internal combustion engine (ICE) cars by the year 2035, with the intention of substituting them with electric vehicles (EV) [4]. Transitioning from internal combustion engine (ICE) vehicles to electric vehicles (EVs) will have a substantial impact on reducing greenhouse gas (GHG) emissions. This is because the transportation sector is responsible for 11.9% of the overall GHG emissions [1]. In Bangladesh, around 1 million electric vehicles (EVs) are leading the way in the shift towards electric power [2]. These electric vehicles are commonly known as battery-powered tricycles or Easy Bikes. According to our survey, basic bicycles operate using four 12V batteries that are linked in series, resulting in a combined voltage of 48V. The basic bicycles can function for a duration of 8 to 10 hours when fully charged. A significant proportion of the energy needed to charge these vehicles is obtained from the combustion of limited nonrenewable fossil fuels, which release greenhouse gases. Furthermore, simple bikes are charged at the peak hours of the grid, in addition to GHG emissions. According to the load curve obtained from PGCB, the grid experiences its highest electricity demand in the evening, namely between 9 p.m. and 12 a.m. Our investigation revealed that the simple bikes' charging period, which spans from 9 p.m. to 6 a.m., suggests that they are exerting extra pressure on the grid during its busiest hours. These findings align with the results provided in our literature review.

In order to mitigate greenhouse gas (GHG) emissions and alleviate strain on the power grid, we suggest the implementation of an electric car charging station that relies on renewable energy sources. Utilizing renewable energy sources like solar power to recharge electric vehicles (EVs) can reduce the annual carbon dioxide emissions per standard bicycle by around 1860.5 kg [5]. The geological conditions in Bangladesh are highly conducive for the utilization of renewable energy sources, particularly solar power [3]. The integration of renewable energy generation with a Battery Energy Storage System (BESS) at the charging station will decrease the system's reliance on the electrical grid [3]. Due to the reduced dependence of the simple bikes on the grid for charging, the grid will endure less pressure during peak hours.

During the process of building and assessing the proposed Electric Vehicle Charging System (EVCS), we came across numerous simulation tools such as PVsyst, HOMER, Simulink, Helioscope, and RETScreen. Upon evaluating their attributes, we decided to choose PVsyst for the purpose of conducting analytical and economic analysis, whereas Simulink was chosen for design reasons. PVsyst includes current components in its library, enabling comprehensive examination. The optimization process is highly effective and straightforward, and the program supports the use of aging and degradation models. Simulink allows for the creation of bespoke blocks to tailor the design process according to our own needs.

1.1.3 Literature Gap

Our inquiry has not yielded a system that integrates Demand Side Management [2] with an On Grid Solar solution. Additionally, we found that On Grid Solar systems lack a backup power source during load shedding [1], or the available battery backup is prohibitively expensive [3]. Consequently, we have chosen to build a system with the most efficient amount of battery power to strike a compromise between cost and backup capacity. Additionally, we will incorporate Demand Side Management into the system to decrease the strain on the power grid during periods of high demand. An On Grid System is more cost-effective than an Off Grid System [5] because it may utilize the grid for energy storage through net metering.

1.1.4 Relevance to Current and Future Industry

Renewable energy-powered electric vehicle charging stations hold significant importance in both present and future sectors due to a multitude of factors.

Initially, there is a growing demand for electric vehicles due to the desire of both customers and governments to reduce greenhouse gas emissions and transition to more environmentally friendly forms of transportation. To meet this demand, a reliable and environmentally-friendly charging infrastructure is necessary. Renewable energy-powered charging stations can contribute to the establishment of this infrastructure by generating electricity from sustainable sources like as solar and wind power. This not only diminishes reliance on fossil fuels, but it also decreases the overall expenses associated with operating and maintaining charging stations.

Furthermore, the utilization of charging stations powered by renewable energy sources can effectively address the challenges associated with integrating the grid and storing energy, which are commonly associated with electric car charging. By producing electricity at the location itself, these charging stations can reduce the demand on the power grid and eliminate the requirement for expensive battery storage solutions. This can enhance their cost-effectiveness and efficiency compared to conventional charging stations.

In a nutshell, Renewable energy-powered charging stations can support the growth of a low-carbon transportation industry and help combat climate change. As the world shifts towards renewable energy, these charging stations may have a significant impact in reducing greenhouse gas emissions and promoting a more sustainable environment. Renewable energy-powered electric vehicle charging stations play a crucial role in both present and future industries. Their use is anticipated to grow alongside the increasing demand for electric vehicles.

1.2 Objectives, Requirements, Specification and Constraint

We conducted a comprehensive assessment of our project's goals, requirements, specifications, and limitations to ensure that all essential elements are in place for its successful execution. We have determined the project's exact specifications and the necessary resources to achieve them. In addition, we thoroughly examined the numerous specifications and constraints of the project in order to identify the most effective approach for their implementation. This enhances our understanding of the project, enabling us to strategize and implement it with greater efficiency.

1.2.1. Objectives

The objective of our project is to analyze and construct an electric car charging station, assess its operational efficiency through data analysis, and compare the results with real-world observations. In addition, we are committed to adhering to the established safety and reliability criteria, while also guaranteeing that our highly trained staff is equipped to maintain sustainability. Our intention is to offer a secure and effective method for charging electric vehicles.

1.2.2 Requirements

Functional Requirements

Solar Photovoltaic Array:
Voltage Range: The system must be able to handle the fluctuating voltage output from the solar PV array, which usually varies between 20V and 80V depending on the intensity of sunshine.
Power Rating: The solar photovoltaic (PV) array must have the capacity to produce enough power to charge the 48V battery, taking into account the usual efficiencies of solar panels and the anticipated duration of sunlight.

Battery
Battery Type: Lithium-ion (Li-ion) or Lead-acid.
The voltage is 48V.
Capacity: Please specify the ampere-hour (Ah) value, for example, 20Ah.
The charging voltage should not exceed 54.6V for Li-ion batteries or 58.8V for lead-acid batteries.
Charging Current: [Indicate the highest possible charging current, for example, 10A].

Charging Controller
A boost converter is an electronic circuit that increases the voltage of a direct current (DC) power source.

Input Voltage Range: The device must be capable of accommodating the full range of input voltages from the solar PV array.
The output voltage is capable of being increased to the necessary charging voltage, which can be up to 54.6V or 58.8V.
Efficiency: Achieving a high level of efficiency, beyond 90%, in order to minimize power losses.
MPPT is an acronym that stands for Maximum Power Point Tracking. Integration is essential for optimizing the power output of solar PV panels.

User Interface and Monitoring
User Interface: An LCD/LED display will be used to provide information on the charging status, battery voltage, current, and any fault circumstances.
The 48V battery charging system, which utilizes solar PV for an EV bike, will meet the functional requirements and guarantee efficient, dependable, and safe operation. This system will maximize the utilization of solar energy for sustainable transportation.

Non-functional Requirements

- A web-based tracking system or customer site can show station owners and bike drivers how much they charge and how much money they make or lose each month.
- As a backup power source in case the solar panels or the grid go down during load shedding on a cloudy day, you might want to put in a gas engine at the station.
- Extra power from solar panels can be sent back to the grid with an optional back feeding feature.
- Smart card prepaid metering simplifies payment for bike drivers. However, standard cash payment would suffice, making a smart card system optional.

The project does not require a solar panel cleaning system, although it is recommended for optimal energy extraction. As an alternative, the panels can be cleaned by hand once a month.

1.2.2 Specifications

TABLE 1.1. SYSTEM SPECIFICATIONS

Subsystem	**Component**	**Specifications**
Solar	Solar Panel	Panel: Mono-perc Max. power: 545W Voc: 49.65V Isc: 13.92A Vmp: 41.80V Imp: 13.04V
	Solar charge controller	MPPT type The most power that a panel can handle is 10,000 Wp.
	Batteries	Battery Type: Lithium-ion or Lithium-polymer Life Cycles: Over 3000 The voltage per cell is 3.7 V.
Charging	DC to DC Boost Converter	The voltage output is 48 volts. Current output: 9 amperes Maximum output ripple: 2%

1.2.3 Technical and Non-technical Consideration and Constraint in Design Process

Significant solar irradiance: The presence of stations with high sun irradiation is crucial as it directly impacts the efficiency of solar panels. Regions with little sun irradiation would need the installation of extra solar panels, leading to increased costs.

Number of vehicles: There is a restriction on the total number of vehicles that may be charged at the same time. In order to accommodate a larger number of vehicles, it is necessary to acquire additional land, batteries, and solar panels. This would increase the initial expense of the charging station.

Position: The gas station must to be easily accessible by electric vehicles. Riders of electric bikes wouldn't travel great distances to charge them if it weren't for this.

Cost of charging: The ability to offer low charging costs is crucial in order to remain competitive with other charging stations. Riders will opt not to charge at our station if the charging rate exceeds that of other charging stations.

1.2.4 Applicable Compliance, Standards and Codes

TABLE 1.2. APPLICABLE STANDARDS AND CODES

Subsystem	Standard	Definition
Charging Socket Outlet	IEC 60320-1	Appliance couplers for household and similar general purposes (IEC C15 connector - T jack)
	NEMA 14-50	Wall socket with 50-amp maximum amperage
Supply Station	IEC 61851-1	Electric vehicle conductive charging system - General requirements
Solar Module	BDS IEC 61215	Terrestrial photovoltaic (PV) modules – Design qualification and type approval
	BDS IEC 61853	Photovoltaic (PV) module performance testing and energy rating
	BDS IEC 61730-1:2019	Photovoltaic (PV) module safety qualification part 1: Requirements for Construction

	BDS IEC 61730-2:2019	Photovoltaic (PV) module safety qualification part 2: Requirements for Testing
Inverter	BDS IEC 62109-1	Safety of power converters for use in photovoltaic power systems - Part 1: General requirements
	BDS IEC 62109-2	Safety of power converters for use in photovoltaic power systems - Part 2: Particular requirements for inverters
	BDS IEC 61683	Photovoltaic systems – Power conditioners
	BDS IEC 62116:2020	Utility-interconnected photovoltaic inverters - Test procedure of islanding prevention
Solar Charge Controller	BDS IEC 62509	Battery charge controllers for photovoltaic systems
Battery	BDS IEC 61427-1	Secondary cells and batteries for renewable energy storage
	BDS IEC 60086-4	Primary batteries - Part 4: Safety of lithium batteries

1.3 Conclusion

Renewable energy-powered Electric Vehicle Charging Stations (EVCS) play a crucial role in both current and future industries. They help to significantly reduce the carbon emissions produced by electric vehicles, decrease dependence on fossil fuels, and support the sustainable expansion of electric vehicles. Utilizing renewable energy in Electric Vehicle Charging Stations (EVCS) can facilitate the shift towards a more sustainable energy system by reducing the need for fossil fuels. As the quantity of electric vehicles increases, the demand for Electric Vehicle Charging Stations (EVCS) will also rise. Renewable energy sources can help fulfill this demand in an eco-friendly manner.

Chapter 2

Project Design Approach

2.1 Introduction

Multiple design approaches are significant in engineering design because they enable engineers to investigate various potential solutions to a problem. This enables engineers to make more informed decisions regarding the optimal approach for a given project. Engineers may detect potential dangers, propose new solutions, and determine the costs and benefits of each design method by considering various options. Furthermore, diverse design techniques enable engineers to capitalize on their strengths while minimizing their shortcomings, all while taking into account the needs of their customer or client. Finally, numerous design techniques allow for the exploration of innovative alternatives while also ensuring that the end product satisfies the customer's expectations.

2.2 Identify Multiple Design Approach

Some design approaches that could meet our requirements are:

Design approach 1: Charging system by Current controlling using a transformer and PWM-generating microcontroller.

Design approach 2: Charging system by solar panel using boost-buck converter with MPPT and PI controller

2.3 Describe Multiple Design Approach

2.3.1 Design of Approach 1:

Charging system by Current controlling using a transformer and PWM-generating microcontroller.

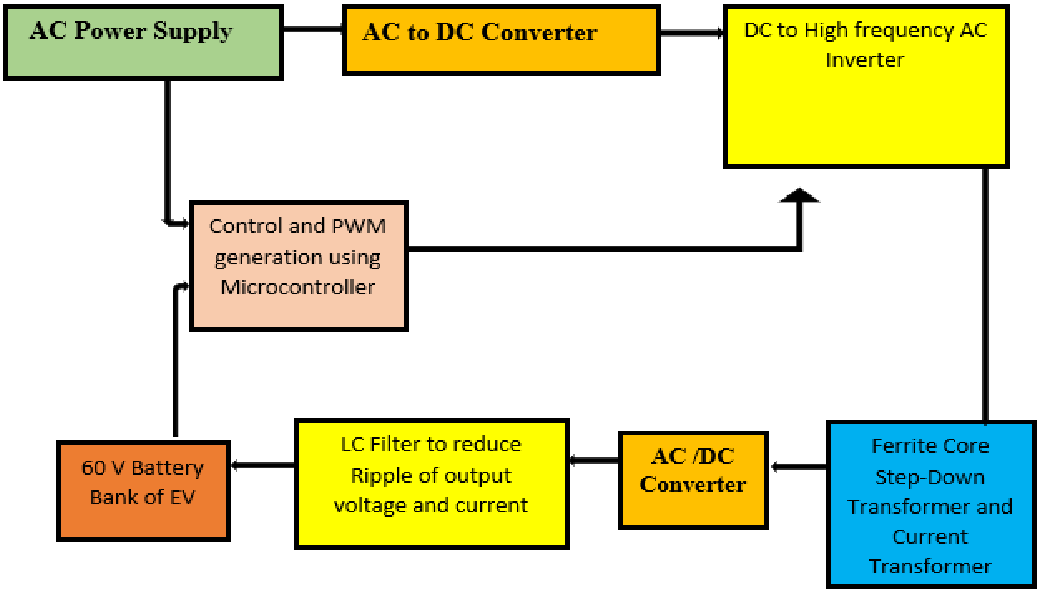


Fig. 2.3.1.: current controlling using transformer and PWM generating microcontroller Block Diagram.

The key distinction between a traditional charger and the suggested charger lies in the utilization of a high frequency ferrite core transformer in the latter. This significantly decreases the weight of the charger. The electrical power obtained from the grid is carefully adjusted through multiple stages to attain the specific charging state required for the battery bank. The diagram below depicts a block representation of the system that includes the proposed charger. The alternating current (AC) voltage from the power grid is initially transformed into direct current (DC) by employing a full wave diode rectifier. The rectified output is supplied to a half bridge inverter that is built using MOSFETs. A microcontroller is employed to deliver the gate signals to the MOSFETs. The inverter produces a high-frequency alternating current (AC) voltage that is then applied to the ferrite core transformer. This voltage is stepped down to the desired level for the purpose of charging.

Nevertheless, since the voltage is alternating current (AC), it is necessary to convert it to direct current (DC) by employing a center tap rectifier. Ultimately, an LC filter is employed to eliminate any oscillation from the direct current (DC) voltage prior to its application across the battery bank for the purpose of charging. The diagram below illustrates the complete configuration of the proposed charger in PSIM.

2.3.2 Design of Approach 2:

Charging system by solar panel using boost-buck converter with MPPT and PI controller

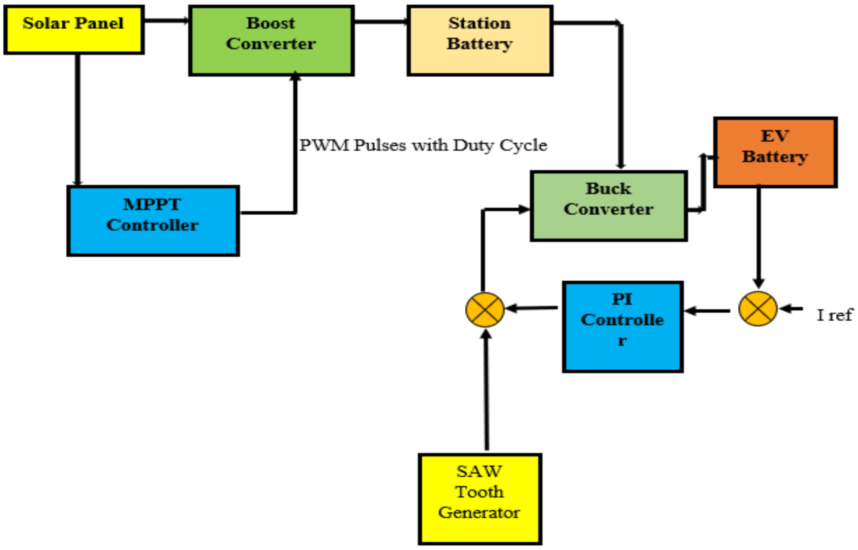


Fig.2.3.2**:** Charging from solar panel using boost -buck converter with MPPT and PI controller.

The approach being proposed exemplifies the concept of green charging. The primary goal of developing an eco-friendly charger is to address the imminent depletion of fossil fuels, mostly caused by the car industry. Figure 1 displays the System Diagram. A Solar fed boost converter is employed as the primary power source for our system batteries, while a Buck converter is utilized to lower the voltage, allowing the vehicle battery to be charged using the same power source. The DC-DC converters are equipped with power MOSFETs, inductors, and capacitors. The solar panel's output current and voltage are continuously monitored and inputted into the MPPT controller, which in turn feeds its output into the boost converter. This work utilizes Modified Incremental Conductance (INC) and Fuzzy Logic Control (FLC) Maximum electricity Point Tracking (MPPT) approaches to enhance the efficiency of extracting solar electricity from photovoltaic (PV) panels. The Constant Current technique is employed as the charging mode for the battery. The reference current is compared to the current from the buck converter, and the resulting difference is then used to control the MOSFET of the buck converter.

2.4 Analysis of Multiple Design Approach

Functional Verification of Multiple Design Solutions:

APPROACH 01: Circuit Design For Charging System Using Ferranti Core Transformer With Microcontroller.

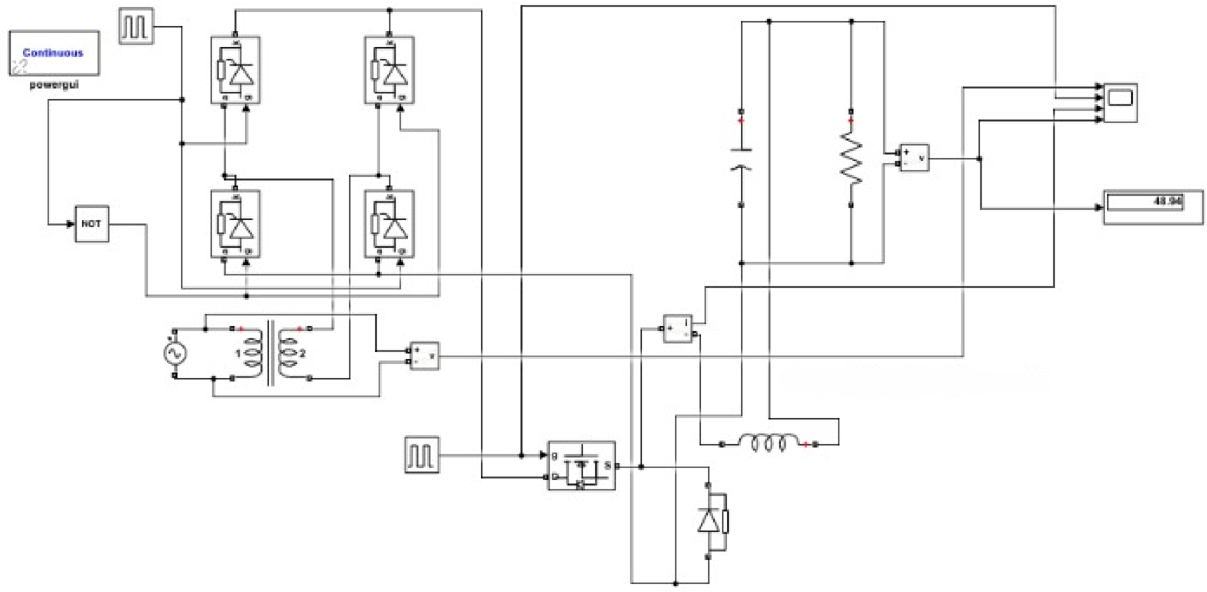
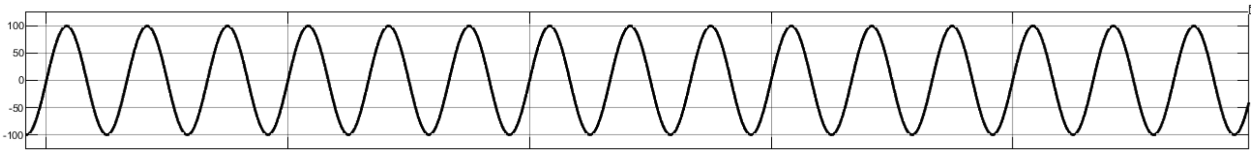
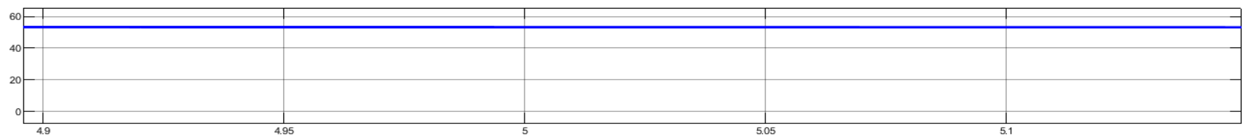


Fig. Design Approach 01

Input:



Output:



Here, we have designed a circuit for our charging system where we've used Ferranti core transformer. We've designed this with microcontroller. After that, we've observed the graph of our input and output.

Alternative design for Approach 01:

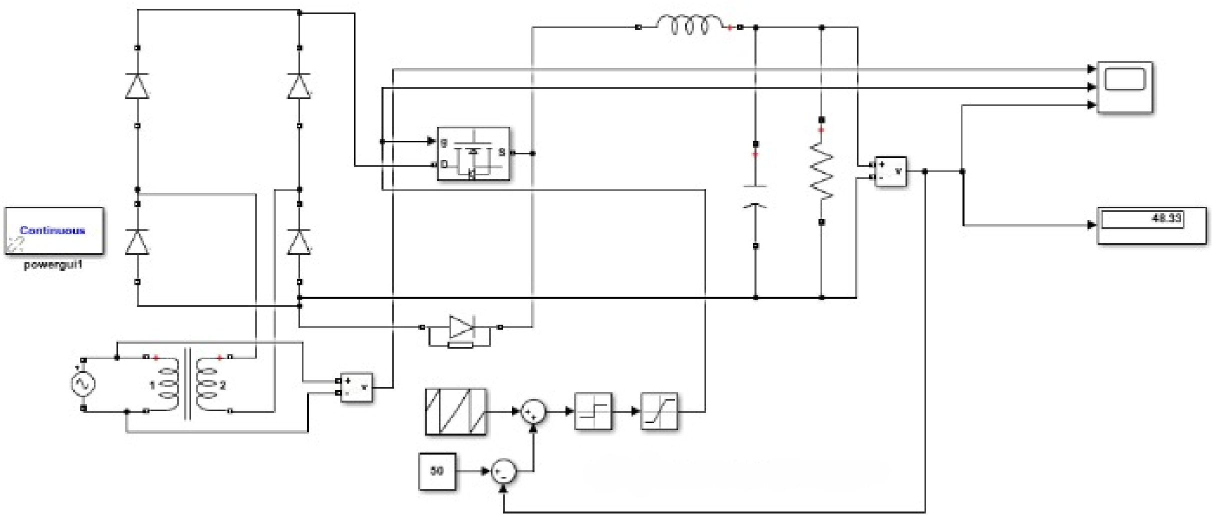
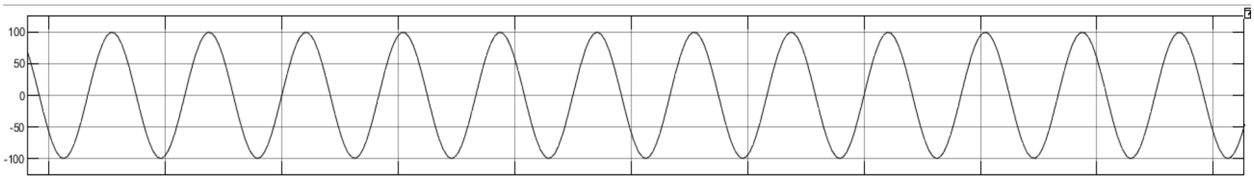
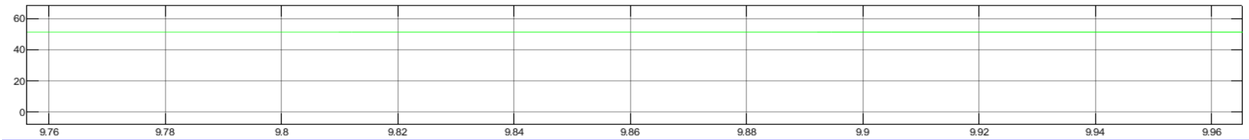


Fig. Alternative design for Approach 01

Input:

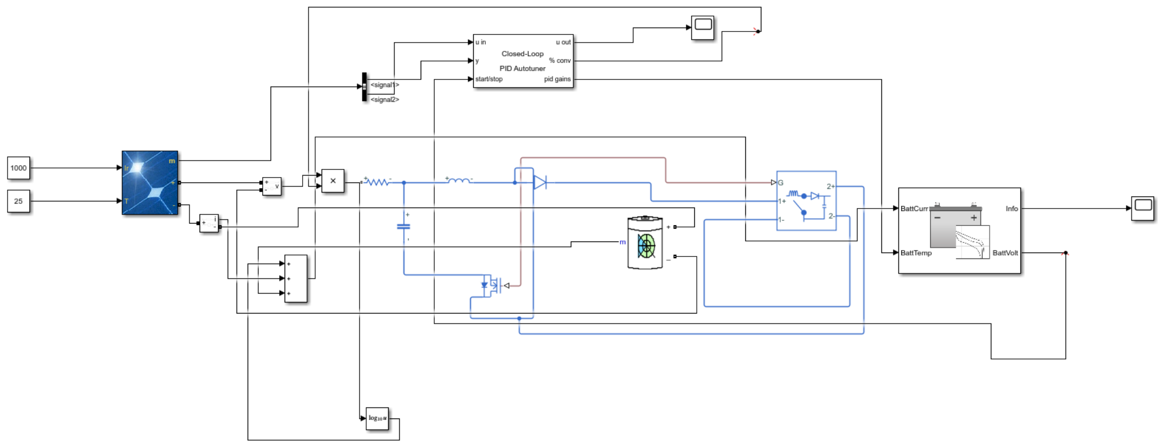


Output:



Here, we’ve designed a circuit for alternative design approach. We’ve changed some tools and parameters for better output. After that, we’ve observed the graph of input and output.

Approach 02: Charging System using PI controller and MPPT controller with Solar Panel.



Output for Design Approach 02:

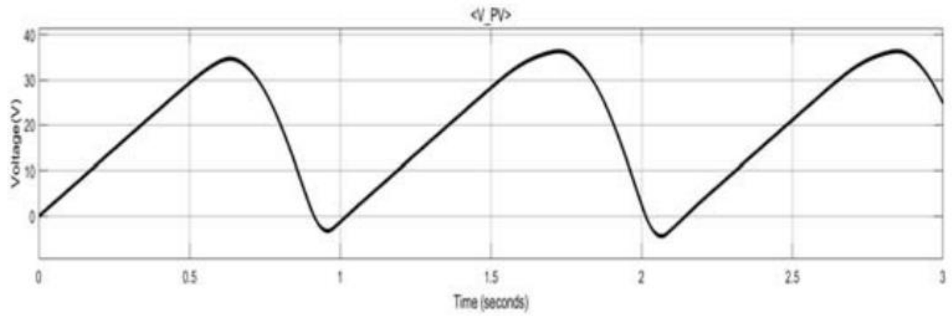


Fig. Modified INC solar panel voltage

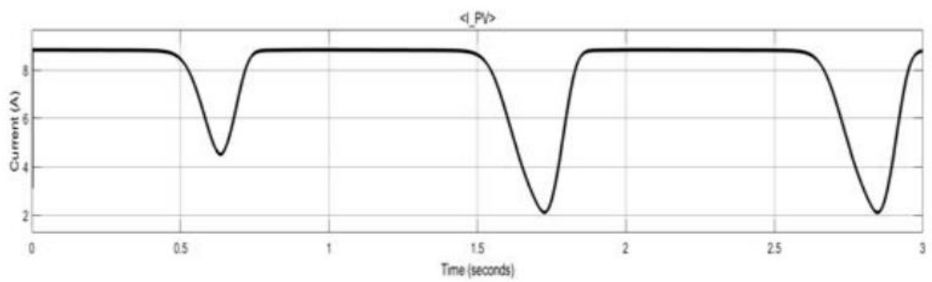
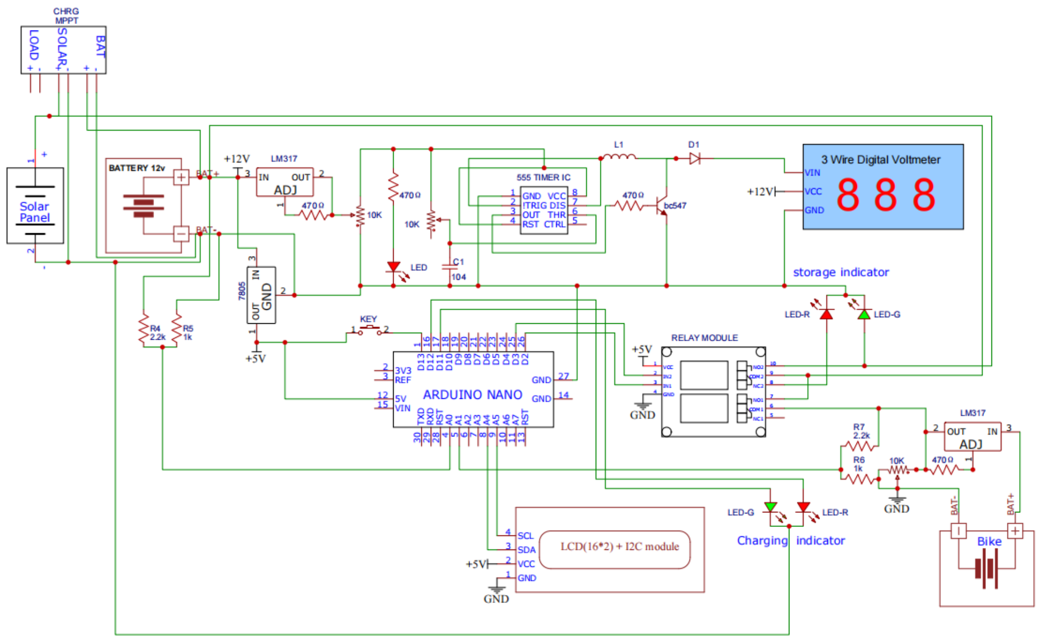


Fig. Modified INC solar panel current

Here, we've designed a circuit for our charging system with PI controller and MPPT controller. Also, we've added solar panel in this system which is more sustainable. After that, we've observed the graph of our input and output.

Alternative design for Approach 02:



Here, we've made an alternative design approach for our charging system and we've observed the output. Finally, we've got our desired circuit.

Output for Alternative of Design Approach 02:

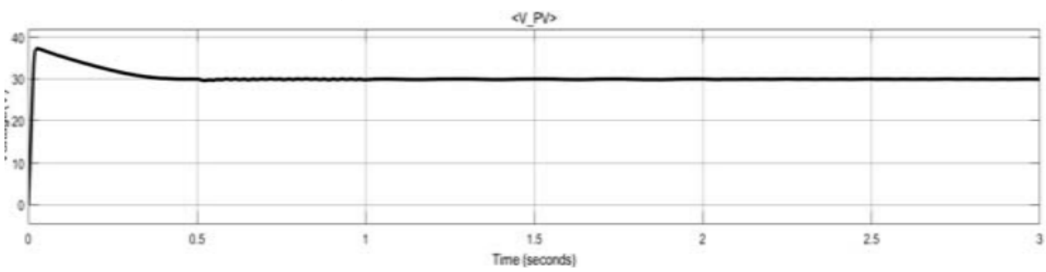


Fig. Solar panel voltage using Modified FLC

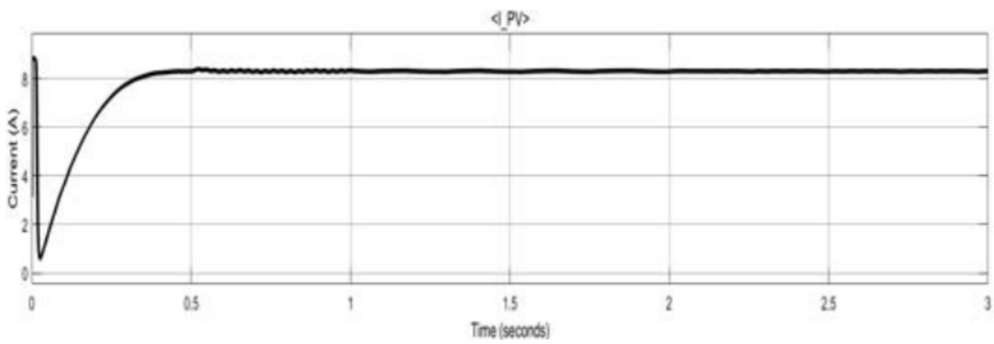


Fig. Modified FLC solar panel current

2.5 Comparison Between Multiple Design Approaches

	Approach 01		Approach 02	
	Design 1	**Design 2**	**Design 1**	**Design 2**
Time	✓			
Power	✓			
Voltage		✓		
Current				✓
Cost Friendly			✓	
Green				✓
Efficiency				✓

2.6 Conclusion

From this table we can see that the 1st design of Approach 1 is better at how fast the charging can be completed than the other design. There is also excess in the power delivering sector. Where we can see the 2nd design of the approach ahead of others in terms of voltage transferring. 1st design of the approach 2 is considered cost effective. But relatively 2nd design of the approach 2 is considered cost effective too as it now so much far behind the 1st design. But the 2nd design transfers more current and it is also very effective in voltage transmission respectively. As the design produces power from solar electricity the is very environmentally friendly. From the above discussion, considering overall effectiveness we can see that design2 of the approach 2 is the optimal solution.

Chapter 3

Use of Modern Engineering and IT Tool

3.1 Introduction

Once we had determined the optimal design strategy, we were tasked with the obligation of selecting appropriate tools for the development and verification of the final prototype. Software and hardware tools were categorized into two distinct groups according to their intended use. Tasks like as 3D modeling, code compilation, and functional verification require the utilization of software tools for simulation, interfacing, and visualization. First, we compiled a comprehensive list of all available resources. Then, we conducted a comparative analysis to determine the most suitable tools for the task. During this approach, we carefully evaluated the disadvantages and benefits of utilizing each distinct software program.

3.2 Select appropriate Engineering and IT tools

- ✔ Solar Panel
- ✔ Solar Control
- ✔ Battery
- ✔ Buck Converter
- ✔ Current Sensor
- ✔ Arduino Nano
- ✔ Relay Module
- ✔ LCD Display
- ✔ Volt Meter

3.2.1 Arduino-Nano:

Arduino is a platform for prototyping electronics that is open source and relies on adaptable, user-friendly hardware and software. This product is specifically designed for individuals who are artists, designers, enthusiasts, or anyone with an interest in creating interactive objects or settings. Arduino is capable of perceiving the surrounding world through the reception of input from a diverse range of sensors. Additionally, it has the ability to manipulate its surroundings by exerting control over lights, motors, and other types of actuators.

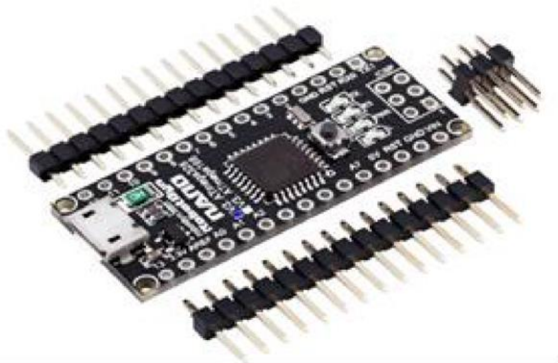


Fig. 3.1 Arduino-Nano

The microcontroller on the board is programmed via the Arduino programming language, which is derived from Wiring, and the Arduino development environment, which is based on Processing. Arduino projects can function alone or establish communication with computer software such as Flash, Processing, or Maxims'. The Arduino Nano is a compact version of a breadboard that is designed to be mounted on a surface and has a built-in USB interface. It is a compact, self-contained, and easily adaptable component for use on a breadboard. The device possesses all the electrical features of the Decimal, along with additional analog input pins and an inbuilt +5V AREF jumper. Physically, it lacks a power jack. The Nano has the ability to autonomously detect and transition to the power source with a greater electrical potential.

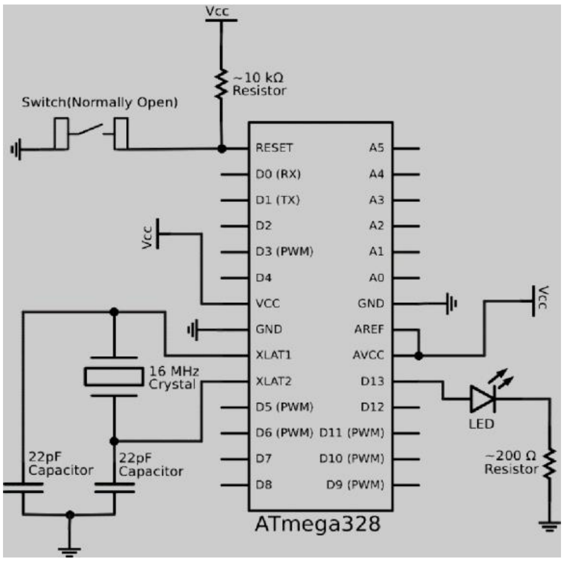


Fig. 3.2 Arduino-Nano Schematic Diagram

The Arduino Nano possesses the breadboard compatibility of the Boarding and the Minibus, but having a smaller physical size than both. As a result, users are provided with a greater amount of space on the breadboard. The pin configuration of this device is compatible with both the Mini and the Basic Stamp. It includes TX, RX, ATN, and GND pins on one side, and power and ground pins on the other side. The upgraded version 3.0 is equipped with ATMEGA328, which provides increased capacity for programming and data memory. It consists of two layers. This increases the vulnerability to hacking and reduces the cost. One of the most notable attributes of the Arduino Nano is its user-friendly nature, as well as its compact and diminutive size.

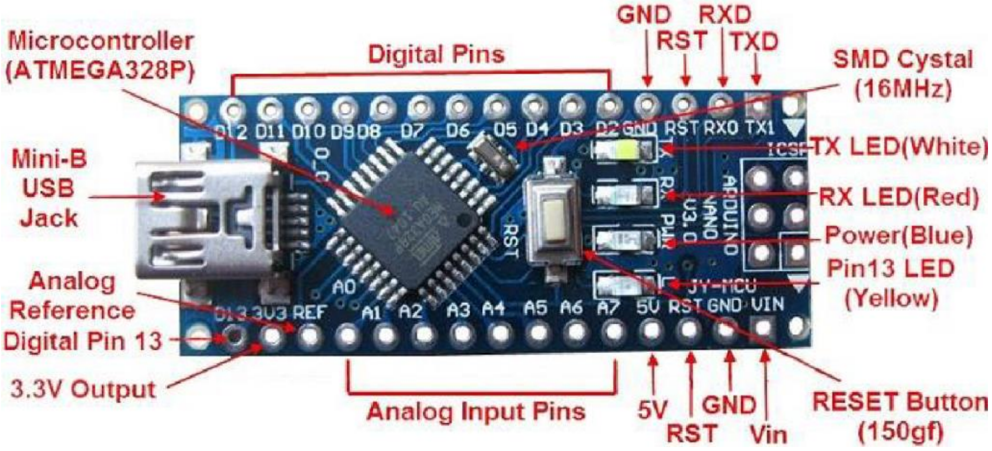


Fig. 3.3 Arduino-Nano

Technical Details:

The microcontroller used is the Atmel ATmega328

The logic level operating voltage is 5V

Recommended input voltage range: 7-12 V

The acceptable input voltage range: 6-20 V

Digital input/output (I/O) Number of pins: 14, with 6 of them capable of providing PWM output.

The number of analog input pins available is 8. These pins are used for DC input. Current per input/output Current: 40 milliamperes

The flash memory capacity is 32 kilobytes, with 2 kilobytes allocated for the boot loader.

SRAM: 2 kilobytes

The clock speed of the device: 16 MHz.

Size: 0.70 inches by 1.70 inches

ATmega 328p:

Fig. 3.4 ATmega 328p

The Microchip Pico Power 8-bit AVR RISC-based microcontroller is a high-performance device that combines several features. It has 32KB ISP flash memory with read-while-write capabilities, 1024B EEPROM, 2KB SRAM, 23 general purpose I/O lines, 32 general purpose working registers, three flexible timer/counters with compare modes, internal and external interrupts, serial programmable USART, a byte-oriented 2-wire serial interface, SPI serial port, a 6-channel 10-bit A/D converter (8-channels in TQFP and QFN/MLF packages), programmable watchdog timer with internal oscillator, and five software selectable power saving modes. The device functions within a voltage range of 1.8 to 5.5 volts. The device delivers high throughputs, approaching 1 Million Instructions Per Second (MIPS) per Megahertz (MHz), by executing strong instructions in a single clock cycle. This allows for a balance between power consumption and processing performance.

3.2.2 Solar

A solar panel refers to a collection of solar photovoltaic modules that are interconnected and installed on a supporting framework. A photovoltaic module is a compact and interconnected unit comprising of solar cells. The solar panel serves as a constituent of expansive photovoltaic systems utilized for the generation and provision of power in commercial and residential settings. The power output of each module is evaluated based on its DC output under Standard Test Conditions (STC) and usually falls within the range of 100 to 320 watts. The module's efficiency directly affects its area for a certain rated output. For example, a module with 8% efficiency and a rated output of 230 watts will have twice the area of a module with 16% efficiency and the same rated output. An individual solar module has a finite capacity to generate electricity; However, most businesses possess multiple modules. A typical photovoltaic system has an assemblage of panels or solar modules, an inverter, and occasionally a battery and/or solar tracker, along with interconnection connections.

Fig.3.5 Solar Panel

Solar cell modules just produce power during periods of sunlight. As they lack the ability to store energy, it is necessary to store a portion of the energy generated in order to maintain the flow of power during periods when the sun is not shining. An evident approach is to utilize batteries, which store electrical energy through chemical means. Electrochemical cells, which convert chemical energy into electrical energy, are coupled in series with batteries. The battery cells consist of two electrodes submerged in an electrolyte solution, resulting in the generation of an electric current upon the formation of a circuit between them. The current is generated by the counteracting chemical reactions occurring between the electrode and the electrolyte within the cell. Secondary or rechargeable batteries are referred to as rechargeable batteries. During the charging process, the cells of the battery convert electrical energy into chemical energy, which is then stored. During the process of discharge, the battery releases the stored chemical energy and converts it into electrical energy. Lead-acid batteries are the predominant battery type in East Africa.

3.2.3 LED

An LED is a type of semiconductor device that produces light when an electric current passes through it. Electrons within the semiconductor material combine with electron holes, resulting in the emission of energy in the form of photons. The color of the light is governed by the energy needed for electrons to move across the band gap of the semiconductor, which corresponds to the energy of the photons. White light can be achieved by employing numerous semiconductors or by applying a coating of light-emitting phosphor on the semiconductor device.

Fig. 3.6 LED

LEDs are referred to as solid-state devices because they produce light within the solid semiconductor material. Solid-state lighting, including organic LEDs (OLEDs), differentiates itself from conventional lighting technologies that rely on heated filaments (such as incandescent and tungsten halogen lamps) or gas discharge (such as fluorescent lamps). The electrons and holes in the LED are confined within energy bands within the semiconductor material. The bandgap of the LED determines the energy of the photons emitted by the device.

The energy of a photon directly dictates the wavelength of the light it emits, and thus, its color. Various semiconductor materials, characterized by distinct bandgaps, emit light of varying colors. The specific wavelength (color) can be adjusted by modifying the composition of the light-emitting, or active, area. LEDs consist of compound semiconductor materials composed of elements from group III and group V of the periodic table, sometimes referred to as III-V materials. Commonly utilized III-V materials for LED production include gallium arsenide (GaAs) and gallium phosphide (GaP). Prior to the mid-1990s, LEDs had a restricted spectrum of colors, with no commercially available blue or white LEDs in particular. The advent of LEDs utilizing the gallium nitride (GaN) material system expanded the range of available colors and unlocked numerous novel applications.

3.2.4 Solar Charge Controller

The solar charger controller has a discharge current rating of 10A and can automatically adapt to either a 12V or 24V system. It is specifically designed for lead-acid batteries, including OPEN, AGM, and GEL types. The Dual USB ports provide a 5V/3A output, which is suitable for charging mobile phones, tablet PCs, and other devices that require a 5V power.This solar charge regulator offers a range of protective features including over-current protection, short-circuit protection, inverse connection protection, low voltage protection, and overcharge protection. It serves as a dependable safeguard for your gadgets.An integrated industrial microcontroller is utilized for automated control, storing diverse user-defined parameters, and ensuring data persistence even during battery depletion. The solar controller will automatically shut down when the voltage drops below a certain threshold.

Fig. 3.7 Solar Charge Controller

Features & Specifications:

- Input Voltage: 12V/24V
- Input Current Max:10A
- Build-in industrial microcontroller.
- The charge management system utilizes a complete 4-stage PWM method.
- The device features a user-friendly interface with one-key configuration, a digital display, and an automatic memory function.
- The device is equipped with dual Mosfet technology. Current reversal safeguards and minimal heat generation.
- The device has built-in safeguards against short-circuits, open-circuits, reverse polarity, and overloads.
- The LCD display is user-friendly and provides clear information about the device's status and data. It can also be used to switch between modes and configure parameters. The device is appropriate for various applications, including home, industrial, and commercial use.
- The recommended sequence for connecting the charge controller is to first connect the battery, followed by the solar panel, and finally the load. You can modify the parameters using a straightforward one-button procedure.
- Dimensions of the product The dimensions of the object are 7 x 13.5 x 2.5 inches (17.8 x 34.3 x 6.4 cm).
- The item weighs 5.6 ounces, which is equivalent to 158.76 grams.

3.2.5 Battery

The MIGHTY MAX ML8-12 12-Volt 8 Ah battery is designed to offer reliable power when required. It utilizes an advanced calcium-alloy grid technology, which ensures outstanding performance and durability in both continuous and intermittent operation. The ML8-12 is a type of battery that uses Absorbent Glass Mat (AGM) technology and has a valve regulated construction. It is specifically designed to be used in enclosed and indoor locations without any leakage or need for maintenance. This battery offers exceptional performance and is compatible with a wide range of models. MIGHTY MAX SLA batteries are employed in a diverse range of applications, such as consumer electronics, electric vehicles, engine starters, golf carts, hunting, lawn and garden tools, medical mobility devices, motorcycles, power sports equipment, portable tools, solar systems, toys and hobby items, access control devices, emergency lighting, security systems, and more.

Fig. 3.8 Battery

3.2.6 Buck-Converter

A buck converter, also known as a step-down converter, is a type of DC-to-DC power converter that reduces voltage while consuming less average current. It takes input from a power supply and delivers it to a load at a lower voltage. A switched-mode power supply (SMPS) is a type of power supply that usually consists of a minimum of two semiconductors (a diode and a transistor, although modern buck converters often use a second transistor instead of a diode for synchronous rectification) and at least one energy storage component, such as a capacitor, inductor, or a combination of both. In order to minimize voltage fluctuations, capacitors (sometimes in conjunction with inductors) are typically incorporated into the output (load-side filter) and input (supply-side filter) of such a converter. The term "buck converter" is used because the voltage across the inductor counteracts or opposes the supply voltage.

Fig. 3.9 DC to DC Buck-Converter

The DC to DC Buck Converter Step Down Module LM2596 Power Supply is a highly efficient step-down switching regulator that can handle a load of up to 3 amps while maintaining great control over both input voltage and load variations. The devices are offered in predetermined output voltages of 3.3 V, 5 V, 12 V, and a customizable output version. The LM2596 series functions at a switching frequency of 150kHz, which enables the use of fewer filter components compared to switching regulators with lower frequencies.

Technical Details of DC to DC Buck converter LM 2596 Power Supply

● The maximum conversion efficiency is 92%.
● Switching frequency: 150KHz
● Maximum output ripple: 30mA9
● Load regulation: ± 0.5%
● Voltage regulation: ± 0.5%
● Dynamic response speed: 200uS at 5%
● Input voltage: 4.75-35V
● Output voltage: 1.25-26V (adjustable)
● Output current: The rated current is 2A, with a maximum of 3A (an additional heat absorber is necessary).
● Conversion Efficiency: Up to 92% (the efficiency increases as the output voltage increases).
● Switching frequency: 150 kHz
● Rectifier: Non-Synchronous Rectification
● Short circuit protection: Current limiting, as the recuperation is not possible
● Operating Temperature: Industrial grade (-40 to +85) (output power 10W or less)

3.2.7 Current Sensor

The ACS712 Current Sensor Module - 5A is capable of detecting current flow of up to 5A.

Accurate detection and regulation of electric current is an essential necessity in a diverse range of applications, such as over-current protection circuits, battery chargers, switching mode power supplies, digital watt meters, and programmable current sources.

The ACS712 Current Sensor Module – 5A utilizes the ACS712 sensor to precisely measure both AC and DC current. The highest detectable current, whether AC or DC, is 5A. The current signal can be read by the analog input/output port of a microcontroller or an Arduino.

Product Description:

Specifications:

- Input Voltage: 4.5V to 5.5V DC
- Measurement Current Range: -5A to 5A
- Sensitivity ranges from 180mV/A to 190mV/A, with a typical value of 185mV/A.

Fig. 3.10 AC Current Sensor

3.2.8 LCD Display

The LCD screen, also known as a liquid crystal display, is an electronic module used for a wide range of applications. The 16x2 LCD display is a fundamental module that finds widespread usage in a variety of devices and circuits. These modules are prioritized over seven sections and numerous more segments.

Fig. 3.11: 16*2 LCD Display

The economic benefits of having an LCD include its ease of programmability, ability to display special and custom characters in seven distinct parts, and the absence of constraints on displaying animations. A 16x2 LCD has the capability to exhibit 16 characters on per line and consists of 2 lines. The LCD screen displays each character using a matrix of pixels measuring 5x7.

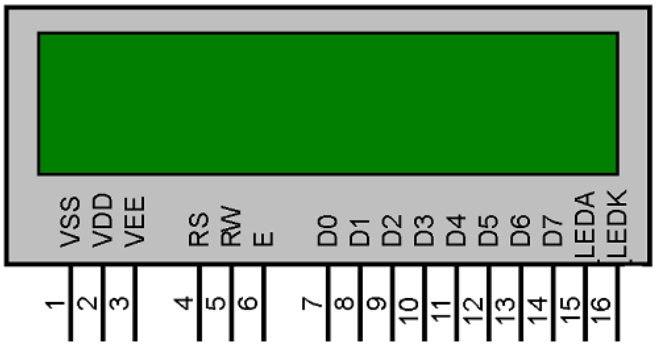


Fig. 3.12 Pin-Out diagram

This LCD display consists of two distinct pieces titled "Command" and "Data". The command register holds the command instructions on the liquid crystal display (LCD). A command is an instruction issued to the LCD (Liquid Crystal Display) to carry out a certain task, such as initiating it, erasing its screen, positioning the cursor, or managing the display.

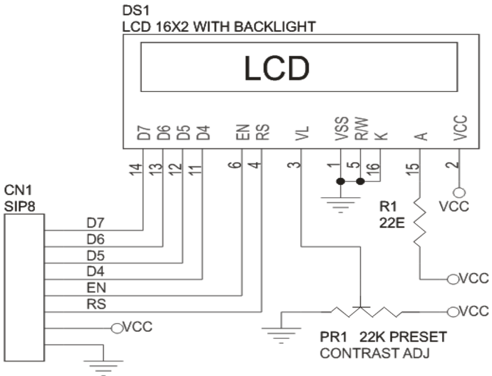


Fig. 3.13 LCD Display with Arduino

Characteristics:

The characteristics of this LCD primarily encompass the following.

- The LCD operates within a voltage range of 4.7V to 5.3V.
- It consists of two rows, with each row capable of displaying 16 characters.
- The current consumption is 1mA when the backlight is not in use.
- Each character can be constructed using a 5×8 pixel box.
- The alphanumeric LCDs display both alphabets and integers.
- The display may operate in two modes: 4-bit and 8-bit.
- It is available with blue and green backlight options.
- The interface exhibits a limited number of uniquely created characters.

3.2.9 Relay

A relay is a switch that is activated by an electrical current. Several relays employ an electromagnet to physically activate a switch, however alternative operating principles, such as solid-state relays, are also utilized. Relays are used where it is necessary to control a circuit by a separate low-power signal, or where several circuits must be controlled by one signal. The first relays were used in long distance telegraph circuits as amplifiers: they repeated the signal coming in from one circuit and re-transmitted it on another circuit. Relays were used extensively in telephone exchanges and early computers to perform logical operations.

Fig. 3.14 Relay

A contactor is a type of relay capable of managing the substantial power needed to directly operate an electric motor or other heavy loads. Solid-state relays utilize semiconductor devices to facilitate switching in power circuits, eliminating the need for any mechanical components. Relays that have precisely calibrated working characteristics and occasionally several operational coils are employed to safeguard electrical circuits from overload or defects. In contemporary electric power systems, these tasks are carried out by digital instruments that are still referred to as "protective relays".

Magnetic latching relays necessitate a single application of coil power to shift their contacts in one direction, and a subsequent, misdirected application to shift them back. Subsequent pulses originating from the identical input do not produce any impact. Magnetic latching relays are beneficial in situations when it is necessary to prevent the contacts from transitioning due to interrupted power. Magnetic latching relays can be equipped with either a single or dual set of coils. When electricity is applied with one polarity on a single coil device, the relay will work in one direction. However, it will reset when the polarity is reversed. When a polarized voltage is delivered to the reset coil of a dual coil device, the contacts will undergo a transition. AC controlled magnetic latch relays utilize single coils that incorporate steering diodes to distinguish between operate and reset instructions.

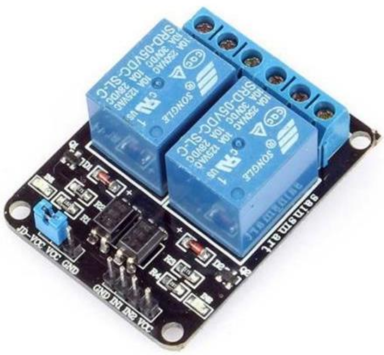


Fig. 3.15 Relay-Module

This module contains a pair of channels, represented by the blue cubes. There exist other types with one, four, and eight channels.

Connections for mains voltage in relation to relays can be categorized into three possibilities.

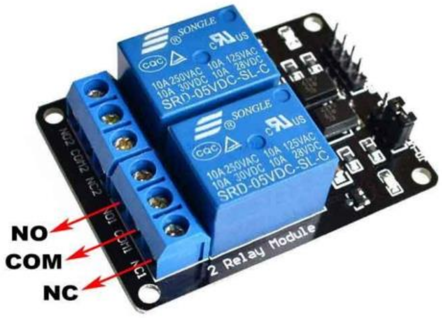


Fig. 3.16 Voltage Connections

COM: shared or commonly used pin
NO: The common pin and the ordinarily open pin are not in touch with each other. When the relay is activated, it establishes a connection with the COM pin and delivers power to a load.
NC: The common pin and the normally closed pin are in touch with each other. The COM and NC pins are always electrically connected, even while the relay is in the off state. When the relay is activated, it opens the circuit and interrupts the power supply to the load.

3.2.10 Voltmeter

Figure 3.18 Voltage Connections

Specification:
Product Category: Mini DC Voltmeter
The display mode is set to a three-digit 0.56in LED digital format. The display color is red.
Quantification Scope: Direct Current The voltage range is 4.5 volts to 30 volts.
Operating Temperature Range: -30℃ to 70℃
Power: Absent
Quantification Issue: Margin of error is ±1%
Input Impedance: Greater than 100 kiloohms Working Current: Less than 23 milliamperes
Refresh Rate: 300 milliseconds per cycle
The cable has a length of 20cm/7.9in. The size of the device is 48*29*22mm/18.9*11.4*8.7in (L*W*H).
Design Element: Reverse Polarity Protection
The package contains a digital voltmeter.

Note:

1. The wiring of the voltmeter is straightforward, requiring only the selection of two lines. It also includes table reversal protection, preventing damage in case of reverse polarity.
2. The initial voltage displayed on the voltmeter is low, with the red reading only 3.2V and the other reading only 2.7V. The green, blue 3.0V voltmeter is capable of accurate measurement. It is the most affordable two-wire voltmeter available worldwide. This will significantly enhance the usability of the lithium battery, particularly for users of the 18650 battery. When the voltage drops below 3.5V, the display brightness decreases, but it does not impact the accuracy of the measurement.
3. To attain maximum measurement precision, the voltmeter will vary its configuration based on the voltage being measured and will automatically adjust the position of the decimal point. Take voltage readings below 10V, with two decimal places displayed; for voltage measurements of 10V, display one decimal place. This device is capable of meeting the requirements of battery users while also addressing the need for accurate measurement of higher voltages.
4. The voltmeter is suitable for motorcycles, cars, and other vehicles to monitor battery voltage and provide timely information on the battery's condition. Alternative voltages can also be employed for the purpose of measuring.

3.3 Use of modern engineering and IT tools

Tools selection

Software for Arduino

The smart microcontroller unit named as Arduino Nano can be programmed with the Arduino software. There is no any requirement for installing other software rather than Arduino. Firstly, Select "Arduino Nano from the Tools, Board menu (according to the microcontroller on your board). The IC used named as ATmega328 on the Arduino Nano comes pre-burned with a boot loader that allows you to upload new code to it without the use of an external hardware programme Communication is using the original STK500 protocol (reference, C header files). We can also bypass the boot loader and program the microcontroller through the ICSP (In Circuit Serial Programming) header. The ATmega16U2 (or 8U2 in the rev1 and rev2 boards) firmware source code is available. The ATmega16U2/8U2 is loaded with a DFU boot loader, which can be activated by: On Rev1 boards: connecting the solder jumper on the back of the board (near the map of Italy) and then resetting the 8U2.   On Rev2 or later boards: there is a resistor that pulling the 8U2/16U2 HWB line to ground, making it easier to put into DFU mode.

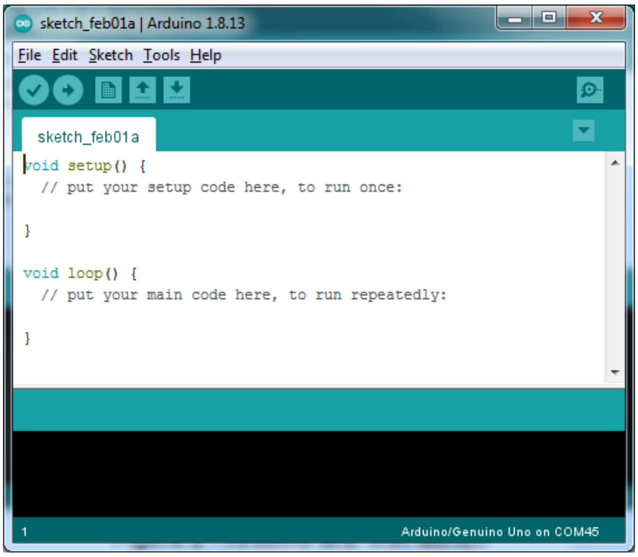


Fig. 3.19 Arduino Software Interface IDE.

The Arduino Nano is one of the latest smart microcontroller units and has a number of facilities for communicating with a computer, another Arduino, or other microcontrollers. The ATmega328 provides UART TTL at (5V) with serial communication, which is available on digital pins 0 -(RX) for receive the data and pin no.1 (TX) for transmit the data. An ATmega16U2 on the board channels this serial communication over USB and appears as a virtual com port to software on the computer. The '16U2 firmware uses the standard USB COM drivers, and no external driver is needed. However, on Windows, an .inf file is required. The Arduino software includes a serial monitor which allows simple textual data to be sent to and from the Arduino board.

The RX and TX LEDs on the board will flash when data is being transmitted via the USB-to-serial chip and USB connection to the computer (but not for serial Communication on pins 0 and 1). A Software Serial library allows for serial communication on any of the Nano's digital pins. The ATmega328 also supports I2C (TWI) and SPI communication. The Arduino software includes a Wire library to simplify use of the I2C bus. Arduino programs are written in C or C++ and the program code written for Arduino is called sketch. The Arduino IDE uses the GNU tool chain and AVR Libc to compile programs, and for uploading the programs it uses avrdude. As the Arduino platform uses Atmel microcontrollers, Atmel's development environment, AVR Studio or the newer Atmel Studio, may also be used to develop software for the Arduino.

Easy EDA

Easy EDA is a web-based EDA tool suite that enables hardware engineers to design, simulate, share-publicly and privately-and discuss schematics, simulations and printed circuit boards. Other features include the creation of a bill of materials, Gerber files and pick and place files and documentary outputs in PDF, PNG and SVG formats. Easy EDA allows the creation and editing of schematic diagrams, SPICE simulation of mixed analogue and digital circuits and the creation and editing of printed circuit board layouts and, optionally, the manufacture of printed circuit boards.

Subscription-free membership is offered for public plus a limited number of private projects. The number of private projects can be increased by contributing high quality public projects, schematic symbols, and PCB footprints and/or by paying a monthly subscription.Registered users can download Gerber files from the tool free of charge; but for a fee, Easy EDA offers a PCB fabrication service. This service is also able to accept Gerber file inputs from third party tools.

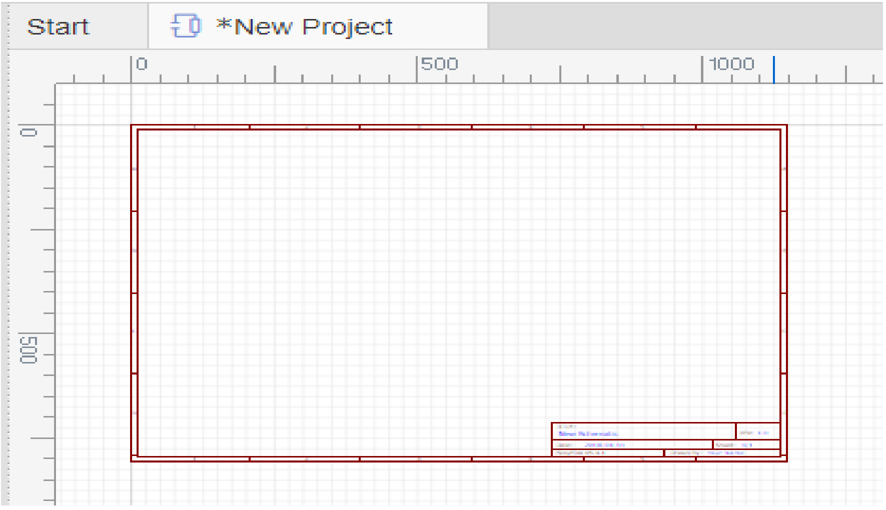


Fig. 3.20 Easy EDA Software Interface

MATLAB:

MATLAB played a crucial role in the project's success as it efficiently handled intricate computations. The task necessitated the processing of large amounts of data, the execution of intricate algorithms, and the implementation of mathematical models connected to operations. A MATLAB-based graphical user interface (GUI) was developed to enhance the efficiency of data retrieval and facilitate the input of data for individuals with minimal technical proficiency. This was done in addition to its computational purpose. MATLAB's proficient graphing and visualization capabilities were utilized to effectively portray project findings, encompassing data trends, system performance, and simulation results. MATLAB's remarkable versatility, which offered crucial computing capabilities, enhanced user engagement, and facilitated the clear and insightful visualization of data, served as the foundation for the entire project, one could argue.

Fig. 3.21 Matlab

3.4 Conclusion

We required software capable of providing statistical data on solar irradiance, PV panels, and inverters for our project. PVsyst was chosen for functional verification and circuit simulation after careful deliberation.

In this particular area, we have mostly acquired knowledge on the process of creating, constructing, and confirming the effectiveness of solutions utilizing modern engineering and IT methodologies. We needed to collect data about the hardware and software that may be employed for this purpose. Consequently, we divided the activities into two distinct categories: software and hardware. Subsequently, we identified the instruments that we may employ for each action. Previously, we conducted a comprehensive comparison and selected the most superior option. In addition, we considered the diverse constraints of the instruments and sought remedies to surmount them. The development and evaluation of the solution utilizing the selected tools. In addition, we had to acquire expertise in specific techniques in order to carry out the tasks. As a result, we sought guidance from manuals, tutorials, articles, and online communities.

Chapter 4

Optimization of Multiple Designs and Finding the Optimal Solution

4.1 Introduction

We must assess the performance of each design based on output efficiency and charge time. We will evaluate both techniques and their different designs to determine the ideal design based on the specified criteria.

Parameter	Original Text	Design 01	Design 02
Power Output	1000 Watts	788 Watts	795 Watts
Voltage	220 V	148 V	156 V
Current	5 Amp	4.2 Amp	3.8 Amp
Charging Duration		3 h	3.3 h
Efficiency		78.8%	79.5%

Parameter	Original Text	Design 01	Design 02
Power Output	250 Watts	218.1 Watts	248.2 Watts
Voltage	29.76 V	24.79 V	29.7 V
Current	8.4 Amp	8.8 Amp	8.3 Amp
Charging Duration		7 h	6.8 h
Efficiency		87.24%	99.28%

Analysis of the first approach:

Original text:

Power output: 1000 watts

Voltage: 220 volts Current: 5 amperes

Design 1:

The power output is 788 watts.

The voltage output is 148 volts.

Current output: 4.2 amperes

Recharging Duration: 3 hours

Effectiveness Computation:

The efficiency is calculated by dividing the output power by the input power and multiplying the result by 100. In this case, the efficiency is 78.8%.

The efficiency is calculated by dividing the output power by the input power and multiplying the result by 100. In this case, the efficiency is 78.8%.

Design 2:

The power output is 795 watts.

The voltage output is 156 volts.

The current output is 3.8 amperes.

Charging duration: 3.3 hours
Calculation of efficiency:
The efficiency is calculated by dividing the output power by the input power and multiplying the result by 100. In this case, the efficiency is equal to (795/1000) * 100, which equals 79.5%.
The efficiency is calculated by dividing the output power by the input power and multiplying the result by 100. In this case, the efficiency is equal to (1000/795) multiplied by 100, which equals 79.5%.

Analysis of the second approach:
Original text:
Power output: 250 watts
Voltage: 29.76 volts Current: 8.4 amperes Design 1 Result:
The power output is 218.1 watts.
The voltage output is 24.79 V.
The current output is 8.8 amperes.
Charging Duration: 7 hours
Calculation of efficiency:
The efficiency is calculated by dividing the output power by the input power and multiplying the result by 100. In this case, the efficiency is 87.24%.
The efficiency is calculated by dividing the output power by the input power and multiplying the result by 100. In this case, the efficiency is 87.24%.

Design 2 has an output power of 248.2 watts.
The voltage output is 29.7 volts.
The current output is 8.3 amperes.
Charging Duration: 6.8 hours
Calculation of efficiency:
The efficiency is calculated by dividing the output power by the input power and multiplying the result by 100. In this case, the efficiency is equal to (248.2/250) × 100, which is 99.28%.
The efficiency is calculated by dividing the output power by the input power and multiplying the result by 100. In this case, the efficiency is 99.28%.

Comparison and Conclusion:

Efficiency:

Approach	**Design 01**	**Design 02**
First	78.8% (Success rate)	79.5% (Success rate)
Second	87.24% (Accuracy rate)	99.28% (Accuracy rate)

Duration of Charging:

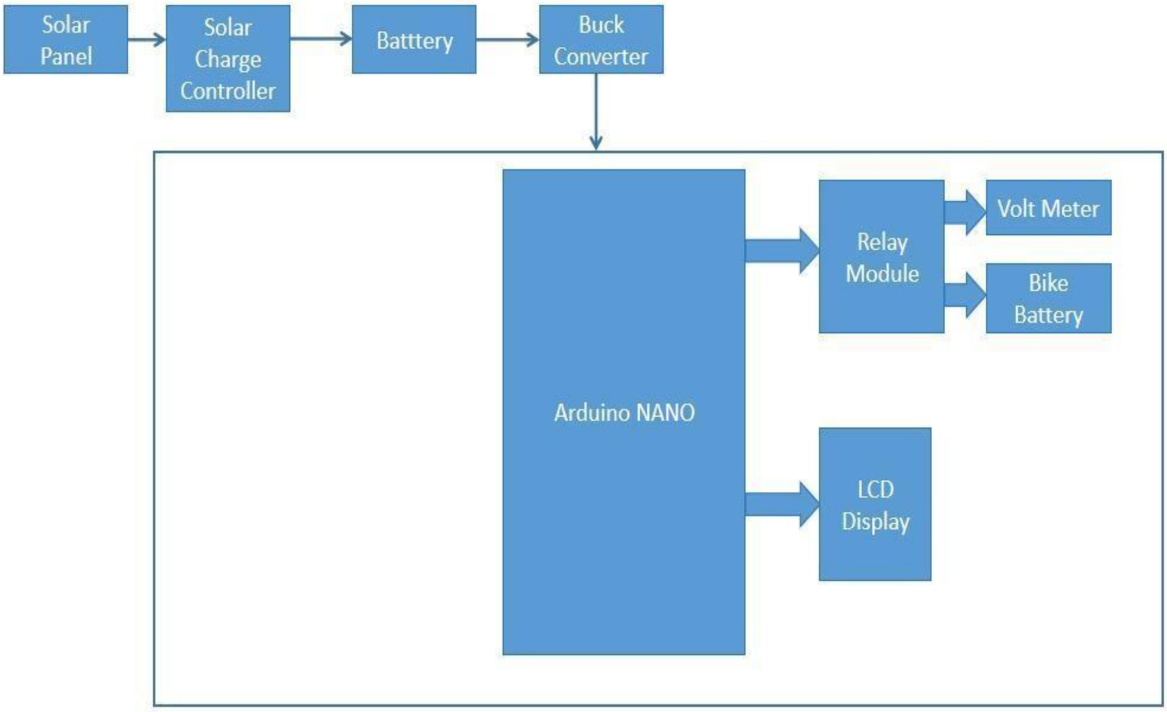
Approach	**Design 01**	**Design 02**
First	3 h	3.3 h
Second	7 h	6.8 h

Based on the analysis, the following observations are made:

Among the designs in the second method, Design 2 exhibits the best efficiency (99.28%) and a lower charging time (6.8 hours) in comparison to Design 1.
Design 2 of the 1st technique exhibits somewhat greater efficiency compared to Design 1 of the same technique, achieving a higher efficiency rate of 79.5%. However, it does require a little longer charging time of 3.3 hours.
Best possible solution:

Based on the criterion of efficiency, Design 2 of the 2nd Approach is the most ideal design due to its nearly flawless efficiency of 99.28%.
If the main aim is to minimize charging time, Design 1 of the 1st Approach is the preferred option, as it offers a charge time of 3 hours.
Design 2 of the 2nd Approach is the most efficient design solution, despite having a longer charging time compared to the designs in the 1st approach.

4.2 Optimization of multiple design approach



4.2.1 Inverter + Solar Controller System

Though MPPT controllers are expensive compared to PWM controllers, they have much higher efficiency. Due to this, we have chosen to use the MPPT controller in our project as the benefits outweigh the cost.

4.2.2 Battery Technology

We have chosen to use lithium-ion batteries for our project as it has higher cycle life expectancy and energy density compared to lead-acid and nickel-metal hydride batteries. The charge-discharge efficiency of lithium-ion batteries is also high and there is no memory effect present.

4.2.3 Load Management

We have chosen to use demand side management in our project as it reduces load on the grid during peak hours and less number of station batteries are required in this approach, helping to keep the upfront cost of the project low.

4.3 Performance evaluation of developed solution

The charger uses solar energy to charge an electric motorcycle battery, gathering sunlight and transforming it into electrical energy. The charging process is controlled by an Arduino Nano, a relay module, a current sensor, and an LCD display and voltmeter.

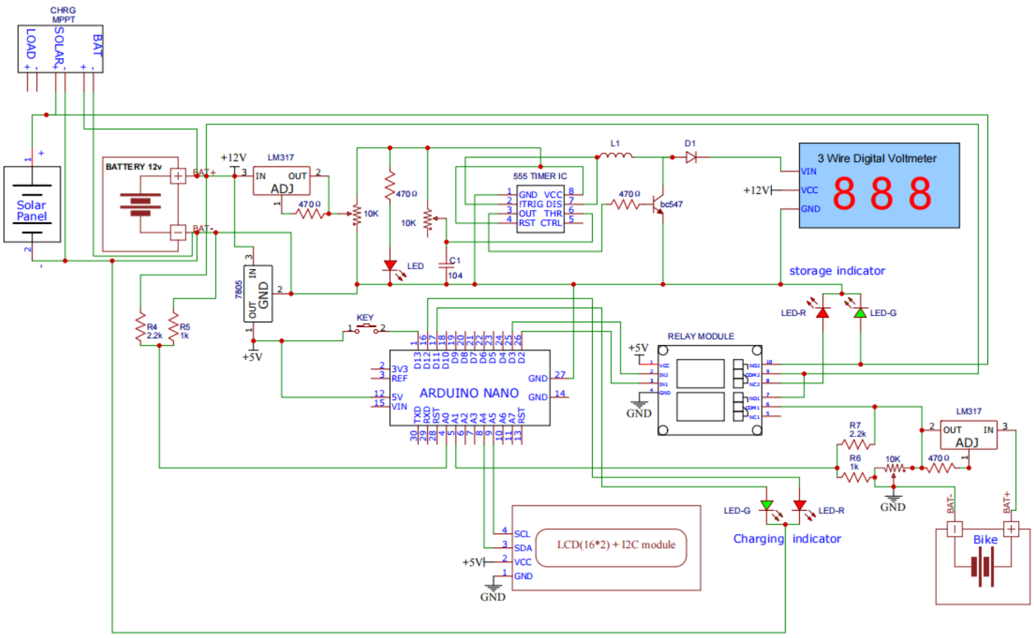
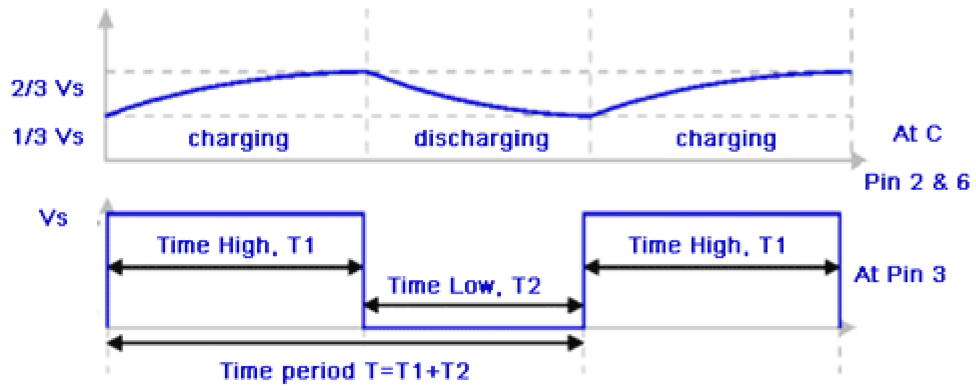


Fig. 4.4.1. Setup of Charging from solar panel using boost -buck converter with MPPT and PI controller in Easy EDA

4.4 Timer 555 A stable Calculator Description

The 555 timer is used to determine the on time and off time of a pulse, which can be utilized for many purposes. The 555 timer A reliable calculator is used to calculate these values, but it requires understanding the formulas based on which the calculator operates.



Parameter	Formulae	Unit
Time High (T1)	0.693 × (R1+R2) × C1	Seconds
Time Low (T2)	0.693 × R2 × C1	Seconds
Time Period (T)	0.693 × (R1+2×R2) × C1	Seconds
Frequency (F)	1.44 / (R1+2×R2) × C1	Hertz (Hz)
Duty Cycle	(T1/T)×100	Percentage (%)

It might be hectic to try different values of Resistor and capacitors to arrive at you desired Time interval and Frequency. So, always keep these below tips in head while selecting your values.

TIPS:

- Period(T) and Frequency(F) are inversely proportional
- Increase in C1 will decrease Frequency (F)
- Increase in R1 will increase High Time (T1) but will not alter low Time (T2)
- Increase in R2 will increase High Time (T1) and also increase low Time (T2)
- So, always set T2 first and then T1
- Increase in R2 will decrease duty cycle

Once we have all these details, we can get to know the complete properties of the output wave. To get used to the formulas lets calculate the value for parameters using these formulas for the circuit diagram given above.

4.5 Conclusion

The ideal design solution for the project includes a fixed tilt arrangement for solar panel tracking, a tilt and MPPT controller, and lithium-ion batteries for enhanced cycle life expectancy. The load regulation is performed by demand side management. A simulation using Easy Eda Simulation was undertaken to evaluate the system's performance. The final design and validation are discussed in Chapter 5.

Chapter 5

Completion of Final Design and Validation

5.1 Introduction

This project introduces a solar-powered charging system for electric bicycles (e-bikes) to encourage sustainable transportation and utilize renewable energy. The system contains a solar panel for solar energy generation, regulated by a solar charge controller, and stored in a battery. The stored energy is transformed utilizing boost and buck converters to maintain acceptable voltage levels for various components. The Arduino Nano microprocessor monitors system conditions using a voltmeter and controls the charging flow through a relay module.

5.2 Completion of final design

Functioning of the system:

The system functions through power generation, energy storage, voltage regulation, and user interface. The solar panel turns sunshine into electrical energy, while the solar charge controller monitors current flow to securely charge the battery. The boost converter alters the battery's voltage to deliver power to the Arduino Nano and other components, while the buck converter regulates voltage to charge the bike battery.

Here is the overall block diagram of our prototype.

5.2.1 Solar power generation and charging station battery:

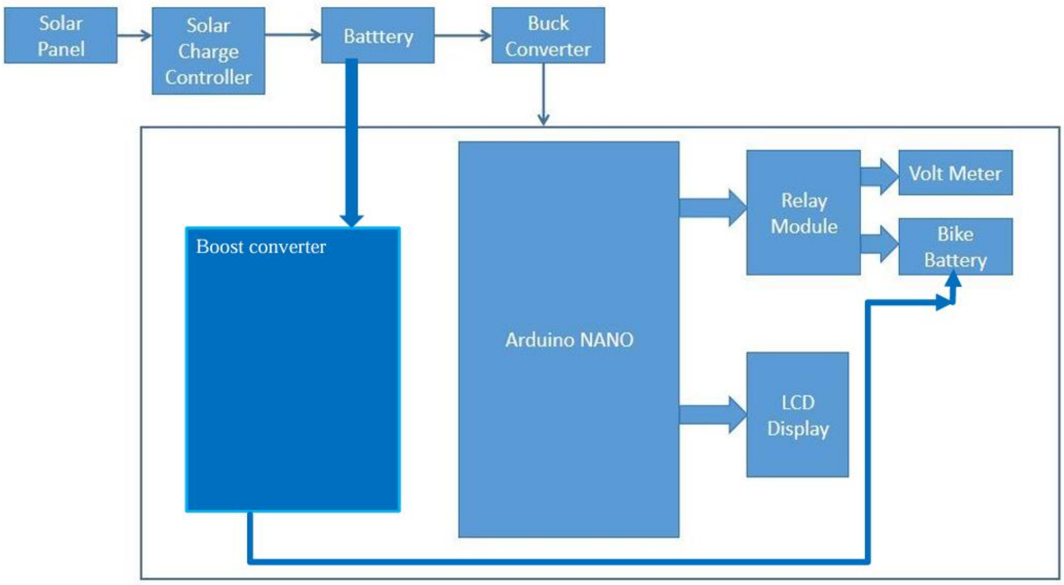


Fig. 5.2.1. Block diagram

In this block diagram, we've displayed our charging system using solar panels, a charging controller, a storage battery etc. From the storage battery, we'll boost the voltage so that we can use that for charging the motorcycle battery. We've used a buck converter for using Arduino Nano. We've also used LCD display, relay module and volt meter.

Fig. 5.2.2. Project Prototype Image

Here is our project prototype image where we've used a 20W solar panel with MPPT charge controller which is linked to the 12V station battery. For further use we've boosted the battery voltage to around 60V. We've used Arduino-Nano, relay module, voltmeter and LCD display.

5.2.2 Control system

We have created a prototype using our block diagram, which is a graphical depiction of the system's design that illustrates the connections between the various components. The prototype is a tangible manifestation of the system that we have developed for the purpose of assessing and analyzing its effectiveness. Below is a comprehensive breakdown of each component of the prototype, outlining their individual functions and features, as well as how they collaborate to accomplish the system's overall objectives. The prototype development procedure entailed transforming the block diagram into a physical and operational system that can be subjected to testing and further improvement. Through the creation of a prototype, we can gain a deeper comprehension of the system's abilities and constraints, allowing us to make any required adjustments prior to proceeding with a complete implementation.

5.2.3 Solar power generation and charging station battery

Fig. 5.2.3. Solar power generation and station battery

We utilize a 20W solar panel in conjunction with an MPPT charge controller for our solar power generating. For our prototype, we choose to utilize a Maximum Power Point Tracking (MPPT) charge controller due to its superior efficiency. The MPPT charge controller is linked to the station batteries. Station batteries will serve as a contingency power source in case of load shedding. During daylight hours, the solar panel produces electrical energy. The MPPT controller optimizes the power extraction from the panels to efficiently charge the station batteries

5.2.4 Safety system

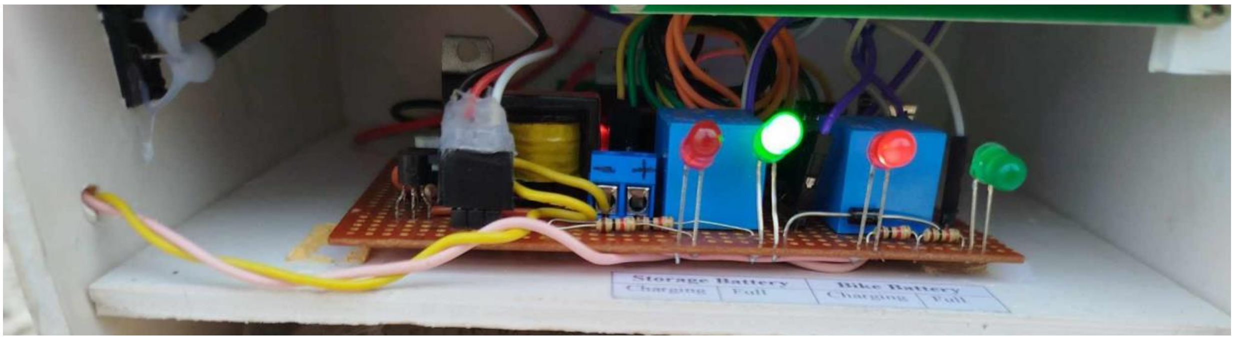


Fig. 5.2.4: Right side Green light is off while charging.

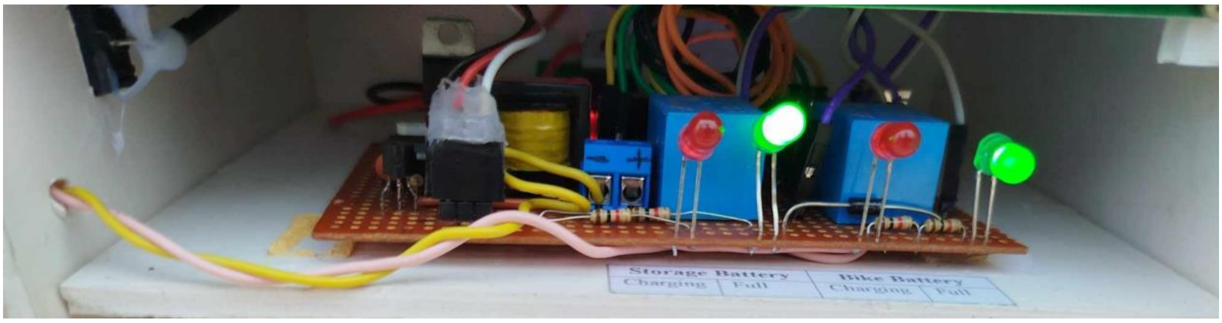


Fig. 5.2.5. Right side Green light is on while charging is complete.

A safety system is employed to prevent battery damage when charging. Relays are used to cut charging when the battery's charge is complete, assuring the safety of both the station and bike battery.

5.2.5 Status LEDs

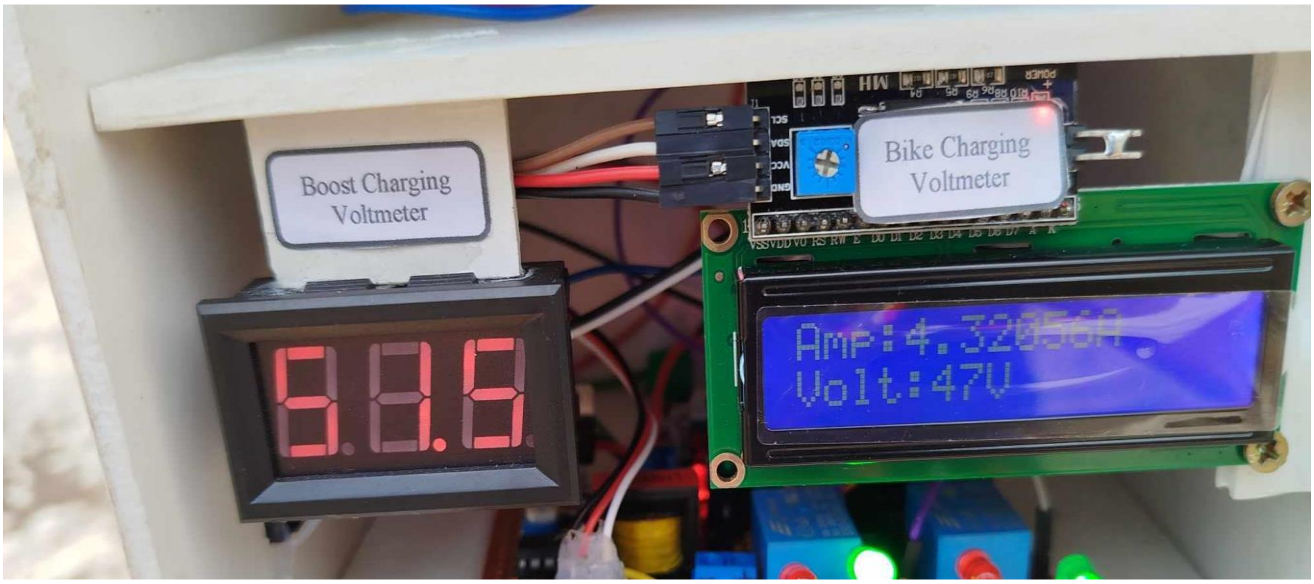


Fig. 5.2.6. Status LEDs

The processes are coordinated using an Arduino Nano microcontroller, which monitors system parameters using a voltmeter and controls the charging flow through a relay module. The system comprises an LCD screen and an LED indication that deliver up-to-the-minute information and status updates to the user. The LCD panel exhibits comprehensive data, including battery voltage, charging status, and system alerts. Meanwhile, the LED indicator offers a swift visual indication of important updates, such as ongoing charging, completed charging, and fault conditions.

5.2.6 BOOST CONVERTER

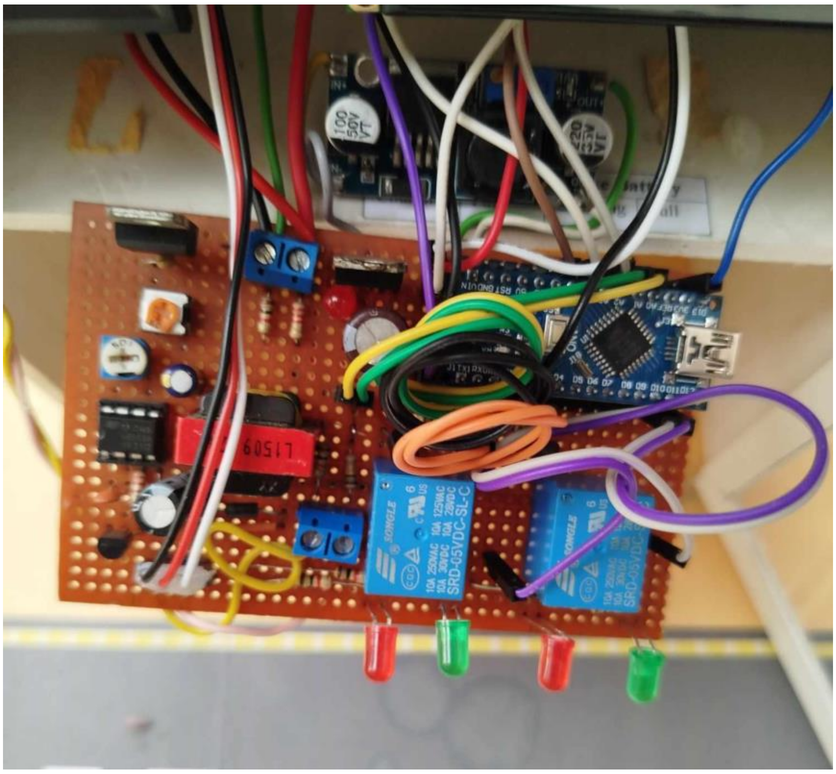


Fig. 5.2.4. Boost converter

A boost converter is necessary for charging a 60V battery from a lower voltage source. It elevates input voltage from a conventional power source to the required 60V, ensuring efficient charging. Modern boost converters use sophisticated control systems to enhance efficiency, eliminate energy wastage, and assure safe operating in varied input conditions. Understanding the operation and structure of a boost converter is vital for establishing efficient and successful charging solutions, which in turn boosts the overall performance and sustainability of electric cars.

Reading	Input (V)	Output (V)
1.	4.25	9.87
2.	5.16	16.70
3.	6.32	27.85
4.	7.5	39.60
5.	8.2	52.13

The performance of our designed boost converter is thoroughly explained in both the accompanying bar graph and table. Here is a comprehensive analysis:

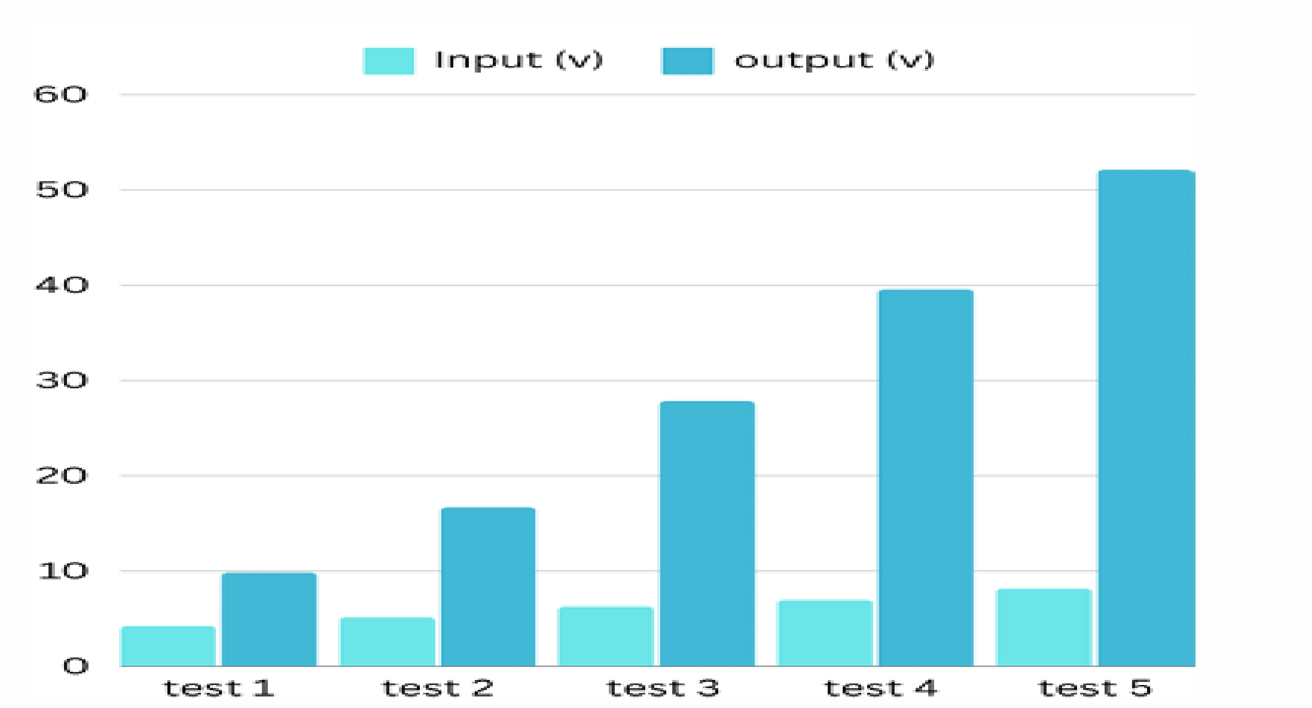


Fig 5.5: input voltage vs. output voltage of our designed boost converter.

Graph Analysis: The bar graph illustrates the correlation between input and output voltages in five different tests. Each set of bars represents a single test, where the left bar displays the input voltage and the right bar displays the output voltage.

First Test:

- Voltage input: Approximately 4.25 volts (shown by the light blue color)

The output voltage is approximately 9.87 volts, indicated by the dark blue color.
The output voltage exceeds the input voltage by more than two times.

Second Test:

- Input: Approximately 5.16 volts - Output: Approximately 16.70 volts - The output voltage is more than three times the input value.

Third test:

- Input: Approximately 6.32 volts - Output: Approximately 27.85 volts - The output voltage is more than four times the input value.

Fourth Test:

- Input: Approximately 7.5 volts - Output: Approximately 39.60 volts - The output voltage is greater than five times the input voltage.

Fifth test:

- Input: Approximately 8.2 volts - Output: Approximately 52.13 volts - The output voltage is over six times more than the input voltage.

Performance Summary: The boost converter is engineered to increase the voltage from a lower input value to a substantially greater output value, as evidenced by both the graph and table. The following are the main observations:

1. Efficiency: The converter efficiently boosts the input voltage to a higher output voltage, and its efficiency improves as the input voltage rises. This is demonstrated by the escalating proportion of output voltage to input voltage observed throughout the tests.

2. Linear Performance: The output voltage consistently and proportionally increases in relation to the input voltage, demonstrating reliable performance over a variety of input values.

3. Scalability: The boost converter is very effective for applications that require huge voltage increases due to its ability to multiply the output voltage by a large factor compared to the input voltage.

Implications: This boost converter is essential in numerous situations when the existing voltage is inadequate and requires amplification. Some examples are power supplies for electronic equipment.

- Battery-powered systems that necessitate greater operating voltages.
- Renewable energy systems require the stabilization and amplification of varying input voltages.

In summary, the data supplied confirms that our proposed boost converter is both extremely efficient and dependable. It can greatly increase the input voltage in order to fulfill the higher voltage needs of various applications.

5.3: Evaluate the solution to meet desired need

Charging through 1hr time:

01:10 pm 01:20 pm 01:30 pm

01:40 pm 01:50 pm 02:00 pm

Fig:5.3: Charging through 1hr time

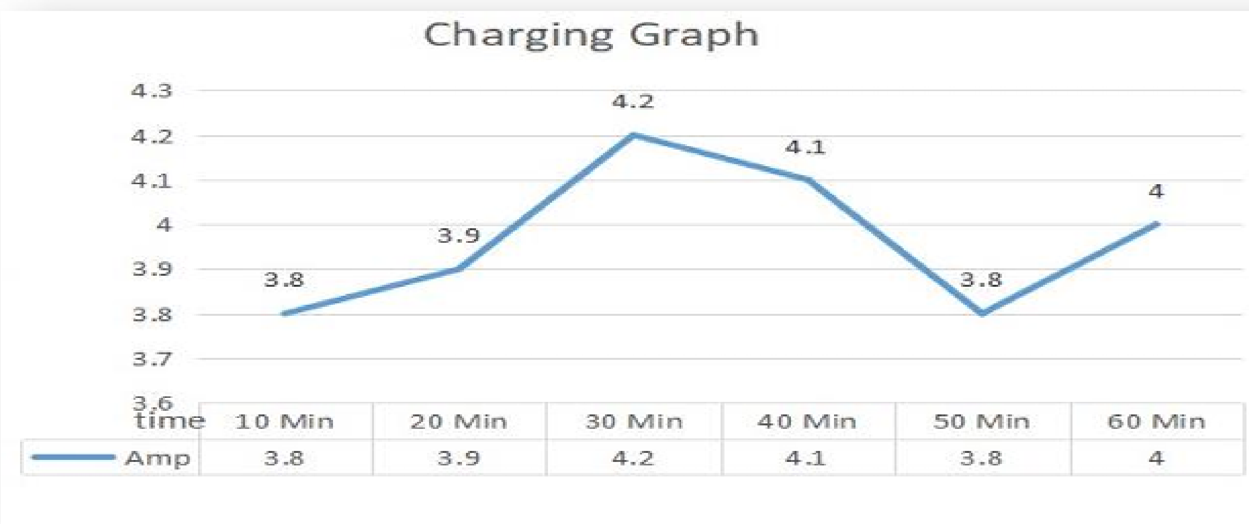


Fig. current reading between 10 min interval.

Analysis of Charging Graph

The graph illustrates the instantaneous electric current (in Amperes) recorded at six distinct time intervals over a 60-minute duration of charging. Below is a comprehensive analysis of each reading:

10 Minutes: The current is 3.8 Amps.
20 Minutes: The current experiences a modest increase to 3.9 Amps.
30 Minutes: The current reaches its maximum value of 4.2 Amps.
40 Minutes: The current experiences a minor reduction to 4.1 Amps.
50 Minutes: The current experiences a noticeable decrease to 3.8 Amps.
60 Minutes: The current increases once again to 4.0 Amps.

The initial surge in current indicates that the charger is gradually reaching its most efficient charging rate.
The user did not provide any text. The spike observed at the 30-minute mark signifies the maximum rate of charging.
The user's text is empty. The minor decline observed at 40 minutes, followed by a significant fall at 50 minutes, may suggest that the battery is approaching a greater level
of charge, prompting the charger to restrict the current flow in order to prevent overcharging.

The user did not provide any text. The increase to 4.0 Amps after 60 minutes may indicate a period of stability, during which the charger adjusts the current for the latter stages of charging.

Calculation of Average Current

To determine the average current during the 60-minute duration, add up all the current measurements and then divide by the total number of measurements:

The average current can be calculated by dividing the sum of the above values (3.8, 3.9, 4.2, 4.1, 3.8, and 4) by 6.

In a systematic and sequential manner:

1. Calculate the sum of the present values:The sum of 3.8, 3.9, 4.2, 4.1, 3.8, and 4 is 23.8.
2. Calculate the quotient of the total and the number of readings (6):The division of 23.8 by 6 results in a value of 3.967 amperes (A).

The mean current during the charging period is 3.967 Amperes Calculation of Charging Time

The charging time is determined by applying the following formula:

The formula for calculating charge time is given by dividing the battery capacity by the product of the charge current and charge efficiency.

Provided:
Battery Capacity: 9 Ampere-Hours (AH)
The average charge current is 3.967 Amps.
Charge Efficiency: Assuming a value of 100% (or 1 for the sake of simplicity)

Apply the given values to the formula:

The charge time can be calculated by dividing 9 ampere-hours by 3.967 amperes.

In a systematic and sequential manner:

1. Compute the outcome:The division of 9 by 3.967 equals 2.27 hours.

The charging time for a 9 AH battery, with an average current of 3.967 Amps and assuming optimum conditions (100% efficiency), is around 2.27 hours.

Practical Considerations:

Charge Efficiency: The effectiveness of the charging process. The charging efficiency in real-world scenarios is frequently lower than 100% due to energy losses, such as heat dissipation. Assuming an efficiency of 90%, the effective charge current would decrease, resulting in a longer charge time.
The user did not provide any text. For instance, assuming an efficiency of 90%, the duration required for charging would be:

The effective current is calculated by multiplying 3.967 by 0.9, resulting in 3.57 A. The charge

$$\textbf{Average current} = \frac{3.8+3.9+4.2+4.1+3.8+4}{6} = \mathbf{3.967A}$$

$$\begin{aligned}\textbf{Charge Time} &= \textbf{Battery Capacity} \div (\textbf{Charge Current} \times \textbf{Charge Efficiency}) \\ &= \mathbf{9AH \div 3.96A} \\ &= \mathbf{2.26\ H}\end{aligned}$$

time is determined by dividing 9 AH by 3.57 A, which equals 2.52 hours.

Summary: The graph depicts the fluctuation in charging current during a 60-minute period, reaching its highest point at the 30-minute mark. The user did not provide any text. The mean current derived from the measurements is 3.967 Amperes. The user did not provide any text. Based on the given average current, it can be predicted that it would take around 2.27 hours to fully charge a 9 AH battery, assuming a 100% efficiency. In practical situations, poorer efficiency would result in a minor increase in the charging time.

This comprehensive examination offers a precise comprehension of the charging process and the computations involved in determining the time required for charging based on current measurements.

5.4 Conclusion

The prototype built for this research indicates the potential of solar electricity to replenish electric vehicle charging stations, reducing dependence on fossil fuels. This solution ensures ongoing charging services during load shedding, enhances energy use, and minimizes energy expenditures. The ability to upload data to a web server enables for remote monitoring and research of the charging station's operational efficiency. Exporting power to the grid allows surplus renewable energy to be returned to the system, boosting overall sustainability.

Chapter 6

Impact Analysis and Project Sustainability

6.1 Introduction

The project's goals—to decrease emissions of greenhouse gases and air pollution by encouraging people to switch from gas-powered to electric vehicles—are not without their flaws. Some of its advantages include a transportation system that uses less energy and produces less greenhouse gas emissions, as well as low operating and maintenance costs for electric vehicle charging stations (EVCS). Nevertheless, there may be constraints, such as power outages caused by load shedding, rising prices for electric vehicle charging, and the amount of time needed to charge an EV. Also, electric vehicle accidents, especially those involving basic bikes, are on the rise in Bangladesh. In spite of these obstacles, the initiative is still expected to generate additional employment opportunities and increase the worldwide use of electric vehicles. This, in turn, will benefit the government and customers alike by decreasing grid demand during peak hours.

6.2 Assess the impact of solution

A brief examination of the impact of renewable energy-based EVCS has been presented, focusing on societal, environmental, economic, health, and legal aspects.

6.2.1 Societal

People could make a smoother transition from internal combustion engines to EVs if they had more convenient charging alternatives, as more charging stations become available. This would allow them to travel greater distances in their electric vehicles, which they were previously unable to accomplish due to a lack of charging facilities. Furthermore, because to the EVCS's minimal grid dependency, there would be less load shedding in an area, resulting in an improved quality of life for residents. Finally, decreased unemployment in society may be seen, as some labor will be required to maintain and operate the EVCS.

6.2.2 Environmental

Electric vehicles (EVs) provide numerous environmental benefits, including lower greenhouse gas emissions and air pollution. This is because they are fueled by clean and sustainable solar energy, with no fossil fuels used to charge them. Furthermore, as more people utilise electric vehicles, the extraction of nonrenewable fossil fuels decreases. Thus, using electric vehicles is an excellent strategy to reduce the environmental impact of transportation.

6.2.3 Economical

The development of electric vehicle charging stations (EVCS) has the potential to significantly benefit the economy. It will generate employment opportunities, resulting in a higher level of living. Furthermore, it will lessen the need to import.

Non-renewable fossil fuels are used to save our foreign cash reserves. It is also more cost effective to travel in EVs because they minimize transportation costs. Furthermore, EVCS's low grid dependency means that less electricity must be imported from other nations. If properly implemented, this initiative will add a new dimension to the renewable sector's industrial potential.

6.2.4 Health

The utilization of renewable energy sources can help to minimize dangerous gas emissions such as nitrogen oxides, sulfur dioxide, and CO2. As a result of the absence of particulate matter, the number of respiratory and cardiovascular disorders may decrease. Using renewable energy sources is an excellent approach to help the environment and keep people healthy.

6.2.5 Legal

As more individuals adopt the proposed EVCS, the number of illegal charging stations would decrease, resulting in less electricity theft from the grid and decreased system loss. To guarantee that EVCS are developed in a safe and responsible manner, distribution firms will develop EVCS-specific criteria. This will help to guarantee that EVCS are used properly and safely.

6.3 SWOT Analysis

SWOT analysis is a crucial instrument for situation monitoring and market analysis. SWOT: Strengths, Weaknesses, Opportunities, and Threats. Internal elements are strengths and weaknesses, whilst external factors are opportunities and dangers [8].The impact of renewable energy-based EVCS is demonstrated below based on a SWOT analysis:

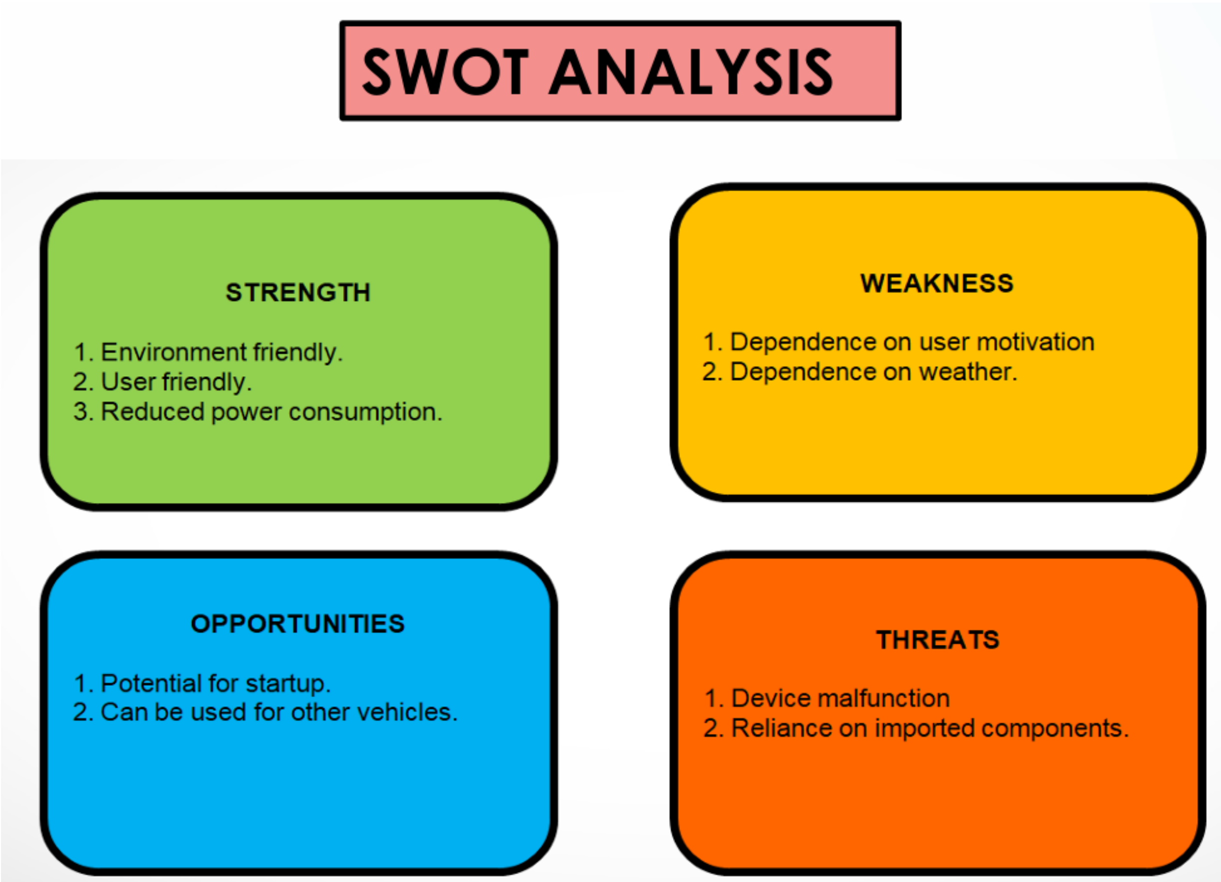


Fig. 6.3.1. SWOT Analysis

6.3.1 Strengths

Installing charge stations for electric vehicles in Bangladesh might help the nation adapt to climate change while also drastically cutting down on air pollution. In 2016, the nation took the initiative to sign the Paris environment Agreement and has since declared plans to adapt to the changing environment[8]. The absence of carbon dioxide emissions makes plug-in electric automobiles environmentally friendly. As foreign countries migrate from fuel-powered automobiles to electric vehicles, the requirement for charging stations is expanding. Charges on imported automobiles are planned to be slashed by 15-50 percent as the Bangladeshi government pushes the adoption of electric vehicles [8]. Companies that introduce electric automobiles to Bangladesh have a higher chance of attracting customers and controlling the market because these cars are still relatively new and unknown. As a result, the requirement for charging stations in Bangladesh is likely to expand considerably.

6.3.2 Weaknesses

Load shedding [7] in Bangladesh happens due to the gap between maximum demand and supply, with 9% of electricity lost due to auxiliary use at generating plants, transmission, and distribution networks. The daily load curve indicates that load increases during peak hours and drops during off-peak hours. The increased energy demand from electric vehicles puts additional strain on infrastructure, impeding charging of electric vehicles. In Bangladesh, a complete charge of an electric auto-rickshaw or simple bike costs 120 to 150 BDT a day, and charging takes 6 to 8 hours everyday. Most electric cars in Bangladesh suffer from speed concerns, and the government forbids the usage of electric vehicles, mostly simple motorcycles and auto-rickshaws, due to their excessive electricity consumption. However, the electricity business operates numerous EV charging stations, and the absence of government aid makes it impossible to spread the usage of electric vehicles. Electric EVs are currently a widespread source of traffic accidents across Bangladesh, as there is no designated road for these vehicles and most drivers are unskilled.

6.3.3 Opportunities

The demand for electric vehicle charging stations is increasing, with a substantial section of the population in Bangladesh lacking energy security. However, the country has made attempts to create renewable energy-based power plants and has witnessed growth in the global car market. In the 2017-2018 fiscal year, there were 5,24,016 registered automobiles, demonstrating a strong development for the car sector [8]. As the number of autos imported each year increases, there is a great possibility that more electric vehicles will reach Bangladesh. To fulfill this demand, more charging stations need to be deployed. Bangladesh's large market, with around 160 million people, is unsaturated due to the absence of viable EV enterprises. The administration has taken aggressive initiatives to adapt to climate change, using resources and international collaborations. This openness allows organizations to create electric vehicle enterprises throughout the country, creating awareness about environmental sustainability. Lithium-ion batteries offer advantages over lead-acid batteries, such as increased power density, longer life, and superior performance at hotter temperatures. This presents a possibility to enhance battery technology and generate demand for EVCS. As fossil fuel supply depletes, prices climb, making electric vehicles a feasible alternative to current fossil fuel-powered automobiles.

6.3.4 Threats

Bangladesh confronts a dearth of power sources and charging stations due to its underdeveloped position. The country's single national system has a total installed capacity of 25,514 megawatts, however demand surpasses supply. Political instability since 1971 has severely influenced the economy, making it a top issue for threats. Electric vehicles (EVs) represent a new era of technology, however due to their early development, there may be a lack of parts. The Bangladesh Road Transport Authority (BRTA) lacks standards for registering EVs, however a legislative framework should be devised to encourage sustainable use of energy-efficient vehicles [7]. The BRTA lacks regulations for registering EVs, making it a potential danger.

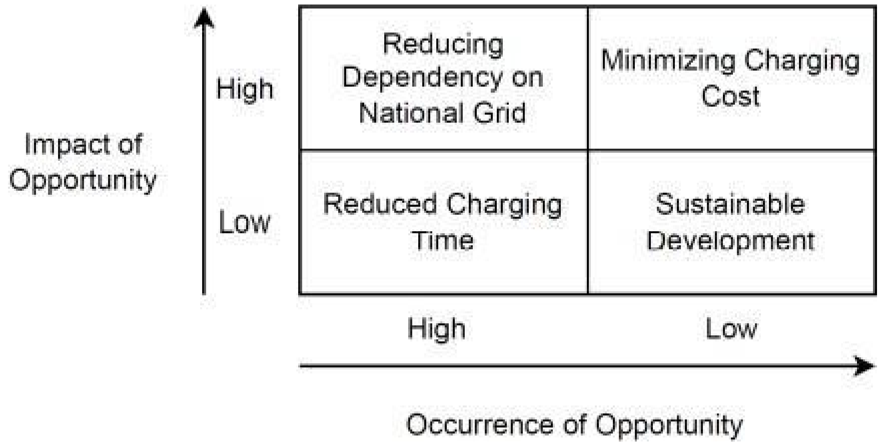


Fig. 6.3.2. Opportunity Matrix

6.4 Evaluate the sustainability

The actual deployment of the charging station system raises sustainability challenges that must be thoroughly investigated and evaluated from multiple perspectives. Several sustainability challenges have been evaluated in terms of their social, environmental, economic, and societal implications.

6.4.1 Social Aspects towards Sustainability

To address the social aspects of sustainability, EVs offer a number of activities, including pleasant service delivery, opportunities for social interaction, and enhanced mobility. The majority of passengers are satisfied with the social aspects, particularly the mobility of the easy bikes. 88% of users respect the function of simple bikes because of their wider service coverage and well-connected servicing facilities. Furthermore, the majority of passengers (56%) say that the easy-bike service is more pleasant than other kinds of public transportation such as buses, vans and rickshaws, while only 37% believe that it is less comfortable because it can only It can accommodate six people at a time. However, these simple bikes make it easier for people of various financial backgrounds and genders to mingle socially. Thus, 48% of respondents believe it has a considerable positive impact on social mixing. However, the majority of passengers (51%) are dissatisfied with the safety features, claiming that frequent bike accidents are caused by uncontrolled movement and bad management. [9]

6.4.2 Economic Aspects towards Sustainability

The cost per full charge for simple bikes in Bangladesh is between 120 and 150 BDT, with typical voyage expenditures between 20 and 40 BDT. In Khulna City Corporation (KCC), passengers pay 15-20 BDT per visit and 5 BDT per kilometer, making the service pricing reasonable and inexpensive. The target population is those who use easy bikes to earn a living, and the idea is to lower the 120BDT threshold to make charging more cheap. This idea benefits the grid and the government, as simple bikes add to the grid's burden during the evening peak. Bangladesh's geographical location makes it excellent for renewable energy sources, such as solar energy. A BESS and renewable energy generation at the charging station would enable the system to run independently of the grid, lessening the pressure on the grid during peak hours. A software research reveals a positive long-term financial cash flow for an on-grid solution.

6.4.3 Environmental Aspects for Sustainability

Easy bikes emit significantly less pollution than motorised vehicles powered by petrol or diesel. 83% of passengers appreciate the impact of simple biking to air pollution [9]. Because easy bikes contribute less to environmental pollution and emit no greenhouse gases, the demand for EVCS will increase, and our effort will help to keep the environment cleaner. As a result, the adverse effects and diseases associated with bronchitis, lung disease, stroke, and other conditions will be reduced. When lithium-ion batteries have served their purpose, proper disposal creates severe environmental concerns. By choosing an on-grid system over an off-grid or hybrid system, we were able to completely remove the use of batteries, making our project more environmentally friendly.

6.5 Conclusion.

The degree to which a project is sustainable influences its efficiency. It is not worth investing time, effort, and money in something that will not last long. In the same way, we carefully assessed our project to determine how sustainable it was. Fortunately, ours is extremely sustainable in all three areas: social, economic, and environmental. This is because there would be no negative environmental implications, such as nuclear waste or air pollution caused by the release of gases such as carbon dioxide.

Chapter 7

Engineering Project Management

7.1 Introduction

To successfully complete an engineering project, you must first understand the components of effective engineering project management. This includes making better use of resources, reducing waste, and completing projects more swiftly and effectively. Project management specialists use cost estimates, project timetables, and the project lifecycle to develop practical and effective project plans. This allows them to detect and reduce project risks such as money restrictions, schedule constraints, and resource availability. Understanding the components of high-quality engineering project management allows you to plan a successful project path while reducing risks.

7.2 Define, plan, and manage engineering projects.

An engineering project manager has a wide range of tasks to guarantee that their team completes projects on time and within budget. Engineering project management is a way used by managers to keep control over their projects, ensuring that team members can achieve the project's final goals while also steering the scope of a project in the right direction. To accomplish this, project managers must apply a wide range of skills, both general managerial skills and those that are more specifically applicable to someone working in the engineering business. The work involved in an engineering project can be realistically accomplished by working group members, but the engineering project manager is responsible with helping this effort, as the execution of an engineering project is a significant task that necessitates a high level of teamwork.

The project consisted of three major phases: topic selection, design, and prototype creation. To address these processes, three stages were designated: EEE400P (problem selection), EEE400D (software development), and EEE400C (hardware implementation). Every stage required the completion of specific activities, which were represented by Gantt charts that showed the amount of time allotted to each step. A log book is also kept to chart progress whenever a peer discussion or a conversation with the project coordinator occurs. Initially, the Gantt charts for EEE400P, EEE400D, and EEE400C were developed during the EEE400P course. The predicted timeline and tasks in the Gantt charts were based on a one-year prediction. The EEE400P and EEE400D Gantt charts were then updated, and project progress in each course was evaluated accordingly. The EEE400C Gantt chart was also revised to comply to the timetable and track project progress during the implementation stage. Technical challenges caused some delays in the plans and duties, but these were quickly resolved once the downsides were addressed.

7.3 Evaluate project progress

Gantt Chart

Planned **Actual**

EEE400P	Week												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Identifying the topic statement	Toushik,Labib												
	Orun,Hedayatul												
Topic confirmation		Toushik,Labib											
		Orun,Hedayatul											
Data collection via survey		Toushik,Labib											
			Orun,Hedayatul										
Research & literature review		Toushik,Labib											
			Orun,Hedayatul										
Concept note preparation			Toushik,Labib										
				Orun,Hedayatul									
Additional research							Toushik,Labib						

							Orun,Hedayatul						
Progress presentation practice										Toushik,Labib			
									Orun,Hedayatul				
Final progress presentation											Toushik,Labib		
										Orun,Hedayatul			

<table>
<tr><th>EEE400D</th><th colspan="13">Week</th></tr>
<tr><td></td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>10</td><td>11</td><td>12</td><td>13</td></tr>
<tr><td>Tool exploration</td><td colspan="4"></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">• Software One (Homer)</td><td colspan="4">Toushik,Labib</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td colspan="4">Orun,Hedayatul</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">2 Software one (PVsyst)</td><td></td><td></td><td colspan="4">Toushik,Labib</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="5">Orun,Hedayatul</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">1. Software three (simulink)</td><td></td><td></td><td></td><td></td><td colspan="4">Toushik,Labib</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td colspan="4">Orun,Hedayatul</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">Data analysis</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="2">Toushik, Labib</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td colspan="6">Orun,Hedayatul</td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">Implementation of design in softwares</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="3">Toushik,Labib</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="6">Orun,Hedayatul</td></tr>
<tr><td rowspan="2">Finalisation of work</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="4">Toushik,Labib</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="4">Orun,Hedayatul</td></tr>
</table>

<table>
<tr><th>EEE400C</th><th colspan="13">Week</th></tr>
<tr><td></td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>10</td><td>11</td><td>12</td><td>13</td></tr>
<tr><td rowspan="2">Gathering Data</td><td colspan="2">Toushik,Labib</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="3">Orun,Hedayatul</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">Obtaining outcome matching with simulation</td><td></td><td></td><td colspan="3">Toushik,Labib</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td colspan="3">Orun,Hedayatul</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">Simulation validation preparation</td><td></td><td></td><td></td><td></td><td></td><td colspan="4">Toushik,Labib</td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td colspan="3">Orun,Hedayatul</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">Practical testing of the prototype</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="5">Toushik,Labib</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="6">Orun,Hedayatul</td><td></td></tr>
<tr><td rowspan="2">Project final report presentation</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="4">Toushik,Labib</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="3">Orun,Hedayatul</td></tr>
</table>

7.4 Conclusion

The successful completion of tasks in EEE400P, EEE400D, and now EEE400C may be attributed to the effective management of the timetable and gantt charts provided among participants. The logbook has also helped keep track of progress and ensure that all chores are done on schedule. Time management has been critical to the project's successful completion, as working as a team and supporting one another has proven to be important in its progress. With these components in place, we were able to obtain the anticipated satisfying results within the timeframe allowed.

Chapter 8
Economic analysis

8.1 Introduction

Economic analysis is an important component of engineering projects since it may provide an accurate depiction of the cost and benefit of implementing a certain project. Economic analysis can assist uncover potential cost reductions or inefficiencies in a project, as well as potential revenue streams. Economic analysis allows engineers to better comprehend the financial ramifications of their projects and make informed decisions about how to continue. Furthermore, economic analysis can provide insight into the potential hazards involved with a project, as well as aid in the identification of risk mitigation techniques. Finally, economic analysis is an important skill for engineers since it may assist them ensure that their projects are both cost effective and lucrative. We selected to do our economic analysis by assessing our actual scenario budget in PVSyst to determine whether the profit generated by the charging station would be sufficient to make it worthwhile.

8.2 Economic analysis

Sl.no	articulars	Specification	Qty.	Unit Price (Taka)	Total Price (Taka)
1	Solar Panel		2	750	1500
2	Solar Control		1	195	195
3	Battery		5	2000	10000
5	Buck Converter		1	100	100
6	Current Sensor		1	250	250
7	Arduino Nano		1	750	750
8	Relay Module		1	220	240
9	LCD Display		1	1200	1200
10	Volt Meter		1		
				Total	13735/=

8.3 Cost benefit analysis

We utilized PVSyst to assess the financial components of our actual project scenario. We have entered the cost of the components and relevant characteristics into PVSyst. The energy output of a photovoltaic (PV) system is directly proportional to the solar irradiance received by the solar panels. Soiling loss is the result of the accumulation of dust, dirt, and other material on the panels, which obstructs the passage of sunlight. The magnitude of this loss can vary considerably, contingent upon the geographical location of the system. Various factors, such as wind, dirt, rain, and bird populations, can influence the extent of soiling loss. We adjusted the soiling loss to a value of 3%. Solar panels experience a decline in electricity generation as they age. To achieve this, we have established a module degradation rate of 0.4% each year. Solar panels typically have a lifespan of around 30 years, during which their efficiency significantly declines. Hence, we have established a project duration of 30 years, as the solar panels and batteries necessitate replacement beyond that timeframe.

As per the data from Bangladesh Bank, the inflation rate in Bangladesh averaged 5.54% in December 2021. Hence, we configured the inflation rate in PVSyst to 5.54%. Based on our survey, we have determined that the charging stations charge approximately 150 BDT for charging a single electric bike. Every simple bicycle possesses a battery capacity of 10 kilowatt-hours. Hence, the price of electricity supplied to the simple bikes is 15 BDT per kilowatt-hour. To maintain competitiveness with other charging stations, we have decided to set the rate at 15 BDT per kilowatt-hour. In addition, we have established a depreciation rate for the equipment using the straight-line method over a period of 30 years.

Upon doing an analysis of the project in PVSyst using the aforementioned criteria, the payback period of the charging station was determined to be 5 years. The ROI was 340%. Hence, the project is viable.

8.4 Evaluate economic and financial aspects

Despite the hefty initial expenditure, it is evident that the charging station is capable of generating a positive net cash flow after 5 years. It is important to acknowledge that the solar panels and battery experience degradation as time passes. It is evident that, over a span of 20 years, the panels have experienced degradation, resulting in a decline in annual profit. After a period of 30 years, it is necessary to replace the panels and batteries of the charging station. Continuing to operate the station with degraded panels would lead to a loss in efficiency.

8.5 Conclusion

Based on our study, we can conclude that the project is profitable within the parameters specified. The economic analysis allows the project team to make informed judgements about the project's cost and viability, as well as identify potential risks and possibilities. It helps to ensure that the project is financially viable and will get the required results. It also aids in identifying cost-cutting and revenue-generating opportunities while keeping the project on track. Project teams may ensure the success and cost-effectiveness of their engineering projects by approaching them economically.

Chapter 9

Ethics and Professional Responsibilities

9.1 Introduction

Ethics and professional obligations refer to the ethical principles and behavioral norms that influence engineers' activity in the profession. They describe engineers' responsibilities to their employers, clients, the public, and the profession itself. They are founded on the principles of honesty, integrity, respect, accountability, fairness, and concern for the greater good. These principles are intended to ensure that engineers act with honesty, uphold public confidence, and apply their knowledge and abilities to the benefit of society.

9.2 Identify ethical issues and professional responsibilities.

There are various ethical concerns and professional duties that may develop in the setting of a renewable energy-powered electric vehicle charging station. Some of these include:

9.2.1 Environmental Responsibility

As a provider of renewable energy solutions, the charging station has a professional obligation to reduce its environmental impact and contribute to the transition to low-carbon transportation. This could include taking steps to save resources, reduce waste, and safeguard natural areas.

9.2.2 Consumer protection.

The charging station is responsible for protecting its clients' interests and providing accurate and clear information about the services it offers. This involves ensuring that customers are reasonably compensated for their electricity usage and that any fees or levies are explicitly stated.

9.2.3 - Health and Safety

The charging station must guarantee that its operations do not jeopardise the health and safety of personnel, customers, or the general public. This may include putting in place suitable safety measures and procedures, as well as providing personnel with training and information.

9.2.4 Data Protection

As a charging service provider, the charging station is likely to gather and process personal information from its consumers. It is responsible for protecting this data and ensuring that it is used in line with applicable laws and regulations, including the General Data Protection Regulation (GDPR).

9.3 Apply ethical and professional responsibilities.

To address ethical concerns and professional duties, the charging station should consider implementing the following measures:

9.3.1: Environmental responsibility.

The charging station can reduce its environmental impact by integrating energy-saving technologies, eco-friendly materials, and waste reduction and recycling programmes. It may also explore offsetting any carbon emissions from its operations.

9.3.2 Consumer protection.

The charging station can defend its customers' interests by offering clear and transparent pricing, terms, and conditions. It can also put in place rules and procedures to address consumer complaints and concerns in a fair and timely manner.

9.3.3 Health and Safety

The charging station can protect the health and safety of its staff, customers, and the general public by implementing suitable safety precautions and procedures. This may include providing personnel with training and resources, maintaining equipment and buildings, and establishing emergency response plans.

9.3.4 Data Protection

To protect its customers' personal data, the charging station can utilize appropriate security measures such as encryption and secure storage to prevent unauthorized access or misuse. It can also verify that it complies with applicable rules and regulations, such as the GDPR, which requires enterprises to seek consumers' consent before collecting and using their personal data.

9.4 Conclusion.

Ethics and professional responsibility play critical roles in the operation and maintenance of an EVCS. This involves adhering to regulatory requirements, assuring adequate maintenance and operation of equipment, and making transparent and responsible financial decisions. Furthermore, environmental responsibility must be prioritized by reducing the EVCS's influence on the natural environment. Consumer protection is also an important factor, as the EVCS must provide a safe and dependable service to its customers. Health and safety must be prioritized, as the EVCS poses threats to both workers and users. Finally, data protection is critical since the EVCS may handle sensitive personal and financial information, which must be kept secure. Failure to maintain ethical and professional standards in these areas can have a negative impact on the EVCS, its stakeholders, and the communities it serves. To ensure the EVCS's success and sustainability, all involved must prioritize ethics and professional responsibility.

Chapter 10

Conclusion and Future Work

10.1 Project Summary

To summarize the project, we performed research and surveys on our problem and developed requirements based on the problem definition. Once the criteria were defined, a variety of design techniques were discovered that could be employed to tackle the problem. The design approaches were evaluated to determine the best one. Then we used various engineering tools and software to identify and evaluate the best solution for our selected design approach. A scaled-down prototype hardware implementation was then constructed and tested to ensure that the system's performance met the requirements. Finally, an economic analysis was conducted to see whether the proposal was feasible.

10.2 Future work.

While the prototype works as intended, more work needs to be done to improve and develop the system even more. The system would become more reliable, robust, and user-friendly as it was developed. It would also result in more consistent profit generating for the EVCS.

Control from the web server: The web server might be expanded to include features such as viewing previous charging sessions, beginning and stopping charging over the web, and creating an automated invoice for each charging session. Other features that could be added include user tracking, MFS payment options (such as bKash and Upay), and so on.

Daily solar forecast using machine learning: Daily prediction of solar output could aid in ensuring that the station batteries can be charged using solar power. If solar power is expected to be insufficient for the following day, off-peak power could be used to charge the station's batteries.

Integration with other renewable energy sources: The EVCS might be integrated with other renewable energy sources, such as wind, to improve the system's overall sustainability and reliability.

Energy storage optimization: The EVCS could experiment with various energy storage technologies and configurations to improve the system's ability to store and use renewable energy efficiently.

Integration with smart grid technologies: The EVCS might be combined with smart grid technologies to optimize the usage of renewable energy resources and increase overall energy system efficiency.

Charging speed improvement: Research and development could be carried out to explore ways to improve the EVCS's charging speed, making the charging procedure more convenient and efficient for users.

Expansion of the system: The prototype might be expanded to include new components or capabilities, such as the capacity to charge different types of cars or to meet increased demand.

Chapter 11

Identification of Complex Engineering Problems and Activities

11.1 Identify the attribute of complex engineering problem (EP)

TABLE 11.1. ATTRIBUTES OF COMPLEX ENGINEERING PROBLEMS (EP)

	Attributes	**Put tick (√) as appropriate**
P1	Depth of knowledge required	√
P2	Range of conflicting requirements	√
P3	Depth of analysis required	√
P4	Familiarity of issues	
P5	Extent of applicable codes	
P6	Extent of stakeholder involvement and needs	√
P7	Interdependence	√

11.2 Provide reasoning how the project address selected attribute (EP)

Depth of knowledge required:

Engineering fundamental and specialization knowledge was used to design the project. While planning the project a good amount of research literature was studied to gather relevant information.

Range of conflicting requirements:

Charging a higher number of vehicles will increase the establishment cost which might not meet the budget specified by stakeholders.

Depth of analysis required:

Data collected from field survey and research literatures were analyzed and 3 alternate design approaches were proposed and compared.

Extent of stakeholder involvement and needs:

Field survey conducted on stakeholders to collect data (easy bike drivers)

Interdependence:

The charging system is heavily dependent on the solar system as it operates by taking stored energy from the station batteries. The station batteries are charged by the solar system.

11.3 Identify the attribute of complex engineering activities (EA)

TABLE 11.2. ATTRIBUTES OF COMPLEX ENGINEERING ACTIVITIES (EA)

	Attributes	**Put tick (√) as appropriate**
A1	Range of resource	√
A2	Level of interaction	√
A3	Innovation	
A4	Consequences for society and the environment	√
A5	Familiarity	

11.4 Provide reasoning how the project address selected attribute (EA)

Range of resource:
Met with one of the stakeholders (easy bike drivers) to know their requirements. Overall project plan is designed (including budget with contingency and work-flow) to be completed within the project timeline.

Level of interaction:
The budget specified by stakeholders might force components with lower specification to be used, bringing down overall performance of the charging station.

Consequences for society and the environment:
There will be significant reduction in GHG emissions and less pollution in the environment. People will have a higher quality of life due to increased employment and less load shedding

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Appendix

Transmitter Programming

```
#include <LiquidCrystal_I2C.h>
LiquidCrystal_I2C lcd(0x27, 16, 2);  // I2C address 0x3F, 16 column and 2 rows 27or3F

int batttery=A0;
int bat;
int charger = A1;
int crg;

int relay1=2;
int relay2=3;

int ledg=11;
int ledr=12;

int button=13;


const int sensorIn = A2;
int mVperAmp = 10; // use 100 for 20A Module and 66 for 30A Module
double Voltage = 0;
double VRMS = 0;
float AmpsRMS = 0;
int watt=0;
int volt = 220;
double kwh=0;
int bill = 0;
float countt =0;
int count = 0 ;


void setup() {
  // put your setup code here, to run once:
Serial.begin(9600);
pinMode(batttery,INPUT);
pinMode(charger,INPUT);
```

```
pinMode(relay1,OUTPUT);
pinMode(relay2,OUTPUT);

pinMode(ledg,OUTPUT);
pinMode(ledr,OUTPUT);

pinMode(button,INPUT);

pinMode(sensorIn , INPUT);

 lcd.init();      // initialize the lcd
  lcd.backlight(); // open the backlight
}

void loop() {
  // put your main code here, to run repeatedly:
bat=analogRead(batttery);
crg=analogRead(charger);
int but=digitalRead(button);

int volt=crg/59.79;
Serial.print("battery");
Serial.print(bat   );
Serial.print("charger");
Serial.println(crg);
Serial.print("button");
Serial.println(but);
 float result;
  int readValue;             //value read from the sensor
  int maxValue = 0;          // store max value here
  int minValue = 1024;          // store min value here

   uint32_t start_time = millis();
   while((millis()-start_time) < 1000) //sample for 1 Sec
   {
       readValue = analogRead(sensorIn);
       // see if you have a new maxValue
       if (readValue > maxValue)
       {
           /*record the maximum sensor value*/
```

```
          maxValue = readValue;
       }
       if (readValue < minValue)
       {
          /*record the maximum sensor value*/
          minValue = readValue;
       }
   }

   // Subtract min from max
   result = ((maxValue - minValue) * 5.0)/18.0;

 Voltage = result;
 VRMS =(Voltage/2.0) *0.707;
 AmpsRMS = ((VRMS * 1000)/mVperAmp)/50;
//watt=AmpsRMS*volt;

 Serial.print(" amp ");
Serial.println(AmpsRMS);



delay(1000);
if(bat>0 && bat<775){
  digitalWrite(relay1,HIGH);
  }
 if(bat>775){
  digitalWrite(relay1,LOW);
  }
if(but==1){
        lcd.clear();
    digitalWrite(relay2,HIGH);
  }
  if(but==0){
      lcd.clear();
    lcd.setCursor(0,0);
lcd.print("Amp:");
lcd.setCursor(4,0);
lcd.print("0");
lcd.print("A                ");
  digitalWrite(relay2,LOW);
```

```
  }
if(crg>=0 && crg<550){
    digitalWrite(ledg,LOW);
        digitalWrite(ledr,HIGH);
  }
if(crg>550){
  digitalWrite(ledr,LOW);
        digitalWrite(ledg,HIGH);



  }
if(but==1 && crg>=30){
  lcd.clear();
   lcd.setCursor(0,0);
lcd.print("Amp:");
lcd.setCursor(4,0);
lcd.print(AmpsRMS,5);
lcd.print("A");
lcd.setCursor(0,1);
lcd.print("Volt:");
lcd.setCursor(5,1);
lcd.print(volt);
lcd.print("V   ");

}

}
```

Log Book

Final Year Design Project (P)

Date/Time /Place	Attendee	Summary of Meeting Minutes	Responsible	Comment by ATC
02.07.2023 (Group meeting-2)	**Students:** 1.Orun 2.Labib 3.Hedayatul 4.Toushik	2. Shared and discussed our project ideas 3. Shortlisting 3 ideas among 5 project ideas 3. Evaluated whether the selected topic ideas are complex engineering problems or not.	Task 1: Everyone Task 2: Everyone Task 3: Everyone **Progress:** Task 1: Completed Task 2: Completed Task 3: Completed	
05.07.2023 (ATC meeting-1)	1.Dr. Md. Mosaddequr Rahman. 2.Mohaimenul Islam. **Students** 1.Orun 2.Labib 3.Hedayatul 4.Toushik	1. ATC Introduction. 2. Directed to do further background research on selected 1 ideas from 3 ideas . 3. Send mail to ATC with our finalized ideas with supporting research papers.	Task 1: Everyone Task 2: Everyone Task 3: Labib **Progress:** Task 1: Completed Task 2: Completed Task 3: Completed	

06.07.2023 (Group meetin g-3)	**Students:** 1.Orun 2.Labib 3.Hedayatul 4.Toushik	1. Background research on efficient charger for electric motorcycle research papers.	Task 1: Everyone **Progress:** Task 1: Completed	
08.07.2023 (Group meetin g-4)	**Students:** 1.Orun 2.Labib 3.Hedayatul 4.Toushik	1. Discussed about how we can make efficient charger for electric motorcycle.	Task 1: Everyone **Progress:** Task 1: Completed	
09.07.2023 (Group meeting-5)	**Students:** 1.Orun 2.Labib 3.Hedayatul 4.Toushik	1. Project Title Selection 2. Writing problem statement . 3. Writing tentative objectives as 4.In depth discussion and study research papers for multiple	Task 1: Everyone Task 2: Everyone **Progress:** Task 1: Completed Task 2: Completed	
10.07.2023 (Group meeting-6)	**Students:** 1.Orun 2.Labib 3.Hedayatul 4.Toushik	1.design approach as a draft for concept note 2. In depth discussion and study research papers for multiple design approach as a draft for concept note 3. Design Methodology for charger.	Task 1: Everyone Task 2: Everyone task 3: Everyone **Progress:** Task 1: Completed Task 2: Completed Task 3: Completed	

11.07.2023 (Group meeting-7)	**Students:** 1.Orun 2.Labib 3.Hedayatul 4.Toushik	1. Identify the functional, non-functional and system level requirements of our project. 2. Discussion about the specification of our project and finding the components based on the specification. 3. Adding references in the concept note. 4. Citing references in the problem statement. 5. Adding comparison criteria. 6. Adding attributes of Complex Engineering Problems in the concept note.	Task 1: Everyone Task 2: Everyone Task 3: Toushik Task 4: Orun & Labib Task 5: Hedayatul task 6: Everyone **Progress:** Task 1: Completed Task 2: Completed Task 3: Completed Task 4: Completed Task 5: Completed Task 6: Completed	
12.07.2023 (Group meeting-8)	**Students:** 1.Orun 2.Labib 3.Hedayatul 4.Toushik	1. Review the draft concept note and take necessary corrections. 2. Update the logbook	Task 1: Everyone Task 2: orun Task 3: Hedayatul Task 4: Everyone	

		3. Mail Draft Concept Book to ATC panel 4. Prepared slide for presentation	**Progress:** Task 1: Completed Task 2: Completed	

23.07.2023 (ATC meeting-2)	**ATC members:** Mohaimenul Islam. **Students:** 1.Orun 2.Labib 3.Hedayatul 4.Toushik	1. Get feedback from the ATC panel and fully correct the draft concept note.	Task 1: Everyone **Progress:** Task 1: Completed	1.Get feedback to identify more for functional requirements and design approach.
30.07.2023 (Group meeting-9)	**Students:** 1.Orun 2.Labib 3.Hedayatul 4.Toushik	1. Planning about writing the project proposal. 2. Planning the tentative budget. 3. Update logbook	Task 1: Everyone Task 2: orun Task 3: Labib **Progress:** Task 1: Completed Task 2: Completed Task 3: Completed	

07.08.2023 (Group meeting-10)	**Students:** 1.Orun 2.Labib 3.Hedayatul 4.Toushik	1. Started working on Budget and Project planning. 2. Started writing the Gantt chart and Tabulation. 3. Started making the flowchart for Methodology part 4. Started making the sustainability matrix.	Task 1: Orun and Hedayatul Task 2: Toushik Task 3: Labib Task 4: Labib **Progress:** Task 1: Partially Completed Task 2: Partially Completed Task 3: Partially Completed Task 4: Partially Completed	
14.08.2023 (Group meeting -11)	1.Orun 2.Labib 3.Hedayatul 4.Toushik	1. Complete the detailed flowchart and start writing the Methodology. 2. Start writing the Expected outcome and impact. 3. Complete the tentative budget for 3 design approaches.	Task 1: Labib Task 2: Orun Task 3: Toushik and Hedayatul **Progress:** Task 1: Completed Task 2: Partially Completed Task 3: Completed	

Final Year Design Project (D)

Date/Time /Place	Attendee	Summary of Meeting Minutes	Responsible	Comment by ATC
20.10.2023 (Group meeting-1)	**Students:** 1.Orun 2.Labib 3.Hedayatul 4.Toushik	1. Shared and discussed our whole project . 2.Discussed about simulation part	Task 1: Everyone Task 2: Everyone **Progress:** Task 1: Completed Task 2: Completed	
21.10.2023 (ATC meeting-2)	1.Orun 2.Labib 3.Hedayatul 4.Toushik	**1.**Divided simulation part among us. 2.Discussed about calculation part.	Task 1: Everyone Task 2: Everyone **Progress:** Task 1: Completed Task 2: completed	

28.10.2023 (Group meeting-3)	1.Orun 2.Labib 3.Hedayatul 4.Toushik	1.Find out some mistake in simulation part and try to fixed it.	Task 1: Everyone **Progress:** Task 1: Completed

30.10.2023 (Group meeting-4)	**Students:** 1.Orun 2.Labib 3.Hedayatul 4.Toushik	1. Make slide for progress presentation.	Task 1: Everyone **Progress:** Task 1: Incompleted
31.10.2023 (Group meeting-5)	**Students:** 1.Orun 2.Labib 3.Hedayatul 4.Toushik	1. Make slide for progress presentation.	Task 1: Everyone **Progress:** Task 1: Completed
09.11.2023 (Group meeting-6)	**Students:** 1.Orun 2.Labib 3.Hedayatul 4.Toushik	1. Done with our design approach 1 simulation.	Task 1: Everyone **Progress:** Task 1: Completed
10.11.2023 (Group meeting-7)	**Students:** 1.Orun 2.Labib 3.Hedayatul 4.Toushik	1. Start calculation part design approach 1	Task 1: Everyone **Progress:** Task 1: Completed

17.11.2023 (Group meeting-8)	**Students:** 1.Orun 2.Labib 3.Hedayatul 4.Toushik	1.Done with our design approach 2 simulation.	Task 1: Everyone Task 5: Hedayatul task 6: Everyone **Progress:** Task 1: Completed
23.11.2023 (Group meeting-9)	**Students:** 1.Orun 2.Labib 3.Hedayatul 4.Toushik	1. Start calculation part design approach 2 2. Update the logbook	Task 1: Everyone Task 2: orun **Progress:** Task 1:

			Completed Task 2: Completed

24.11.2023 (ATC meeting-10)	**ATC members:** Mohaimenul Islam. **Students:** 1.Orun 2.Labib 3.Hedayatul 4.Toushik	1. Get feedback from the ATC panel and correct some calculation part	Task 1: Everyone **Progress:** Task 1: Completed	1.Get feedback to calculation part.
30.11.2023 (Group meeting-11)	**Students:** 1.Orun 2.Labib 3.Hedayatul 4.Toushik	1. Planning about final presentation. 2. Update logbook	Task 1: Everyone Task 2: Toshio **Progress:** Task 1: Completed Task 2: Completed	

06.12.2023 (Group meeting-12)	**Students:** 1.Orun 2.Labib 3.Hedayatul 4.Toushik	1. Report review	Task 1: Everyone. **Progress:** Task 1: Partially Completed
12.12.2023 (Group meeting-13)	1.Orun 2.Labib 3.Hedayatul 4.Toushik	1.Make slide for final presentation.	Task 1: Everyone **Progress:** Task 1: Completed

20.12.2023 (Group meeting-14)	1.Orun 2.Labib 3.Hedayatul 4.Toushik	1. Complete the report.	Task 1: Everyone **Progress:** Task 1: Completed

Final Year Design Project (C)

Date	**Attendance**	**Summary of Meeting**	**Responsible**	**Comment by ATC**
15.01.24	All Members	Discuss about the project and buy components	All	
20.01.24	All Members	• Ordered some components • Bought two 12V battery • Develop in simulation part	Task 1: Orun Task 2: Hedayatul,Toushik Task 3: Labib	Task Complete
25.01.24	Labib	Do the Mathematical Calculation	Labib	Some corrections need to do
09.02.24	All Members	1. Mathlab works and graphs	Task 1: Labib Task 2: Hedayatul, Orun	Need to overview some points

		2. Problem statements, objectives, requirements and specifications 3. Design approach, methodology, project plan	Task 3: Labib and Toushik	
11.02.24		Make slides and overview previous reports	All	
13.02.24	All Members	Discuss about mistakes and solution for that	All	
14.02.24	All Members	Overview the slides and draft report	All	
15.02.24	All Members	Discuss about the whole project and future work	All	
16.02.24		Try to do the simulation part	Labib	Suggested to do in other software
18.02.24	Toushik and Labib	Necessary Components	Hedayatul	Task done
20.02.24	Hedayatul and Orun	Boost converter design	All	Suggested to work more to get an adequate result
25.02.24	All Members	Discuss about making the boost converter from 12V to get 60V	Hedayatul, Labib	
01.03.24	Hedayatul and Labib	Proper boost converter for the project	All	Task done
06.03.24	All Members	Make slides for progress presentation	All	Some information needs to be added

10.03.24	All Members	1. Testing the components that we ordered 2. Making the prototype with Cardboard 3. Connecting the components	Task 1: Hedayatul, Labib Task 2: Toushik Task 3: Orun	
17.03.24	All Members	Making the charger to get 60V output	All	Task complete
25.03.24	Hedayatul, Orun, Labib	Buck converter design for Arduino nano for safety purposes	Labib and Orun	
01.04.24	All Members	Initially done with one storage battery and one charging battery	Hedayatul and Toushik	Suggested to add 3 more 12V battery
16.04.24	All Members	Project ready with 12V storage battery and 48V charging battery for Bike	All	Task done
25.04.24	All Members	Writing the report	All	Some errors occurred and suggested fixing them
05.05.24	All Members	Writing the report	All	
01.06.24	All Members	Writing the report	All	Task Completed