A Major Project Report on

Solar and Wind Power Based Electrical Vehicles

Submitted in partial fulfillment for the award of the degree of Bachelor of Technology in

Electronics and Communication Engineering

by

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Under the esteemed Guidance of

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CERTIFICATE

This is to certify that the Major Project titled "Solar and Wind Power Based Electrical Vehicles" is a bonafide work carried over by Ms. Akshara Punreddy (21321A0409) in partial fulfilment of the requirements for the award of the degree Bachelor of Technology in Electronics and Communication Engineering from Bhoj Reddy Engineering College for Women, Hyderabad, affiliated to Jawaharlal Nehru Technological University Hyderabad (JNTUH) during the Fourth Year second semester of their B. Tech course (academic year 2024-2025).

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Table of Contents

List of Figures

List of Figures

Abstract

The Solar-Wind Electric Vehicle (SWEV) is a forward-thinking innovation in sustainable transportation that combines solar and wind energy harvesting systems with electric vehicle (EV) technology to improve energy efficiency, extend operational range, and reduce environmental impact. By integrating two renewable energy sources, the SWEV addresses key limitations of traditional EVs, such as limited range and dependence on external charging infrastructure. The design features high-efficiency photovoltaic panels mounted on the roof, hood, and other surfaces to maximize sunlight capture, converting solar energy into electricity that is stored in an onboard battery system. At the same time, a lightweight wind turbine is strategically positioned to harness airflow during vehicle motion, generating additional power and supplementing the energy provided by the solar panels. This dual energy collection system allows the vehicle to generate power both while in motion and when stationary, ensuring continuous energy accumulation and minimizing the need for frequent recharging from external power sources. The onboard battery, typically a lithium-ion or solid-state system, stores the harvested energy and powers the electric motor, while a smart power management system optimizes the distribution of energy between the motor, battery, and auxiliary systems, enhancing overall performance and efficiency. The combination of solar and wind energy significantly reduces the vehicle's carbon footprint by eliminating greenhouse gas emissions, contributing to cleaner air and supporting global efforts to combat climate change. The SWEV's simple yet effective design also promotes energy independence by reducing reliance on fossil fuels and electricity grids, aligning with the broader shift toward renewable energy adoption and sustainable development. While challenges such as limited surface area for solar panels, weather dependency, and the need for further advancements in photovoltaic efficiency and battery storage remain, ongoing technological progress is steadily addressing these obstacles.

Chapter 1

Introduction

1.1 Introduction

The Solar-Wind Electric Vehicle (SWEV) represents a significant leap forward in the pursuit of sustainable and eco-friendly transportation. As the global community grapples with the dual challenges of energy security and environmental degradation, the integration of renewable energy sources into the automotive industry has become a focal point of innovation. The SWEV is a pioneering concept that combines solar and wind energy harvesting systems with electric vehicle (EV) technology to create a more efficient, self-sustaining mode of transport. This approach not only reduces reliance on fossil fuels but also contributes to the reduction of greenhouse gas emissions, aligning with global efforts to combat climate change and promote greener mobility solutions.

At the heart of the SWEV's design are high-efficiency photovoltaic panels and a compact wind turbine, strategically integrated to maximize energy capture. The solar panels, mounted on the vehicle's roof and hood, convert sunlight into electrical energy, which is stored in an onboard battery system. Simultaneously, the wind turbine harnesses airflow during vehicle motion, generating additional power to further enhance the vehicle's energy efficiency. This dual energy system ensures that power generation occurs both while the vehicle is stationary and in motion, thereby extending the operational range and minimizing the need for frequent external charging.

The primary objective of the SWEV project is to demonstrate the feasibility of utilizing renewable energy to power electric vehicles, thereby reducing the consumption of fossil fuels and decreasing carbon emissions. By leveraging readily available solar and wind energy, the project aims to provide a cost-effective, environmentally friendly alternative to traditional gasoline-powered vehicles. The SWEV not only lowers operational costs by utilizing free energy from natural sources but also addresses the growing demand for energy independence and sustainable transportation solutions.

Despite its numerous advantages, the development of SWEV technology is not without challenges. Limitations in surface area for solar panels, dependency on weather conditions, and the current state of battery storage technology pose significant hurdles. However, ongoing advancements in photovoltaic efficiency, battery capacity, and lightweight materials are gradually addressing these limitations, enhancing the practicality and scalability of the SWEV concept.

In conclusion, the Solar-Wind Electric Vehicle stands as a testament to the potential of renewable energy integration in the automotive sector. This project not only contributes to the reduction of environmental pollution but also paves the way for a future where transportation is driven by clean, sustainable energy. As technology continues to evolve, the SWEV is poised to become a cornerstone in the shift towards a greener, more resilient transportation ecosystem.

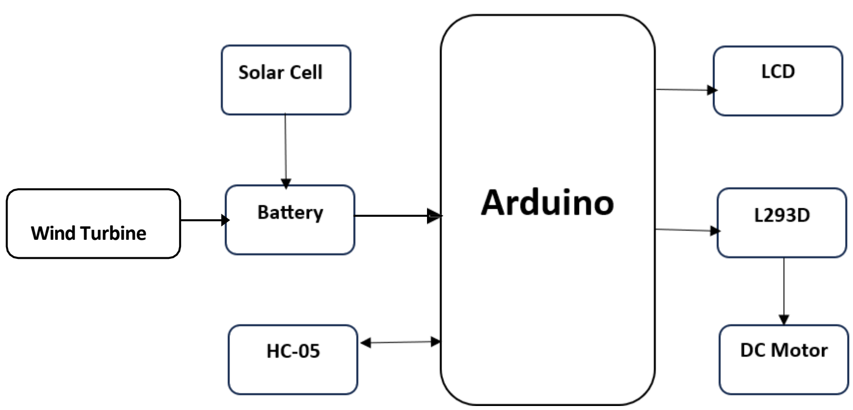


Figure 1.1: Block Diagram of Solar and Wind Power Electric Vehicles

1.2 Literature Survey

Electric vehicle are seen as a means of reducing carbon emissions for transport operations. The first mass produced fully electric vehicle was the Nissan leaf. The number of leafs sold passed 50,000 on the 14th feb, 2013 and the total mileage covered by leafs has exceeded 161millions miles.

The sales of battery electric vehicles such as the leaf are exceeding those of the Toyota prius, the first mass produced hybrid vehicle, at an equivalent stage of its market life. e-ISSN: 2582-5208 International Research Journal of Modernization in Engineering Technology and Science

Vehicle to grid technology, allowing electric vehicles to act as a powersources, is seen as major selling point for electric vehicle technology. The use of vehicle batteries in this way means that overnight charging the vehicles can be used as localized buffers to smooth the load on the power supply grid. This project not only contributes to the reduction of environmental pollution but also paves the way for a future where transportation is driven by clean, sustainable energy.

The US Department of defense is investing $20million to demonstrate the concept using a fleet of electric vehicles and it is believed that the use of the vehicles in this way will offset the increased purchase costs of the electric vehicles.

A further advantage offered by battery electric vehicles is the removal of emissions from the point of operations, offering improved air quality in congested cities.

Despite the sales achieved, EV uptake has so far fallen short of expectations. The main reasons are related to perceptions of poor performance and range along with cost.

Most of the vehicles are running on the gasoline fuels. These vehicles exhaust hazards gases. This increases the environmental pollution in the world. In recent years to reduce the pollution researchers have given the solution of EV’s or hybrid vehicles and many countries adopted this as one of the best solutions to reduce pollution. The popularity is due to battery and silent operations. The present challenge is the optimization of best battery and charging. This project not only contributes to the reduction of environmental pollution but also paves the way for a future where transportation is driven by clean, sustainable energy.

1.3 Aim of the Project

The aim of this project is to design and develop a Solar-Wind Electric Vehicle (SWEV) that utilizes renewable energy sources solar and wind to power an electric vehicle. By integrating photovoltaic panels and a wind turbine into the vehicle's structure, the project seeks to reduce reliance on fossil fuels, lower carbon emissions, and promote sustainable transportation. This project aims to create a cost-effective, eco-friendly vehicle that can generate power both while in motion and when stationary, contributing to energy efficiency, environmental preservation, and long-term energy security.

1.4 Objectives

- To explore the integration of solar and wind energy in electric vehicles (EVs).
- To assess the efficiency and sustainability of Solar-Wind Electric Vehicles (SWEVs).
- To provide insights into the design and functionality of the SWEV system
- To reduce dependency on fossil fuels by utilizing renewable energy sources for vehicle propulsion
- To minimize environmental pollution through the development of a zero-emission transportation system.
- To analyze the performance of solar panels and wind turbines under varying environmental conditions.
- To design an efficient energy management system for storing and distributing power to the electric motor.
- To develop a lightweight and cost-effective vehicle structure that maximizes energy efficiency.
- To promote awareness and encourage adoption of green technologies in transportation.
- To evaluate the feasibility of integrating hybrid renewable systems into existing electric vehicle frameworks.
- To implement a monitoring system for real-time tracking of energy input, battery status.

1.5 Organization of the Report

Chapter 1 consists of Solar and Wind power based electrical vehicles Chapter 2 consists of Introduction to embedded system. Chapter 3 consists of Solar and Wind power based electrical vehicles. Chapter 4 Hardware description existing work, proposed work and results. Chapter 5 consists of Software details. Chapter 6 consists of advantages, disadvantages, and applications. Chapter 7 consists of Hardware details. Chapter 8 consists of Result. Chapter 9 conclusion of this project. Chapter 10 consists of references.

1.6 Conclusion

The integration of solar and wind energy into electric vehicles presents a promising solution to current energy challenges. The SWEV not only enhances energy efficiency but also contributes to a more sustainable future by reducing dependence on fossil fuels. Further research and development in this area could lead to widespread adoption and significant environmental benefits.

Chapter 2

Introduction to Embedded System

Each day, our lives become more dependent on 'embedded systems', digital information technology that is embedded in our environment. More than 98% of processors applied today are in embedded systems, and are no longer visible to the customer as 'computers' in the ordinary sense. An Embedded System is a special-purpose system in which the computer is completely encapsulated by or dedicated to the device or system it controls. Unlike a general-purpose computer, such as a personal computer, an embedded system performs one or a few pre-defined tasks, usually with very specific requirements. Since the system is dedicated to specific tasks, design engineers can optimize it, reducing the size and cost of the product. Embedded systems are often mass-produced, benefiting from economies of scale. The increasing use of PC hardware is one of the most important developments in high-end embedded systems in recent years. Hardware costs of high-end systems have dropped dramatically as a result of this trend, making feasible some projects which previously would not have been done because of the high cost of non-PC-based embedded hardware. But software choices for the embedded PC platform are not nearly as attractive as the hardware.

Typically, an embedded system is housed on a single microprocessor board with the programs stored in ROM. Virtually all appliances that have a digital interface watches, microwaves, VCRs, cars utilize embedded systems. Some embedded systems include an operating system, but many are so specialized that the entire logic can be implemented as a single program.

Physically, Embedded Systems range from portable devices such as digital watches and MP3 players, to large stationary installations like traffic lights, factory controllers, or the systems controlling nuclear power plants.

2.1 Features of Embedded Systems

The versatility of the embedded computer system lends itself to utility in all kinds of enterprises, from the simplification of deliverable products to a reduction in costs in their development and manufacture. Complex systems with rich functionality employ special operating systems that take into account major characteristics of embedded systems. Embedded operating systems have minimized footprint and may follow real-time operating system specifics.

The special computers system is usually less powerful than general-purpose systems, although some expectations do exist where embedded systems are very powerful and complicated. Usually, a low power consumption CPU with a limited amount of memory is used in embedded systems. Many embedded systems use very small operating systems; most of these provide very limited operating system capabilities.

Since the embedded system is dedicated to specific tasks, design engineers can optimize it, reducing the size and cost of the product, or increasing the reliability and performance. Some embedded systems are mass-produced, benefiting from economies of scale. Some embedded systems have to operate in extreme environment conditions such as very high temperature & humidity

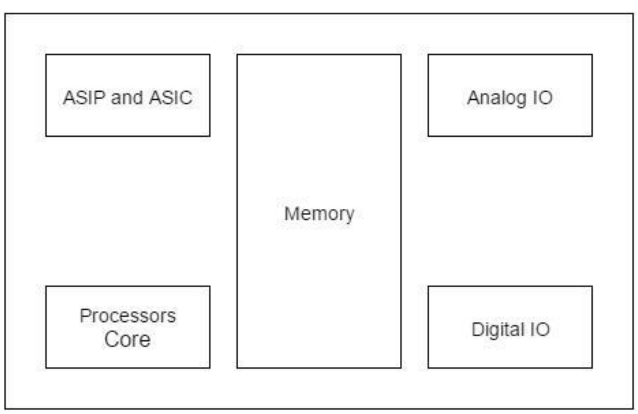


Figure: 2.1 Features of Embedded System

2.2 Working of Embedded System

Embedded systems operate from the combination of hardware and software that focuses on certain operations. An embedded system at its heart has microcontroller or microprocessor hardware on which user writes the code in form of software for control of the system. Here is how it generally works:

- Hardware Layer: Some of the hardware elements that are incorporated in an embedded system include the sensor, actuator, memory, current I/O interfaces as well as power supply. These components are interfaced with the micro controller or microprocessor depending up on the input signals accepted.

- Input/Output (I/O) Interfaces: They to give the system input in form of data from sensors or inputs made by the users and the microcontroller processes the data received. The processed data is then utilized to coordinate the output devices such as displays, motors or communication modules.

- Firmware: which is integrated within a system's hardware comprises of certain instructions to accomplish a task. Such software is often used for real time processing and is tuned to work in the most optimal manner on the system hardware.

- Processing: Depending on the given software and the input data received from the system's inputs the microcontroller calculates the appropriate output or response and manages the system's components.

- Real-time Operation: Some of the most common systems are real time, this implies that they have the ability to process events or inputs at given time. This real time capability makes sure that the system accomplishes its intended function within stated time demands.

For instance, therein an embedded system in a washing machine, the microcontroller would interface with the buttons (selections made by a user), sensors, for instance water levels, temperature and timers; it would control outputs such as motors, heaters and displays .

Hence, among others based on the program intended for washing cycles.

Therefore, the importance of embedded system in modern technology cannot be underestimated because the provide dedicated and reliable system that are efficient for specific use. This is evident from their applications in home use items such as refrigerators, bio-medical applications, and industrial applications where they offer an additional advantage to improving functionality of the many systems. Embedded systems are very important in our lives since they offer automation, enhanced performance and accuracy in our daily lives. Despite the mentioned restrictions like high development costs, and application specific solutions, the advantages clearly outweigh the mentioned drawbacks making the FPGA devices a crucial element of the present-day world.

Embedded systems are specialized computing systems designed to perform dedicated functions or tasks within larger systems. Unlike general-purpose computers, embedded systems are optimized for efficiency, reliability, and real-time performance. They typically consist of a microcontroller or microprocessor, memory, input/output interfaces, and are often embedded into devices like household appliances, automobiles, medical equipment, and industrial machines. These systems play a crucial role in modern technology by enabling automation, control, and communication in various applications, making devices smarter and more responsive.

Embedded systems are the backbone of modern electronic devices, integrating hardware and software to execute specific functions with minimal user intervention. These systems are often designed to operate under real-time constraints and are tailored to meet the requirements of the device they control. From simple applications like digital watches and microwave ovens to complex systems in aerospace and robotics, embedded systems are essential for ensuring precision, speed, and reliability. Their ability to perform dedicated tasks efficiently makes them indispensable in today’s technologically advanced world.

Embedded systems are increasingly becoming more powerful and compact, enabling the development of intelligent devices across various industries. These systems are often built around microcontrollers or microprocessors that are programmed to perform specific tasks reliably and consistently. With advancements in Internet of Things (IoT) technology, and the embedded systems now play a significant role in connecting devices to the internet for data collection, monitoring, and control. Their adaptability and scalability make them vital components in applications ranging from smart homes to industrial automation.

2.3 Conclusion

Embedded systems are specialized computing systems designed to perform dedicated tasks with efficiency, reliability, and low power consumption. They integrate hardware and software to control devices and processes in real-time across various applications, from consumer electronics to industrial automation. Their scalability and versatility continue to drive innovation in technology, shaping modern-day solutions.

Chapter 3

Solar and Wind Power-Based Electric Vehicles

3.1 Introduction

In this chapter we will discuss about Existing/Proposed System, block diagram and methodology for Solar and Wind Power-Based Electric Vehicles.

3.2 Existing System

One prominent alternative is Battery Electric Vehicles (BEVs), which operate solely on electricity stored in batteries. These vehicles are charged from the grid or renewable energy sources, making them a clean option with zero tailpipe emissions. Recent advancements in battery technology have significantly improved the range and efficiency of BEVs, making them increasingly viable for everyday use. As the infrastructure for charging stations expands, BEVs are becoming more accessible to consumers, contributing to a shift towards greener transportation.

Another noteworthy option is Plug-in Hybrid Electric Vehicles (PHEVs). These vehicles combine a conventional internal combustion engine with an electric motor and a rechargeable battery. PHEVs can be charged from the grid, allowing for electric-only driving over shorter distances while still having the flexibility to use gasoline or diesel for longer trips. This dual capability addresses range anxiety, making PHEVs an attractive choice for drivers who may not have consistent access to charging facilities.

Hydrogen Fuel Cell Vehicles (FCVs) represent another innovative approach. These vehicles utilize hydrogen gas to generate electricity through a fuel cell, producing only water vapor as a byproduct. FCVs offer the advantage of quick refueling times and longer ranges compared to Another noteworthy option is Plug-in Hybrid Electric Vehicles (PHEVs). These vehicles combine a conventional internal combustion engine with an electric motor and a rechargeable battery. These vehicles are charged from the grid or renewable energy.

However, the infrastructure for hydrogen refueling is still developing, which presents challenges for widespread adoption.

Compressed Natural Gas (CNG) vehicles provide a different alternative by using compressed natural gas instead of traditional gasoline or diesel. CNG vehicles emit fewer pollutants than their gasoline counterparts and often benefit from lower fuel costs. While they do not eliminate emissions entirely, they represent a step towards cleaner transportation.

Biofuel vehicles also play a significant role in the sustainable transportation landscape. These vehicles run on biofuels derived from organic materials, such as ethanol and biodiesel. By utilizing renewable sources like plant materials and animal waste, biofuel vehicles reduce greenhouse gas emissions and decrease reliance on fossil fuels. The integration of biofuels into existing infrastructure can provide an immediate solution while transitioning to more advanced technologies.

Additionally, some vehicles are equipped with solar panels that harness sunlight to generate electricity directly. These solar electric vehicles can reduce the need for grid charging, especially in sunny regions, and extend the driving range through solar energy capture. This innovative approach aligns well with the goals of sustainability and energy independence.

Lastly, regenerative braking systems are an essential feature in many electric and hybrid vehicles. These systems capture energy that would typically be lost during braking and convert it back into usable power for the vehicle. By increasing overall energy efficiency, regenerative braking extends the driving range and enhances the performance of electric vehicles.

PHEVs can be charged from the grid, allowing for electric-only driving over shorter distances while still having the flexibility to use gasoline or diesel for longer trips. This dual capability addresses range anxiety, making PHEVs an attractive choice for drivers who may not have consistent access to charging facilities.

In conclusion, the landscape of sustainable transportation is diverse, with various systems available beyond Solar-Wind Hybrid Electric Vehicles. Each alternative offers unique advantages and challenges, and the choice of system often depends on specific use infrastructure availability, and regional energy policies. As technology continues to evolve and the push for greener solutions intensifies, these alternatives will play a crucial role in shaping the future of transportation.

3.3 Proposed System

The proposed system aims to develop a hybrid electric vehicle powered by both solar and wind energy, providing an innovative solution to reduce the harmful environmental impacts caused by fossil fuel-based transportation. The central concept revolves around utilizing freely available and renewable energy sources solar radiation and wind flow to generate electricity on the go. A high-efficiency solar panel is mounted on the vehicle to capture sunlight and convert it into electrical energy, while a compact wind turbine is strategically placed to harness wind energy generated by the vehicle’s motion or natural airflow. The combined power from these sources is regulated through a smart charge controller and stored in a rechargeable battery pack, which supplies energy to a lightweight brushless DC motor integrated into the wheel mechanism. This motor delivers smooth and efficient propulsion, enabling the vehicle to move without emitting any pollutants. The system may also include a monitoring module to display real-time data such as battery voltage, power input from solar and wind sources, and motor status. The primary aim of this project is to build a functional hardware model of a hybrid electric vehicle that demonstrates the potential of renewable energy integration in transportation. By focusing on sustainability, innovation, and energy efficiency, the project aspires to contribute toward reducing carbon emissions and promoting a greener future through clean mobility solutions.

The proposed system not only addresses environmental concerns but also emphasizes practicality and adaptability. The hybrid approach ensures a continuous power supply even in less favorable weather conditions—solar energy during sunny periods and wind energy during vehicle motion or breezy conditions. This dual-source energy model improves the vehicle's reliability and range compared to conventional solar-only systems. Additionally, the use of lightweight materials and energy-efficient components helps in reducing the overall energy consumption, making the vehicle more viable for real-world applications.

integrating renewable energy harvesting with intelligent energy management, the system is expected to pave the way for future developments in off-grid, sustainable transportation, especially in remote or rural areas where conventional charging infrastructure may not be readily available.

3.4 Conclusion

In conclusion, the proposed system enhances traditional solar electric vehicles by integrating both solar and wind energy sources. This dual-harvesting approach improves reliability and energy efficiency. Advancements in solar cells, energy storage, and lightweight materials further boost performance. Together, these innovations promote sustainable and self-reliant green transportation for the future.

Chapter 4

Hardware Description

4.1 Arduino

The Arduino Uno R3 is a microcontroller board based on the ATmega328(datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.

The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter.

Revision 2 of the Uno board has a resistor pulling the 8U2 HWB line to ground, making it easier to put into DFU mode.

Revision 3 of the board has the following new features:

- 1.0 pinout: added SDA and SCL pins that are near to the AREF pin and two other new pins placed near to the RESET pin, the IOREF that allow the shields to adapt to the voltage provided from the board. In future, shields will be compatible both with the board that use the AVR, which operate with 5V and with the Arduino Due that operate with 3.3V. The second one is a not connected pin that is reserved for future purposes.
- Stronger RESET circuit.
- Atmega 16U2 replace the 8U2.

"Uno" means one in Italian and is named to mark the upcoming release of Arduino 1.0. The Uno and version 1.0 will be the reference versions of Arduino, moving forward. The Uno is the latest in a series of USB Arduino boards, and the reference model for the Arduino platform; for a comparison with previous versions, see the index of Arduino boards.

Revision 2 of the Uno board has a resistor pulling the 8U2 HWB line to ground, making it easier to put into DFU mode.

4.2 Memory

The ATmega328 has 32 KB (with 0.5 KB used for the boot loader). It also has 2 KB of SRAM and 1 KB of EEPROM (which can be read and written with the EEPROM library).

4.3 Power

The Arduino Uno can be powered via the USB connection or with an external power supply. The power source is selected automatically. External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the Gnd and Vin pin headers of the POWER connector.

The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts. The power pins are as follows:

- VIN-The input voltage to the Arduino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.
- 5V-The regulated power supply used to power the microcontroller and other components on the board. This can come either from VIN via an on-board regulator, or be supplied by USB or another regulated 5V supply.
- 3V3- A 3.3-volt supply generated by the on-board regulator. Maximum current draw is 50 mA.
- GND- Ground pins.

4.4 Input and Output

Each of the 14 digital pins on the Uno can be used as an input or output, using pin Mode digital Write, and Read functions. They operate at 5 volts. Each pin can provide or receive a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20-50 k Ohms. In addition, some pins have specialized functions:

- Serial: 0 (RX) and 1 (TX). Used to receive (RX) and transmit (TX) TTL serial data. These pins are connected to the corresponding pins of the ATmega8U2 USB-to-TTL Serial chip.
- External Interrupts: 2 and 3**.** These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value. See the attach Interrupt () function for details.
- PWM: 3, 5, 6, 9, 10, and 11**.** Provide 8-bit PWM output with the analog Write () function.
- SPI: 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK)**.** These pins support SPI communication using the SPI library.
- LED: 13**.** There is a built-in LED connected to digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off.

  The Uno has 6 analog inputs, labeled A0 through A5, each of which provide 10 bits of resolution (i.e. 1024 different values). By default they measure from ground to 5 volts, though is it possible to change the upper end of their range using the AREF pin and the analog Reference() function. Additionally, some pins have specialized functionality:
- TWI: A4 or SDA pin and A5 or SCL pin**.** Support TWI communication using the Wire library. There are a couple of other pins on the board:
- AREF. Reference voltage for the analog inputs. Used with analog Reference().
- Reset**.** Bring this line LOW to reset the microcontroller. Typically used to add a reset button to shields which block the one on the board.

  See also the mapping between Arduino pins and ATmega328 ports. The mapping for the Atmega8, 168, and 328 is identical.

4.5 Communication

The Arduino Uno has a number of facilities for communicating with a computer, another Arduino, or other microcontrollers. The ATmega328 provides UART TTL (5V) serial communication, which is available on digital pins 0 (RX) and 1 (TX). An ATmega16U2 on the board channels The ATmega328 also supports I2C (TWI) and SPI communication. The Arduino software includes a Wire library to simplify use of the I2C bus; see the documentation for details. For SPI communication, use the SPI library.

The 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, a .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.

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 Uno'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; see the documentation for details. For SPI communication, use the SPI library.

Programming:

The Arduino Uno can be programmed with the Arduino software (download). Select "Arduino Uno from the Tools Board menu (according to the microcontroller on your board). For details, see the reference and tutorials.
The ATmega328 on the Arduino Uno comes pre burned with a boot loader that allows you to upload new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol (reference, C header files).
You can also bypass the bootloader and program the microcontroller through the ICSP (In-Circuit Serial Programming) header; see these instructions for details.
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.

  You can then use Atmel's FLIP software (Windows) or the DFU programmer (Mac OS X and Linux) to load a new firmware. Or you can use the ISP header with an external , the programmer (overwriting the DFU boot loader). See this user-contributed tutorial for more information.

Power Supply

The input to the circuit is applied from the regulated power supply. The a.c. input i.e., 230V from the mains supply is step down by the transformer to 12V and is fed to a rectifier. The output obtained from the rectifier is a pulsating d.c voltage. So in order to get a pure d.c voltage, the output voltage from the rectifier is fed to a filter to remove any a.c components present even after rectification. Now, this voltage is given to a voltage regulator to obtain a pure constant dc voltage.

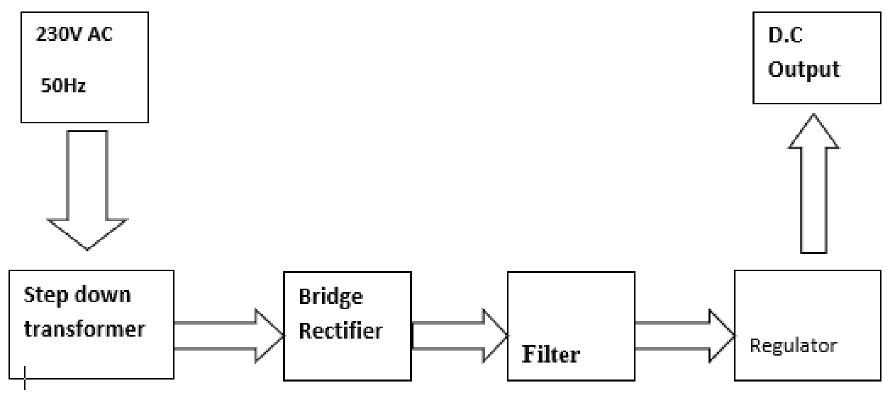


Figure 4.1 Block diagram of Power Supply

Transformer:

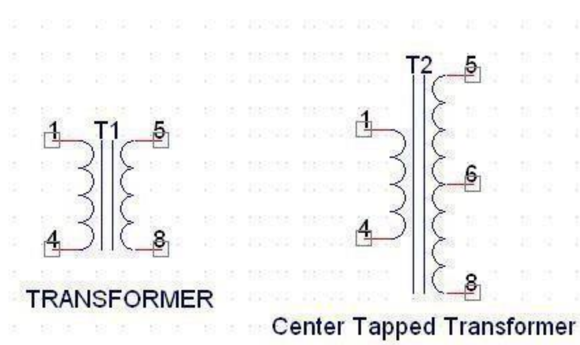


Figure 4.2 Transformer

A transformer consists of two coils also called as "Windings" namely Primary and Secondary

They are linked together through inductively coupled electrical conductors also called as CORE. A changing current in the primary causes a change in the Magnetic Field in the core & this in turn induces an alternating voltage in the secondary coil. If load is applied to the secondary then an alternating current will flow through the load. If we consider an ideal condition then all the energy from the primary circuit will be transferred to the secondary circuit through the magnetic field.

$$P_{primary} = P_{secondary} \qquad \frac{V_s}{V_p} = \frac{N_s}{N_p}$$

$$I_p V_p = I_s V_s$$

Rectifier:

A rectifier is a device that converts an AC signal into DC signal. For rectification purpose we use a diode, a diode is a device that allows current to pass only in one direction i.e. when the anode of the diode is positive with respect to the cathode also called as forward biased condition & blocks current in the reversed biased condition.

Rectifier can be classified as follows:

1) Half Wave rectifier
2) Full Wave rectifier

A rectifier is a device that converts an AC signal into DC signal. For rectification purpose we use a diode, a diode is a device that allows current to pass only in one direction i.e. when the anode of the diode is positive with respect to the cathode also called as forward biased condition & blocks current in the reversed biased condition.

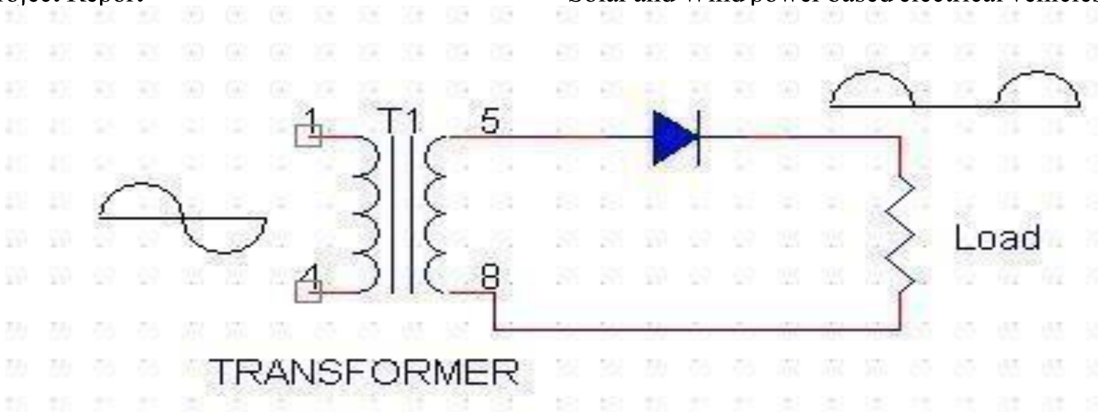


Figure 4.3 Half Wave Rectifier

This is the simplest type of rectifier as you can see in the diagram a half wave rectifier consists of only one diode. When an AC signal is applied to it during the positive half cycle the diode is forward biased & current flows through it. But during the negative half cycle diode is reverse biased & no current flows through it. Since only one half of the input reaches the output, it is very inefficient to be used in power supplies.

2) Full wave rectifier

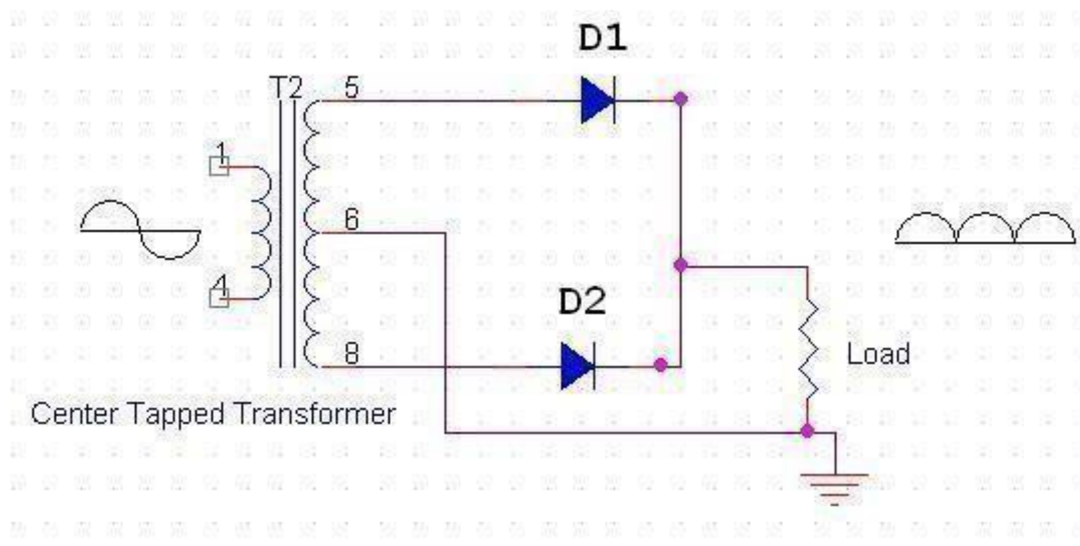


Figure 4.4 Full Wave Rectifier

Half wave rectifier is quite simple but it is very inefficient, for greater efficiency we would like to use both the half cycles of the AC signal. This can be achieved by using a center tapped transformer i.e. we would have to double the size of secondary winding & provide connection to the center.

During the negative half cycle diode D2 conducts & D1 is reverse biased. Thus we get both the half cycles across the load.

One of the disadvantages of Full Wave Rectifier design is the necessity of using a center tapped transformer, thus increasing the size & cost of the circuit. This can be avoided by using the Full Wave Bridge Rectifier.

Filter Capacitor:

Even though half wave & full wave rectifier give DC output, none of them provides a constant output voltage. For this we require to smoothen the waveform received from the rectifier. This can be done by using a capacitor at the output of the rectifier this capacitor is also called as "Filter Capacitor" or "Smoothing capacitor" or "Reservoir Capacitor". Even after using this capacitor a small amount of ripple will remain.

We place the Filter Capacitor at the output of the rectifier the capacitor will charge to the peak voltage during each half cycle then will discharge its stored energy slowly through the load while the rectified voltage drops to zero, thus trying to keep the voltage as constant .

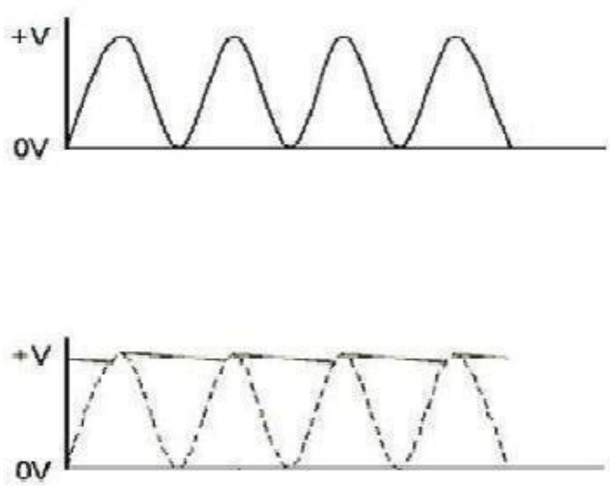


Figure 4.5 Wave forms of Filter capacitor

This can be done by using a capacitor at the output of the rectifier this capacitor is also called as "Filter Capacitor" or "Smoothing capacitor" or "Reservoir Capacitor".

If we go on increasing the value of the filter capacitor then the Ripple will decrease. But then the costing will increase. The value of the Filter capacitor depends on the current consumed by the circuit, the frequency of the waveform & the accepted ripple.

$$C = \frac{V_r F}{I}$$

Where,

Vr= accepted ripple voltage.(should not be more than 10% of the voltage)

I= current consumed by the circuit in Amperes.

F= frequency of the waveform. A half wave rectifier has only one peak in one cycle so

F=25 Hz

Whereas a full wave rectifier has Two peaks in one cycle so F=100 Hz.

Voltage Regulator:

A Voltage regulator is a device which converts varying input voltage into a constant regulated output voltage. Voltage regulator can be of two types

1) Linear Voltage Regulator

Also called as Resistive Voltage regulator because they dissipate the excessive voltage resistively as heat.

2) Switching Regulators.

They regulate the output voltage by switching the Current ON/OFF very rapidly. Since their output is either ON or OFF it dissipates very low power thus achieving higher efficiency as compared to linear voltage regulators. But they are more complex & generate high noise due to their switching action. For low level of output power switching regulators tend to be costly but for higher output wattage they are much cheaper than linear regulators.

The most commonly available Linear Positive Voltage Regulators are the 78XX series where the XX indicates the output voltage. And 79XX series is for Negative Voltage Regulators.

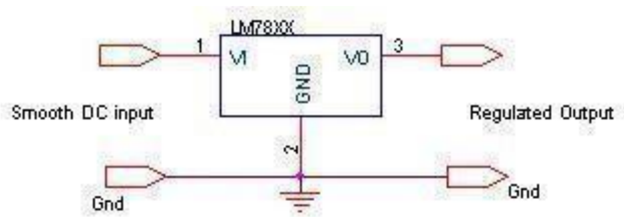


Figure 4.6 pin diagram of voltage regulator

After filtering the rectifier output the signal is given to a voltage regulator. The maximum input voltage that can be applied at the input is 35V.Normally there is a 2-3 Volts drop across the regulator so the input voltage should be at least 2-3 Volts higher than the output voltage. If the input voltage gets below the Vmin of the regulator due to the ripple voltage or due to any other reason the voltage regulator will not be able to produce the correct regulated voltage.

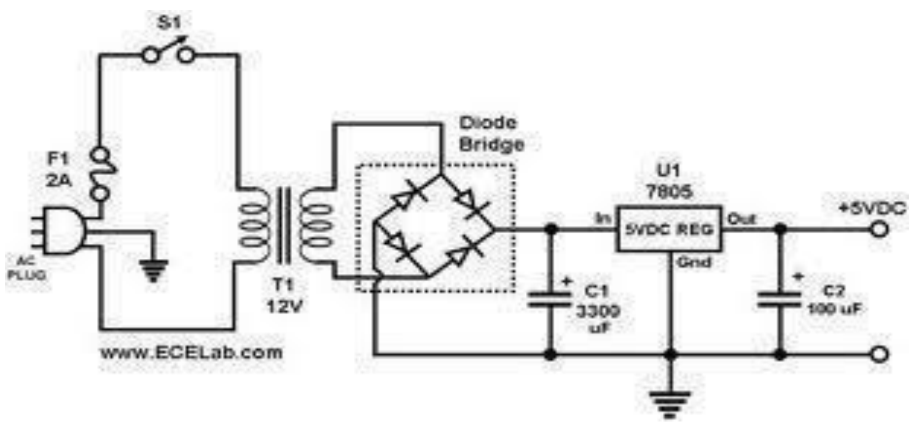


Figure 4.7 Circuit Diagram of power supply

IC7805

7805 is an integrated three-terminal positive fixed linear voltage regulator. It supports an input voltage of 10 volts to 35 volts and output voltage of 5 volts. It has a current rating of 1 amp although lower current models are available. Its output voltage is fixed at 5.0V. The 7805 also has a built-in current limiter as a safety feature and 7805 is manufactured.

Many companies, including National Semiconductors and Fairchild Semiconductors.

The 7805 will automatically reduce output current if it gets too hot. The last two digits represent the voltage; for instance, the 7812 is a 12-volt regulator. The 78xx series of regulators is designed to work in complement with the 79xx series of negative voltage regulators in systems that provide both positive and negative regulated voltages, since the 78xx series can't regulate negative voltages in such a system.

The 7805 & 78 is one of the most common and well-known of the 78xx series regulators, as it's small component count and medium-power regulated 5V make it useful for powering TTL devices.

IC7812

Here is a 7812, but this is not a power supply with a 12V output voltage and load current 1A. IC LM7812 only serves as the input voltage of an LM723 regulator IC. So these power supply circuits with a larger load current capability with a variable voltage at the maximum voltage of 6V.

Output voltage range of the 7812-voltage regulator circuit is 2.5V-6V with 6A-8A load current. increasing load current through the transistor BD139 and TIP142 are sourced from the DC voltage of a transformer 10A.

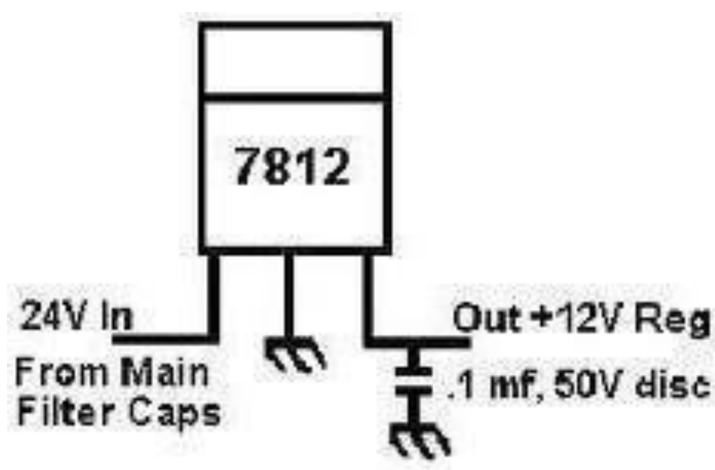


Figure 4.8 7812 Pin Connection

4.6 Automatic (Software) Reset

Rather than requiring a physical press of the reset button before an upload, the Arduino Uno is designed in a way that allows it to be reset by software running on a connected computer. One of the hardware flow control lines (DTR) of theATmega8U2/16U2 is connected to the reset line of the ATmega328 via a 100 nano-farad capacitor. When this line is asserted (taken low), the reset line drops long enough to reset the chip. The Arduino software uses this capability to allow you to upload code by simply pressing the upload button in the Arduino environment. This means that the boot loader can have a shorter timeout, as the lowering of DTR can be well-coordinated with the start of the upload.

This setup has other implications. When the Uno is connected to either a computer running Mac OS X or Linux, it resets each time a connection is made to it from software (via USB). For the following half-second or so, the boot loader is running on the Uno. While it is programmed to ignore malformed data (i.e. anything besides an upload of new code), it will intercept the first few bytes of data sent to the board after a connection is opened. If a sketch running on the board receives one-time configuration or other data when it first starts, make sure that the software with which it communicates waits a second after opening the connection and before sending this data.

USB over current Protection:

The Arduino Uno has a resettable poly fuse that protects your computer's USB ports from shorts and over current. Although most computers provide their own internal protection, the fuse provides an extra layer of protection. If more than 500 mA is applied to the USB port, the fuse will automatically break the connection until the short or overload is removed.

The Arduino Uno features a resettable polyfused to protect your computer's USB ports from overcurrent and short circuits. If the current exceeds 500 mA, the polyfused increases resistance, cutting off the connection to prevent damage. Once the issue is resolved, the fuse automatically resets, ensuring convenience and reusability. This provides an additional layer of safety alongside the computer’s built-in USB protection.

Solar Cell

Figure 4.9: Solar cell

Although this is basically a junction diode, but constructional it is little bit different form conventional p-n junction diode. A very thin layer of p-type semiconductor is grown on a relatively thicker n-type semiconductor. We provide few finer electrodes on the top of the p-type semiconductor layer. These electrodes do not obstruct light to reach the thin p-type layer. Just below the p-type layer there is a p-n junction. We also provide a current collecting electrode at the bottom of the n-type layer. We encapsulate the entire assembly by thin glass to protect the **solar cell** from any mechanical shock.

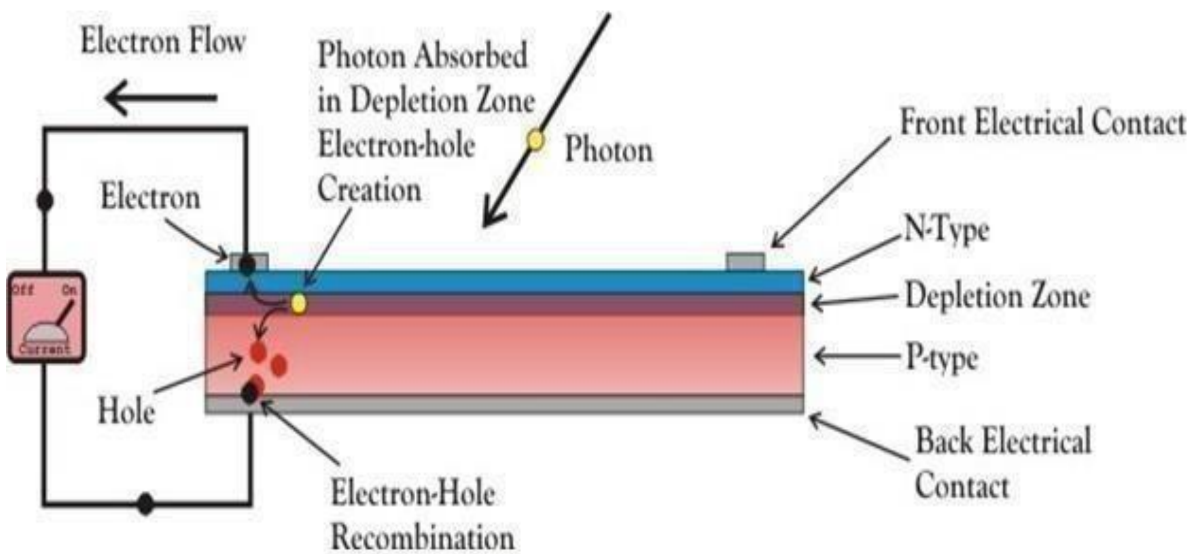


Figure 4.10: Working of solar cell

When light reaches the p-n junction, the light photons can easily enter in the junction, through very thin p-type layer. The light energy, in the form of photons, supplies sufficient energy to the junction to create a number of electron-hole pairs. The incident light breaks the thermal equilibrium condition of the junction. The free electrons in the depletion region can quickly come to the n-type side of the junction. Similarly, the holes in the depletion can quickly come to the p- type side of the junction. Once, the newly created free electrons come to the n-type side, cannot further cross the junction because of barrier potential of the junction.

Similarly, the newly created holes once come to the p-type side cannot further cross the junction became of same barrier potential of the junction. As the concentration of electrons becomes higher in one side, i.e. n-type side of the junction and concentration of holes becomes more in another side, i.e. the p-type side of the junction, the p-n junction will behave like a small battery cell. A voltage is set up which is known as photo voltage.

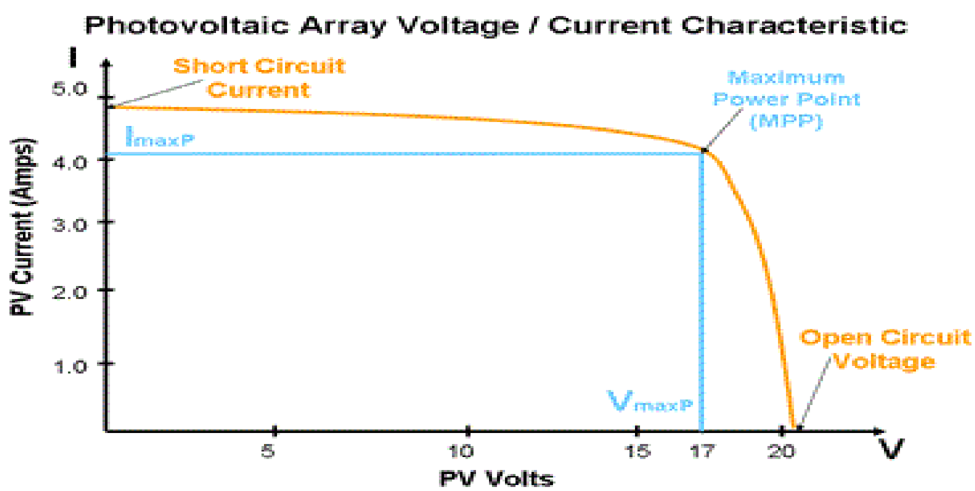


Figure 4.11: V-I characteristics of solar cell

Wind turbine:

Wind Turbine Wind is a renewable source of energy. A wind turbine is used to convert the kinetic energy of the wind into electric. The generator connected to the shaft of the blades the mechanical energy to electric energy. The wind turbine is of two types depending upon the rotating axis of the blades, first is vertical axis wind turbine and horizontal axis wind turbine. The output of the turbine depends on the speed of the wind. The power generated by the turbine is fluctuating. In order to obtain continuous supply of power first the electricity is stored in a battery unit and then it is transferred to the load.

Figure 4.12: Wind turbine

Battery:

Batteries are a collection of one or more cells whose chemical reactions create a flow of electrons in a circuit. All batteries are made up of three basic components: an anode (the '-' side), a cathode (the '+' side), and some kind of electrolyte (a substance that chemically reacts with the anode and cathode).

When the anode and cathode of a battery is connected to a circuit, a chemical reaction takes place between the anode and the electrolyte. This reaction causes electrons to flow through the circuit and back into the cathode where another chemical reaction takes place. When the material in the cathode or anode is consumed or no longer able to be used in the reaction, the battery is unable to produce electricity. At that point, your battery is "dead" Batteries that must be thrown away.

Batteries that can be recharged are called secondary batteries.

HC-05 - Bluetooth Module

Figure 4.13: Bluetooth module

- Serial Bluetooth module for Arduino and other microcontrollers
- Operating Voltage: 4V to 6V (Typically +5V)
- Operating Current: 30mA
- Range: <100m
- Works with Serial communication (USART) and TTL compatible
- Follows IEEE 802.15.1 standardized protocol
- Uses Frequency-Hopping Spread spectrum (FHSS)
- Can operate in Master, Slave or Master/Slave mode
- Can be easily interfaced with Laptop or Mobile phones with Bluetooth Supported baud rate: 9600,19200,38400,57600,115200,230400,460800

Usage of HC-05 Bluetooth module:

The HC-05 is a very cool module which can add two-way (full-duplex) wireless functionality to your projects. You can use this module to communicate between two microcontrollers like Arduino or communicate with any device with Bluetooth functionality like a Phone or Laptop.

There are many android applications that are already available which makes this process a lot easier. The module communicates with the help of USART at 9600 baud rate hence it is easy to interface with any microcontroller that supports USART. We can also configure the default values of the module by using the command mode. So if you looking for a Wireless module that could transfer data from your computer or mobile phone to microcontroller or vice versa then this module might be the right choice for you. However do not expect this module to transfer multimedia like photos or songs; you might have to look into the CSR8645 module for that.

HC-05 :

The HC-05 has two operating modes, one is the Data mode in which it can send and receive data from other Bluetooth devices and the other is the AT Command mode where the default device settings can be changed. We can operate the device in either of these two modes by using the key pin as explained in the pin description.

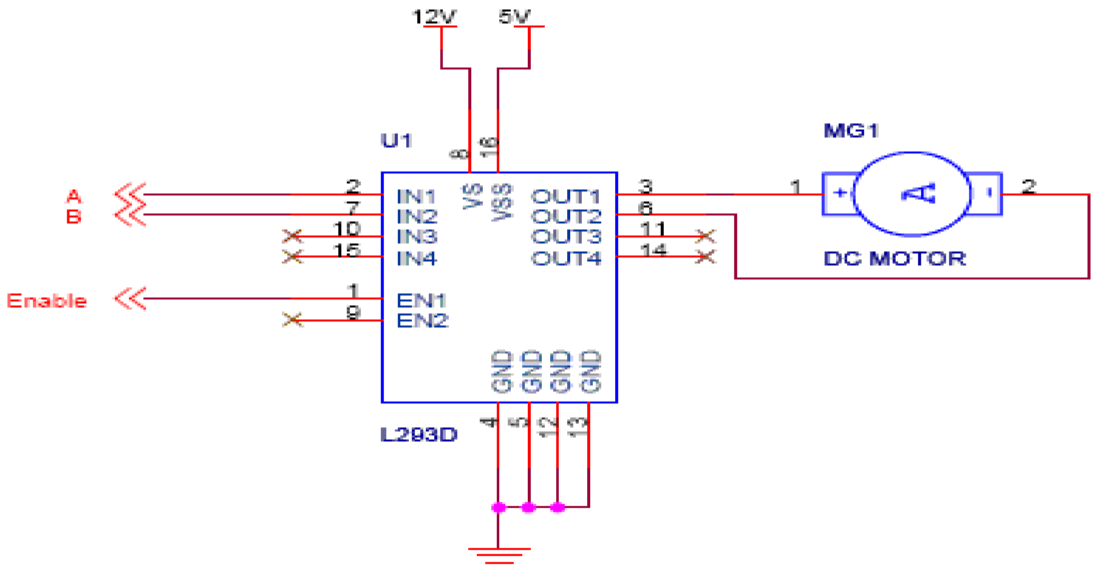
It is very easy to pair the HC-05 module with microcontrollers because it operates using the Serial Port Protocol (SPP).

L293D DRIVER IC:

L293D is a dual H-Bridge motor driver, so with one IC we can interface two DC motors which can be controlled in both clockwise and counter clockwise direction and if you have motor with fix direction of motion the you can make use of all the four I/O to connect up to four DC motors. L293D has output current of 600mA and peak output current of 1.2A per channel. Moreover, for protection of circuit from back EMF output diodes are included within the IC. The output supply (VCC2) has a wide range from 4.5V to 36V, which has made L293D a best choice.

As you can see in the circuit, three pins are needed for interfacing a DC motor (A, B, Enable). If you want the o/p to be enabled completely then you can connect Enable to VCC and only 2 pins needed from controller to make the motor work. As per the truth mentioned in the image above its fairly simple to program the microcontroller. It’s also clear from the truth table of BJT circuit and L293D the programming will be same for both of them, just keeping in mind the allowed included within the IC. The output supply (VCC2) has a wide range from 4.5V to 36V, which has made L293D a best choice.

A simple schematic for interfacing a DC motor using L293D is shown below.



Truth Table

A	B	Description
0	0	Motor stops or Breaks
0	1	Motor Runs Anti-Cloclwise
1	0	Motor Runs Clockwise
1	1	Motor Stops or Breaks

For above truth table, the Enable has to be Set (1). Motor Power is mentioned 12V, but you can connect power according to your motors.

Figure 4.14: Interfacing a DC motor using L293D

As you can see in the circuit, three pins are needed for interfacing a DC motor (A, B, Enable). If you want the o/p to be enabled completely then you can connect Enable to VCC and only 2 pins needed from controller to make the motor work. As per the truth mentioned in the image above its fairly simple to program the microcontroller. It's also clear from the truth table of BJT circuit and L293D the programming will be same for both of them.

DC Motor:

An electric motor is a machine which converts electrical energy into mechanical energy.

In any electric motor, operation is based on simple electromagnetism. A current-carrying conductor generates a magnetic field; when this is then placed in an external magnetic field, will experience a force proportional to the current in the conductor, and to the strength of the external magnetic field. As you are well aware of from playing with magnets as a kid, opposite (North and South) polarities attract, while like polarities (North and North, South and South) repel. The internal configuration of a DC motor is designed to harness the magnetic interaction between a current-carrying conductor and an external magnetic field to generate rotational motion.

Let's start by looking at a simple 2-pole DC electric motor (here red represents a magnet or winding with a "North" polarization, while green represents a magnet or winding with a "South"

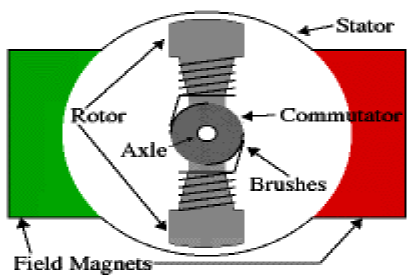


Figure 4.15: operation of DC motor

Every DC motor has six basic parts axle, rotor (a.k.a., armature), stator, commutator, field magnet(s), and brushes. In most common DC motors (and all that Beamers will see), the external magnetic field is produced by high-strength permanent magnets1. The stator is the stationary part of the motor this includes the motor casing, as well as two or more permanent magnet pole pieces. The rotor (together with the axle and attached commutator) rotates with respect to the stator. The rotor consists of windings (generally on a core), the windings being electrically connected to the commutator. The above diagram shows a common motor layout with the rotor inside the stator (field) magnets. The geometry of the brushes, commutator contacts.

The windings are such that when power is applied, the polarities of the energized winding and the stator magnet(s) are misaligned, and the rotor will rotate until it is almost aligned with the stator's field magnets. As the rotor reaches alignment, the brushes move to the next commutator contacts, and energize the next winding. Given our example two-pole motor, the rotation reverses the direction of current through the rotor winding, leading to a "flip" of the rotor's magnetic field, driving it to continue rotating.

In real life, though, DC motors will always have more than two poles (three is a very common number). In particular, this avoids "dead spots" in the commutator. You can imagine how with our example two-pole motor, if the rotor is exactly at the middle of its rotation (perfectly aligned with the field magnets), it will get "stuck" there. Meanwhile, with a two-pole motor, there is a moment where the commutator shorts out the power supply (i.e., both brushes touch both commutator contacts simultaneously). This would be bad for the power supply, waste energy, and damage motor components as well. Yet another disadvantage of such a simple motor is that it would exhibit a high amount of torque "ripple" (the amount of torque it could produce is cyclic with the position of the rotor).

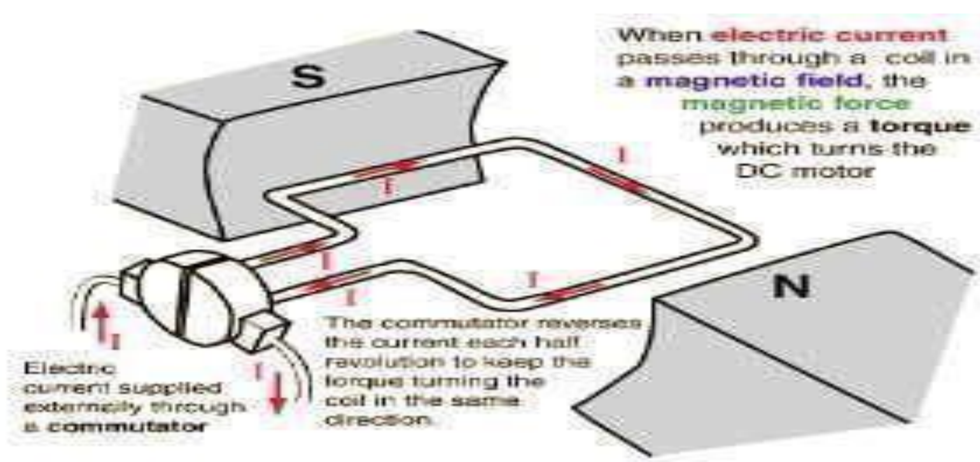


Figure 4.16: Force in DC motor

This would be bad for the power supply, waste energy, and damage motor components as well. In particular, this avoids "dead spots" in the commutator. You can imagine how with our example two-pole motor, if the rotor is exactly at the middle of its rotation.

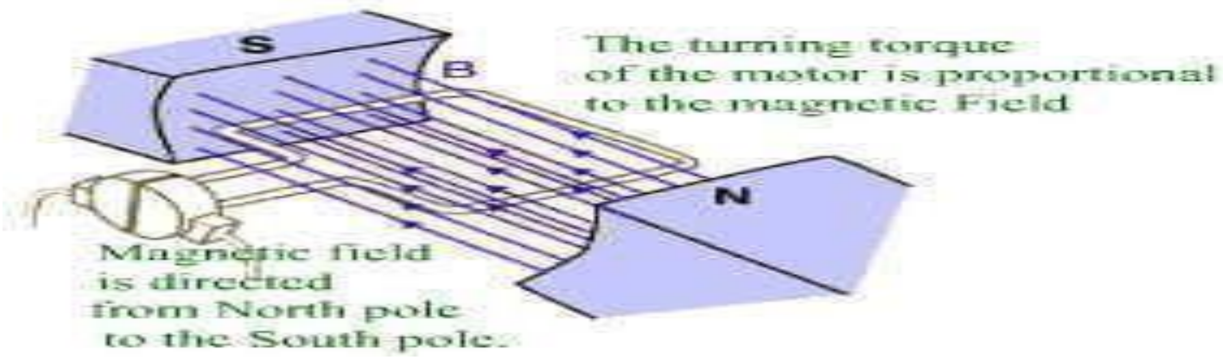


Figure 4.17: Magnetic field in DC motor

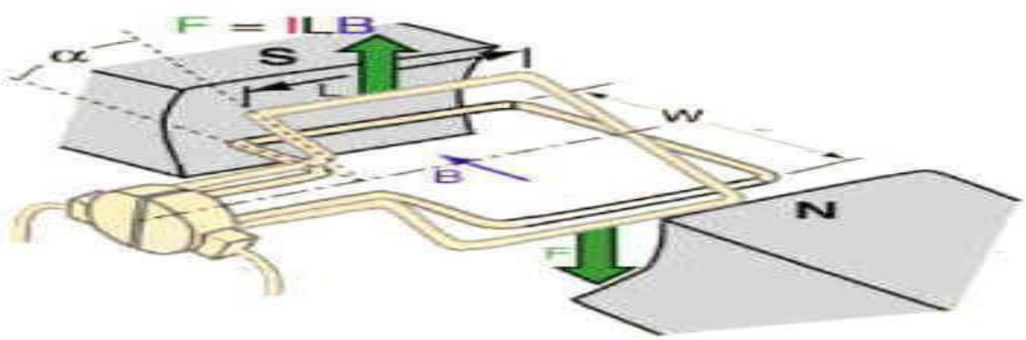


Figure 4.18: Torque in DC motor

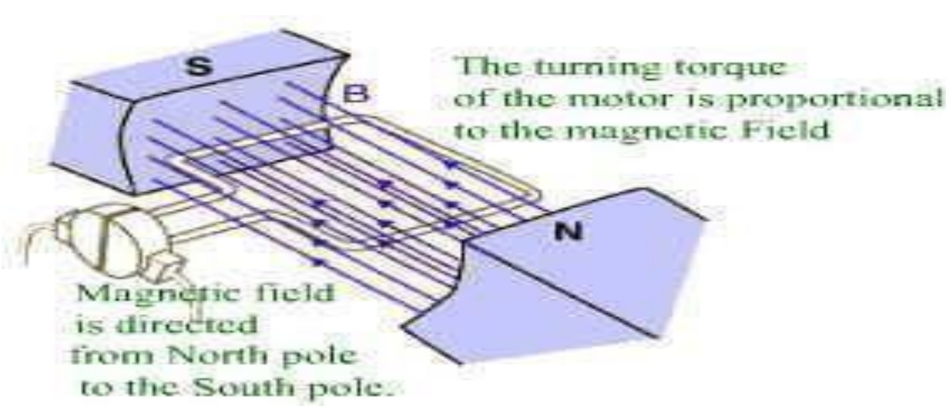


Figure 4.19: Current flow in DC Motor

Battery:

Figure 4.20: Battery

Batteries are a collection of one or more cells whose chemical reactions create a flow of electrons in a circuit. All batteries are made up of three basic components: an anode and some kind of electrolyte (a substance that chemically reacts with the anode and cathode). When the anode and cathode of a battery is connected to a circuit, a chemical reaction takes place between the anode and the electrolyte. This reaction causes electrons to flow through the circuit and back into the cathode where another chemical reaction takes place. When the material in the cathode or anode is consumed or no longer able to be used in the reaction, the battery is unable to produce electricity. At that point, your battery is “dead” Batteries that must be thrown away after use are known as primary batteries. Batteries that can be recharged are called secondary batteries.

4.7 Conclusion

In conclusion, the hardware aspects of solar electric vehicles include solar panels that capture sunlight, power management systems that regulate energy flow, and efficient battery storage for energy retention. These components work together to provide energy independence and optimize the vehicle's performance. Future advancements aim to improve the efficiency and durability of these hardware elements, enhancing the overall effectiveness of solar-powered transportation.

Chapter 5

Software Description

5.1 Introduction

This tutorial will walk you through downloading, installing, and testing the Arduino software (also known as the Arduino IDE - short for Integrated Development Environment). Before you jump to the page for your operating system, make sure you've got all the right equipment.

We will need:

- A computer (Windows, Mac, or Linux)
- An Arduino-compatible microcontroller (anything from this guide should work)
- A USB A-to-B cable, or another appropriate way to connect your Arduino-compatible microcontroller to your computer (check out this USB buying guide if you're not sure which cable to get).

Figure 5.1: An A-to-B USB Cable

If you're new to Arduino in general, you want to check out this tutorial to familiarize yourself with everyone's favourite microcontroller platform. If you're ready to get started, click on the link in the column on the left that matches up with your operating system, or you can jump to your operating system here.

Windows:

This page will show you how to install and test the Arduino software with a Windows operating system (Windows 8, Windows 7, Vista, and XP).Windows 8, 7, Vista, and XP

- Go to the Arduino download page and download the latest version of the Arduino software for Windows.
- When the download is finished, un-zip it and open up the Arduino folder to confirm that yes, there are indeed some files and sub-folders inside. The file structure is important so don't be moving any files around unless you really know what you're doing.
- Power up your Arduino by connecting your Arduino board to your computer with a USB cable (or FTDI connector if you're using an Arduino pro). You should see the an LED labed 'ON' light up. (This diagram shows the placement of the power LED on the UNO).
- If you're running Windows 8, you'll need to disable driver signing, so go see the Windows 8 section. If you're running Windows 7, Vista, or XP, you'll need to install some drivers, so head to the Windows 7, Vista, and XP section down below.

Windows 8

Windows 8 comes with a nice little security 'feature' that 'protects' you from unsigned driver installation. Some older versions of Arduino Uno come with unsigned drivers, so in order to use your Uno, you'll have to tell Windows to disable driver signing. This issue has been addressed in newer releases of the Arduino IDE, but if you run into issues, you can try this fix first.

- From the Metro Start Screen, open Settings (move your mouse to the bottom-right-corner of the screen and wait for the pop-out bar to appear, then click the Gear icon)
- Click 'More PC Settings'

- Click ‘General’
- Scroll down, and click ‘Restart now’ under ‘Advanced startup’.
- Wait a bit.
- Click ‘Troubleshoot’.
- Click ‘Advanced Options’
- Click ‘Windows Startup Settings’
- Click Restart.

Windows 7, Vista, and XP

Installing the Drivers for the Arduino Uno (from Arduino.cc)

- Plug in your board and wait for Windows to begin it’s driver installation process
- After a few moments, the process will fail, despite its best efforts.
- Click on the Start Menu, and open up the Control Panel
- While in the Control Panel, navigate to System and Security. Next, click on System
- Once the System window is up, open the Device Manager

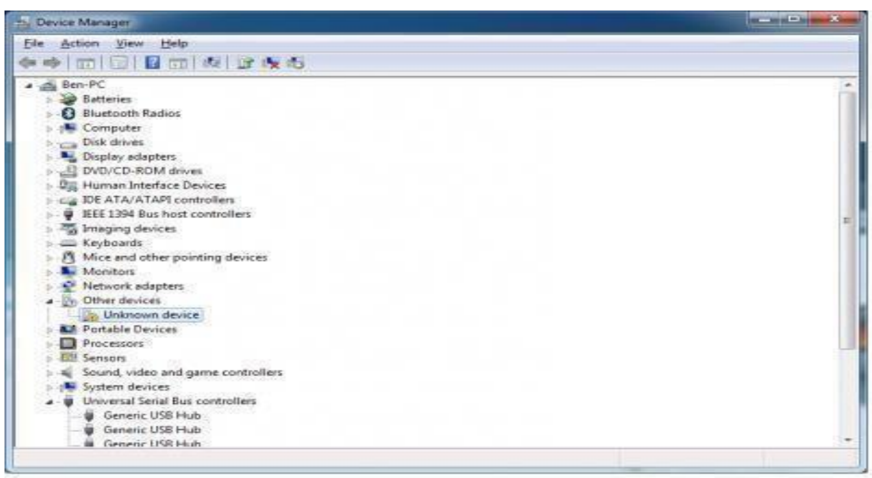


Figure 5.2: Device Manager

- Look under Ports (COM & LPT). You should see an open port named “Arduino UNO (COM)”. If there is no COM & LPT section, look under ‘Other Devices’ for ‘Unknown Device’
- Other Devices’ for ‘Unknown Device’

- Right click on the “Arduino UNO (COMxx)” or “Unknown Device” port and choose the “Update Driver Software” option
- Next, choose the “Browse my computer for Driver software” option.

Figure 5.3: Driver Software

- Finally, navigate to and select the Uno’s driver file, named “ArduinoUNO.inf”, located in the “Drivers” folder of the Arduino Software download (not the “FTDI USB Drivers” sub-directory). If you cannot see the .inf file, it is probably just hidden. You can select the ‘drivers’ folder with the ‘search sub-folders’ option selected instead.
- Windows will finish up the driver installation from there
- After following the appropriate steps for your software install, we are now ready to test your first program with your Arduino board!
- Launch the Arduino application
- If you disconnected your board, plug it back in
- Open the Blink example sketch by going to:

  File

  Examples

  1.Basics

  Blink

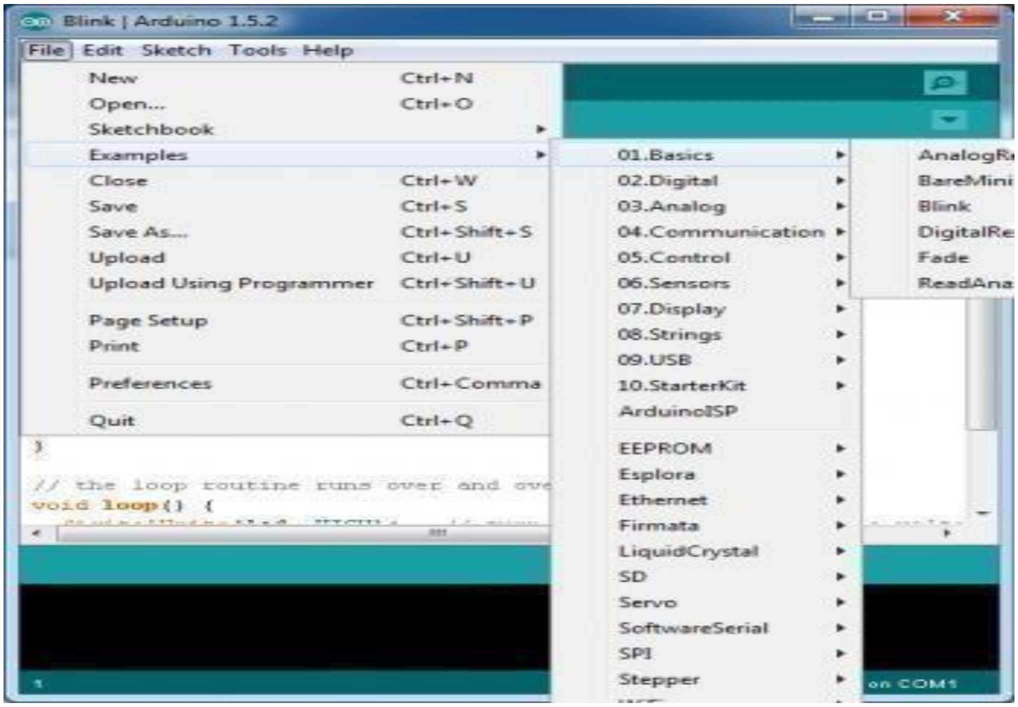


Figure 5.4: Arduino Software

- Select the type of Arduino board you're using: Tools > Board > your board type

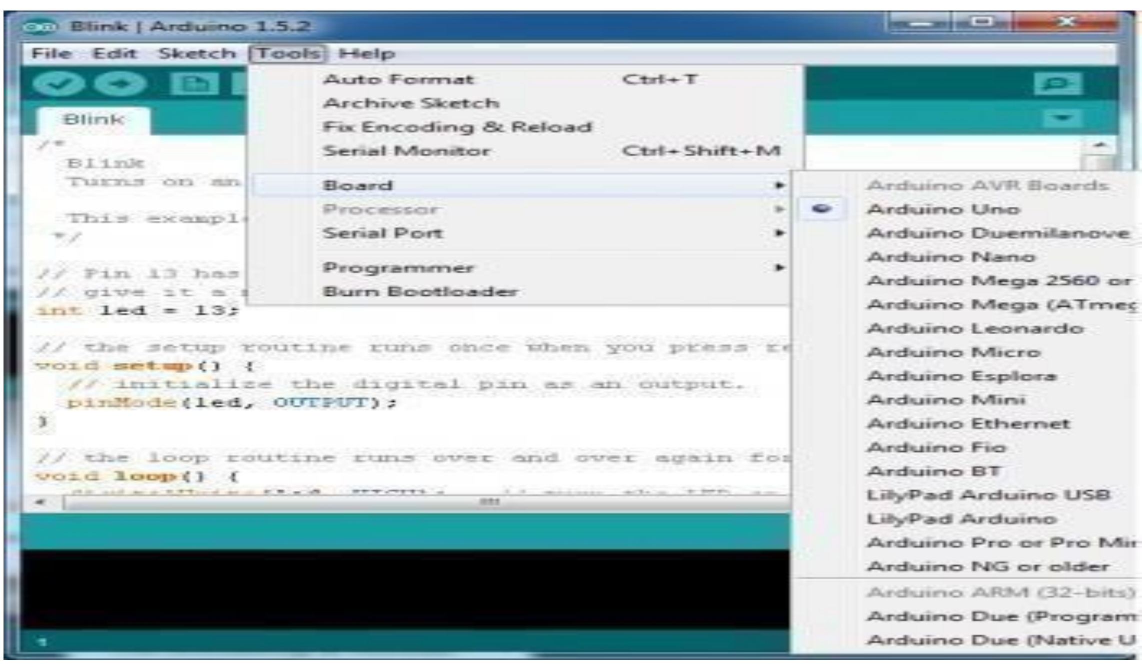


Figure 5.5: Tool box in Arduino

- Select the serial/COM port that your Arduino is attached to: Tools > Port > COM

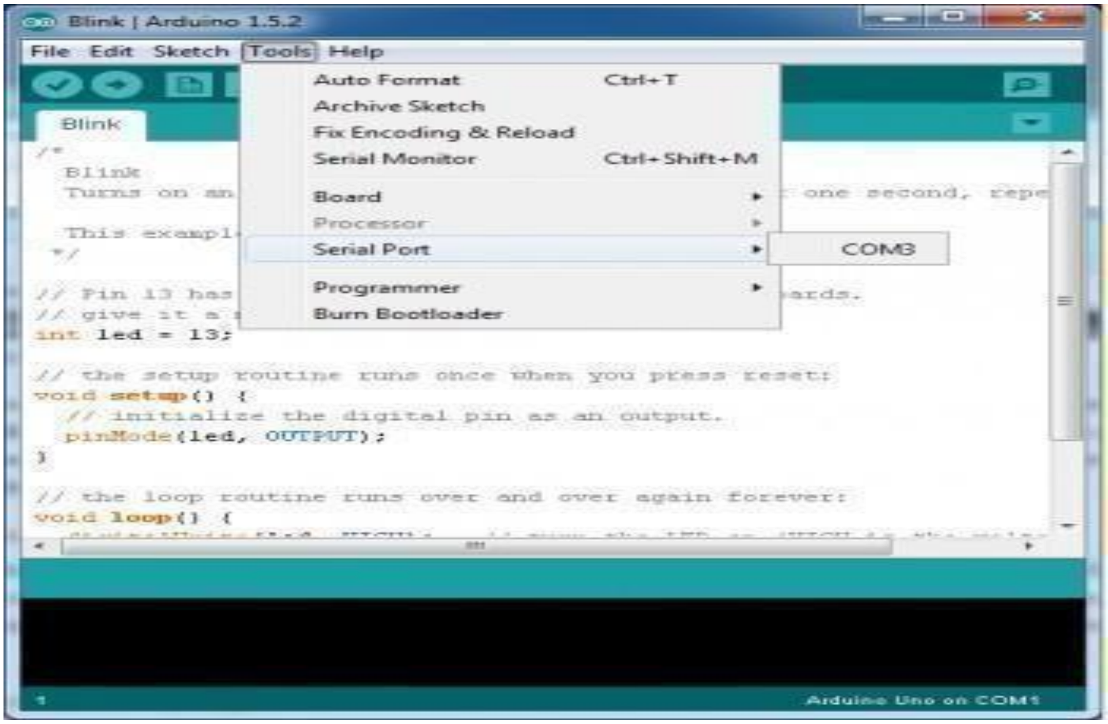


Figure 5.6: Serial Port

- If you're not sure which serial device is your Arduino, take a look at the available ports, then unplug your Arduino and look again. The one that disappeared is your Arduino.
- With your Arduino board connected, and the Blink sketch open, press the 'Upload' button.
- This page will show you how to install and test the Arduino software on a Mac computer running OSX.
- Go to the Arduino download page and download the latest version of the Arduino software for Mac.
- When the download is finished, un-zip it and open up the Arduino folder to confirm that yes, there are indeed some files and sub-folders inside. The file structure is important so don't be moving any files around unless you really know what you're doing.
- Power up your Arduino by connecting your Arduino board to your computer with a USB cable (or FTDI connector if you're using an Arduino pro). You should see the LED labed 'ON' light up.

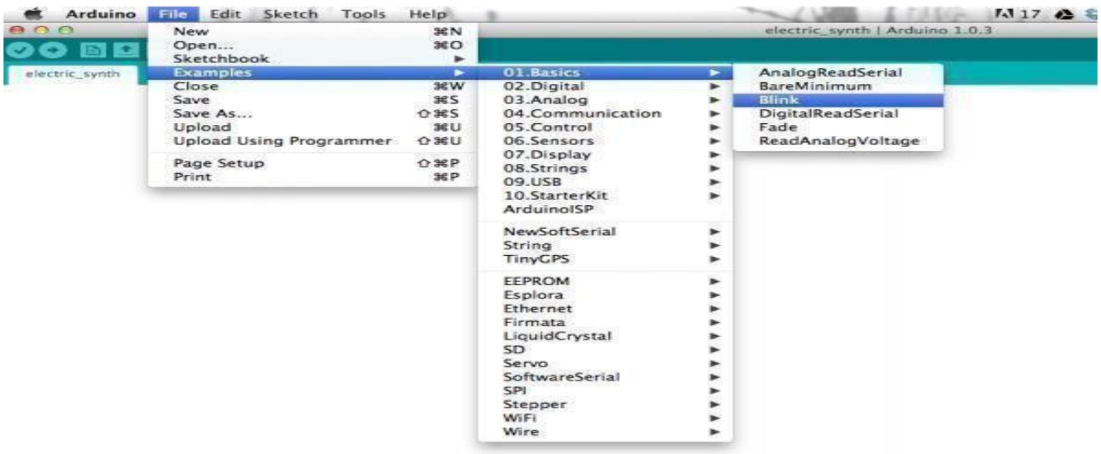


Figure 5.7: Blink

- Select the type of Arduino board you're using: Tools > Board > your board type

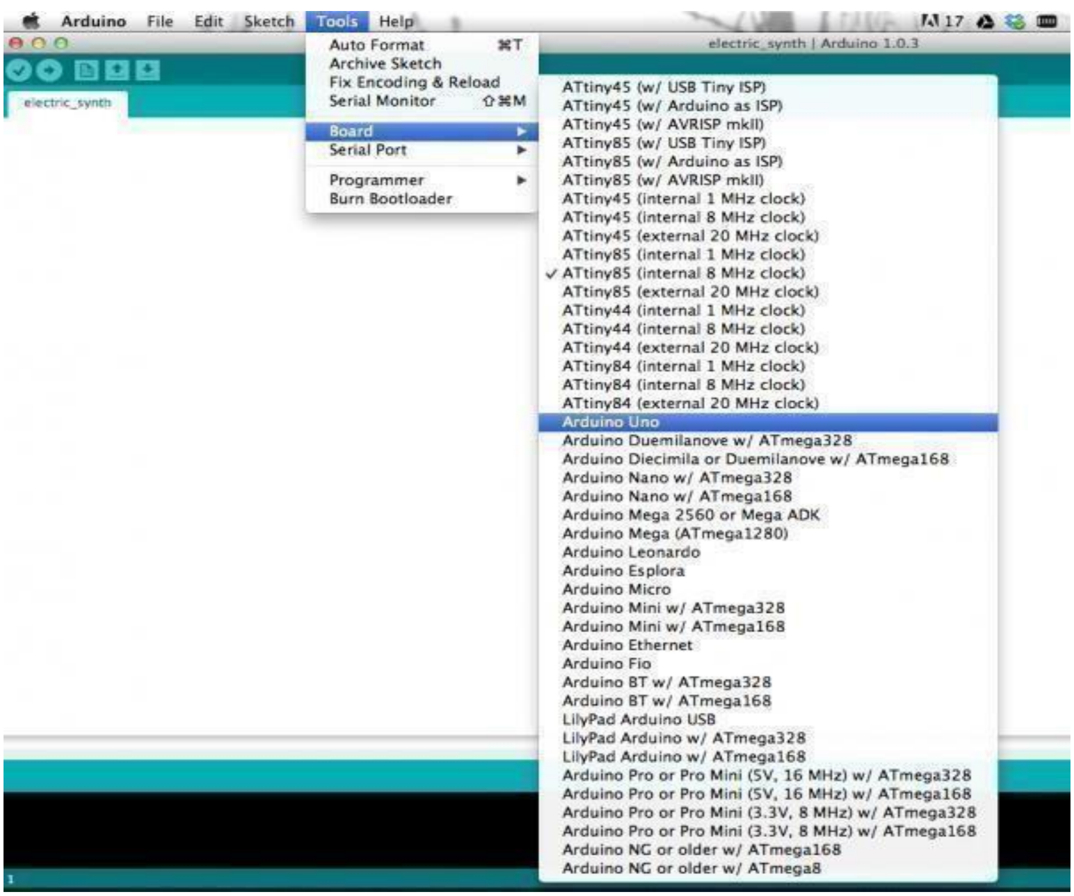


Figure 5.8: Board setup

- Select the serial port that your Arduino is attached to: Tools > Port (it'll probably look something like "/dev/tty.usbmodemfd131" or "/dev/tty.usbserial-131" but probably with a different number)
- If you're not sure which serial device is your Arduino, take a look at the available ports, then unplug your Arduino and look again. The one that disappeared is your Arduino.
- With your Arduino board connected and the Blink sketch open, press the 'Upload' button After a second, you should see some LEDs flashing on your Arduino, followed by the message 'Done Uploading' in the status bar of the Blink sketch.
- If everything worked, the onboard LED on your Arduino should now be blinking! You just programmed your first Arduino.
- An Arduino is a popular open-source single-board microcontroller. Learn how to program one and let the possibilities take shape.

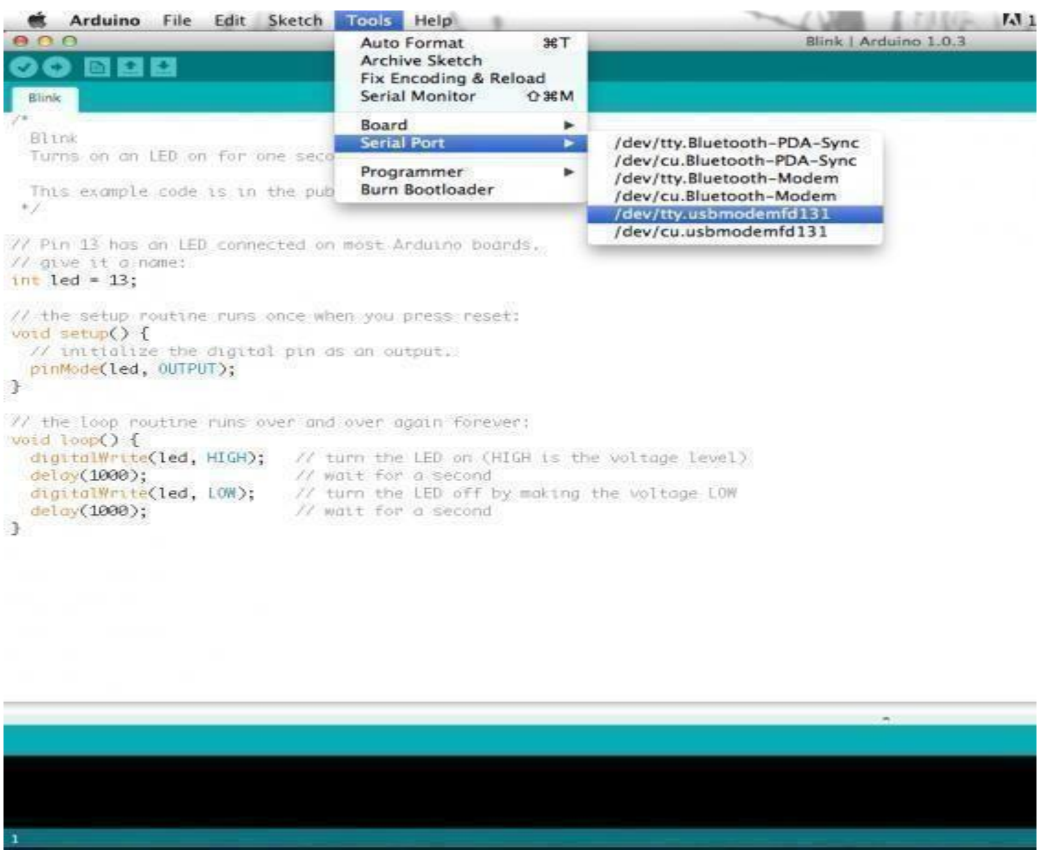


Figure 5.9 : Installation of windows

5.2 Hack an Arduino:

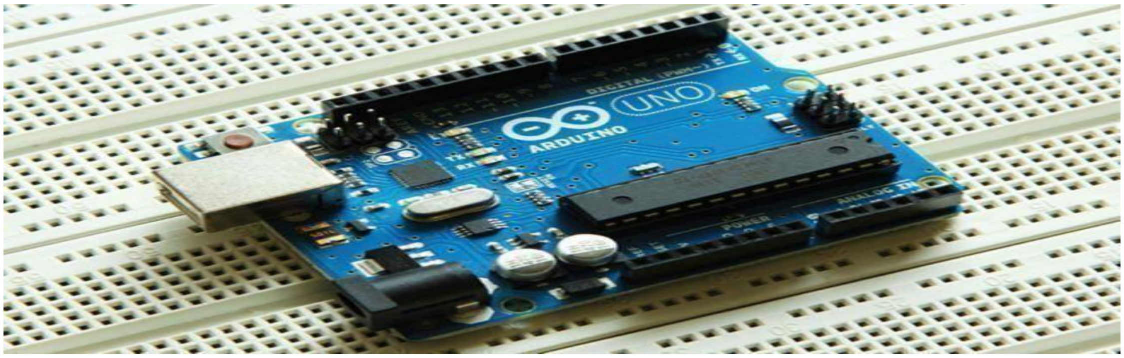


Figure 5.10: Hack on Arduino

STEP 1

Arduino microcontrollers come in a variety of types. The most common is the Arduino UNO, but there are specialized variations. Before you begin building, do a little research to figure out which version will be the most appropriate for your project.

STEP2

To begin, you'll need to install the Arduino Programmer, aka the integrated development environment (IDE).

STEP3

Connect your Arduino to the USB port of your computer. This may require a specific USB cable. Every Arduino has a different virtual serial-port address, so you 'll need to reconfigure the port if you're using different Arduinos.

STEP4

Set the board type and the serial port in the Arduino Programmer. STEP5

Test the microcontroller by using one of the preloaded programs, called sketches, in the Arduino Programmer. Open one of the example sketches, and press the upload button to load it. The Arduino should begin responding to the program: If you've set it to blink an LED light, for example, the light should start blinking.

STEP6

To upload new code to the Arduino, either you'll need to have access to code you can paste into the programmer, or you'll have to write it yourself, using the Arduino programming language create your own sketch. An Arduino sketch usually has five parts: a header describing the sketch and its author; a section defining variables; a setup routine that sets the initial conditions of variables and runs preliminary code; a loop routine, which is where you add the main code that will execute repeatedly until you stop running the sketch; and a section where you can list other functions that activate during the setup and loop routines. All sketches must include the setup and loop routines.

STEP7

once you've uploaded the new sketch to your Arduino, disconnect it from your computer and integrate it into your project as directed.

5.3 Conclusion

In conclusion, the software of solar electric vehicles involves systems for energy management, monitoring solar panel performance, and optimizing battery usage. It ensures the efficient conversion of solar energy, controls power distribution, and maximizes the vehicle's range. Future software advancements will focus on improving real-time data analysis and adaptive algorithms to further enhance the vehicle's energy efficiency and performance.

Chapter 6

Advantages, Disadvantages and Application

6.1 Advantages

1. Environment Friendly - Electric buses have clean energy and can be a good alternative to diesel transportation vehicles to reduce environmental pollutants.
2. Better Working Condition - The electric bus is much quieter than a diesel bus, giving travelers a more pleasant experience and significantly reducing the environmental noise.
3. Easy Maintenance - The cost of maintenance is about 25% lower than the maintenance cost of a diesel bus, since the electric motor doesn’t need the same level of services the diesel engine needs.
4. Economical - Electric engine’s energy losses are significantly lower than diesel engine’s energy losses, so the cost per kilometer of electric bus travel is about a third of the cost of a diesel bus ride.
5. Renewable Energy Source- Solar power is abundant and inexhaustible.
6. Reduced Operating Costs- Charging EVs using solar energy reduces dependence on grid electricity, lowering costs.
7. Low Environmental Impact-Solar power reduces carbon emissions, promoting green energy.
8. Off-Grid Capability-Solar EV chargers can function in remote locations without access to the grid.
9. Scalability-Solar systems can be tailored to the specific energy needs of individuals or fleets.

6.2 Disadvantages:

1. High Cost - As of today, the electric bus is significantly more expensive than a diesel bus, but the cost is expected to go down.
2. Limited Range - The conventional charging system limits the driving distance.

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3. Intermittency: Solar energy generation depends on sunlight availability, making it less reliable during cloudy weather or nighttime.
4. High Initial Costs: Solar panels and installation require significant upfront investment.
5. Space Requirements: Large solar panels may be needed to charge EVs, especially for high-capacity batteries.
6. Efficiency Issues: Solar panels have relatively low efficiency (~15-22%), which may limit charging capacity.
7. Adjustments must be made to the energy system according to the area in which the bus operates. Building a working plan (schedule) for an electric bus should consider a variety of parameters about the energy system.

6.3 Applications

1. Solar-powered charging stations in urban and rural areas.
2. Integration of solar panels into EVs for auxiliary power (e.g., running cooling systems or extending range).
3. Off-grid solar EV chargers for remote locations.
4. Use in sustainable smart cities and microgrids.
5. Commercialized four-wheel drives.
6. Usable in areas where fuel-based vehicles are not permitted.
7. For public transport

Chapter 7
Hardware Details

The "Solar and Wind Power Electrical Vehicles" is a significant initiative aimed at developing and implementing electric vehicles (EVs) powered by renewable energy sources, specifically solar and wind power. This project aims to contribute to a more sustainable transportation system by reducing reliance on fossil fuels and mitigating greenhouse gas emissions.

The project encompasses a wide range of activities, including:

- Research and development of advanced battery technologies to improve energy storage capacity and efficiency.
- Design and engineering of solar panels and wind turbines specifically optimized for integration into electric vehicles.
- Development of intelligent energy management systems to maximize the utilization of renewable energy sources and optimize vehicle performance.
- Establishment of charging infrastructure, including solar and wind-powered charging stations, to support the widespread adoption of electric vehicles.
- Publiceducation and awareness campaigns to promote the benefits of solar and wind-powered electric vehicles and encourage their adoption.

The project is expected to have a significant impact on the environment, economy, and society. By reducing reliance on fossil fuels, it will help to mitigate climate change and improve air quality. The development of new technologies and industries related to renewable energy and electric vehicles will create jobs and stimulate economic growth. The increased adoption of electric vehicles will also lead to reduced traffic congestion and improved public health.

The "Solar and Wind Power Electrical Vehicles" project is a crucial initiative that has the potential to revolutionize the transportation sector and contribute to a more sustainable future. By harnessing the power of the sun and wind, we can create a cleaner, greener, and more efficient transportation system that benefits both the environment and society.

Hardware Components Used in the Project:

1. Solar Panel and Wind Turbine:

Purpose: These are primary energy generation components. Solar Panel: Converts sunlight into electrical energy.

Figure 7.1: Solar Panel

Wind Turbine: Harnesses wind energy during motion.

Figure 7.2: Wind Turbine

2. Battery:

Purpose: Stores the energy generated by the solar panel and wind turbine.

Specification: Capable of handling continuous charge-discharge cycles efficiently.

3. Arduino Board: Purpose: Acts as the brain of the system, controlling energy flow and monitoring.

Features: Compatible with the required sensors and modules.

4. HC-05 Bluetooth Module:

Purpose: Enables wireless communication and real-time monitoring of system parameters.

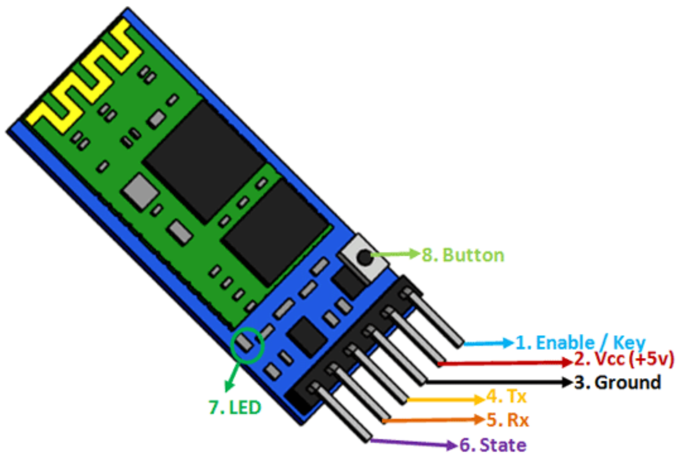

Figure 7.3: Bluetooth Module

5. LCD Display:

Purpose: Provides feedback to the user, showing critical system metrics like battery status and power usage.

6. L293D Motor Driver:

Purpose: Drives the DC motor by translating control signals from the Arduino.

Figure 7.4: L293D Moter Driver

7. DC Motor:

Purpose: Propels the vehicle using energy supplied from the battery.

Figure 7.5: DC Motor

8. Wires, Connectors, and Chassis:

Purpose: These components integrate and provide physical structure to the system.

7.2 Conclusion

This chapter includes all the hardware details which used in Solar and Wind power based electrical vehicles.

Chapter 8

Result

Solar and Wind Power-Based Electrical Vehicles, successfully integrates renewable energy sources solar panels and wind turbines to power an electric vehicle. The 140 Wp solar panel generates up to 25V DC during optimal sunlight hours, while the wind turbine complements this by harnessing airflow during motion. Energy is efficiently stored in a battery system, protected from overcharging and deep discharge by a charge controller.

The Arduino microcontroller manages energy flow and system components, while an LCD display provides real-time monitoring. This setup powers a DC motor for eco-friendly vehicle operation, showcasing reduced reliance on fossil fuels and a significant step towards sustainable transportation.

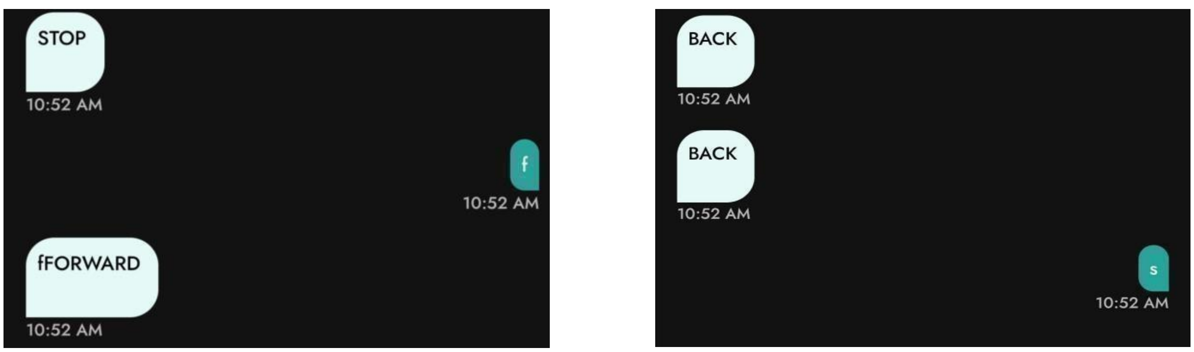

Figure 8.1: Command window

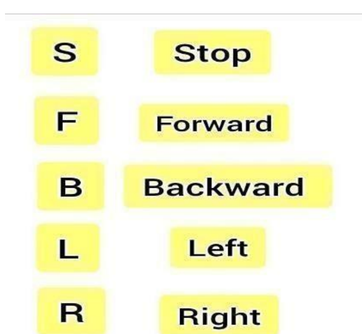

Figure 8.2: Commands

Figure 8.3: Front view of SWEV

Solar and Wind Power Based Electric Vehicle (SWEV) utilizes both solar panels and a small wind turbine to generate renewable energy, which is stored in a battery and used to power the vehicle's electric motor. This dual-source energy system ensures efficient charging even during low sunlight conditions, improves overall energy availability, and reduces dependence on sources.

Figure 8.4: Side view of SWEV

By combining two natural energy sources, the system ensures better energy reliability in varying weather conditions, making the vehicle more sustainable, environmentally friendly, and suitable for long-term use in clean transportation solution.

Chapter 9

Conclusion and Future Scope

9.1 Conclusion:

This project focuses on researching, designing, building, and testing a working prototype of a solar and wind-powered electric bus aimed at promoting sustainable and eco-friendly transportation. By integrating solar and wind energy systems, the hybrid setup reduces dependence on fossil fuels, achieves zero emissions, and optimizes energy efficiency for consistent operation. The project emphasizes innovative design, construction, and renewable energy utilization, offering a cost-effective solution with lower maintenance compared to traditional fuel-based vehicles. Features like regenerative braking, advanced battery management, and real-time monitoring enhance energy storage efficiency, safety, and system performance. Ideal for remote areas with limited infrastructure, this prototype not only demonstrates the practical application of clean energy in public transit but also supports climate change mitigation and the shift toward greener, smarter cities.

This solar and wind-powered electric bus prototype highlights energy resilience by generating its own power, reducing reliance on external charging. Ideal for remote areas, it uses real-time monitoring for efficient energy management and safety. The project supports sustainability and drives innovation in clean, self-sustaining public transport.

9.2 Future Scope:

To enhance EV charging efficiency and user experience, key improvements include better internet connectivity for real-time updates, advanced software for locating nearby stations with GPS and online payments, stronger server security, regular system updates, and smart charging features like automatic payments and invoicing.

References

[1] Cloud-Based Charging Management of Electric Vehicles in a Network of Charging Stations Cuiyu Kong∗, Bhaskar Prasad Rimal†, Bishnu P. Bhattarai‡, and Michael Devetsikiotis

[2] Solar and Wind Energy Based Charging Station for Electric Vehicles C. Chellaswamy1, V. Nagaraju2, R. Muthammal3 Professor, Department of

[3] Design and Analysis of a Solar-Powered Electric Vehicle Charging Station for Indian Cities Aanya Singh 1, Shubham Sanjay Shaha 1, Nikhil P G 2, Yendaluru Raja Sekhar 3, Shaik Saboor 1

[4] Press Trust of India. Electric Vehicle Market in India Expected to Hit 63 Lakh Units per Annum Mark by 2027: IESA.

[5] Suzuki, K.; Kobayashi, Y.; Murai, K.; Ikezoe, K. Impact of Electric Vehicle Charging on Power System with High Penetration of Electric Vehicles: Simulation and Quantitative Analysis Based on Real World Usage Data. In SAE Technical Paper Series; SAE International: Warrendale, PA, USA, 2020

[6] Kostopoulos, E.D.; Spyropoulos, G.C.; Kaldellis, J.K. Real-World Study for the Optimal Charging of Electric Vehicles. Energy Rep. 2020, 6, 418–426.

[7] Brenna, M.; Foiadelli, F.; Leone, C.; Longo, M. Electric Vehicles Charging Technology Review and Optimal Size Estimation. J. Electr. Eng. Technol. 2020, 15, 2539–2552.

[8] Chandra Mouli, G.R.; Van Duijsen, P.; Grazian, F.; Jamodkar, A.; Bauer, P.; Isabella, O. Sustainable E-Bike Charging Station That Enables AC, DC and Wireless Charging from Solar Energy. Energies 2020, 13, 3549.

[9] Altaleb, H.; Rajnai, Z. Electric Vehicle Charging Infrastructure and Charging Technologies. Haditechnika 2020, 54, 8–12.

[10] Al Wahedi, A.; Bicer, Y. Development of an Off-Grid Electrical Vehicle Charging Station Hybridized with Renewables Including Battery Cooling System and Multiple Energy Storage Units. Energy Rep. 2020, 6, 2006–2021.

[11] Mohamed, K.; Wolde, H.K.; Alarefi, S.M.S. Optimal Space Utilisation for Solar Powered EV Charging Station. In Proceedings of the 2020 6th IEEE International Energy Conference (ENERGYCon), Gammarth, Tunisia, 28 September–1 October 2020.

[12] Kumar, R.; Rajoria, C.S.; Sharma, A.; Suhag, S. Design and Simulation of Standalone Solar PV System Using PVsyst Software: A Case Study. Mater. Today 2020, 46, 5322–5328.

[13] Y. Yang, Q. Jia, X. Guan, X. Zhang, Z. Qiu and G. Deconinck, "Decentralized EV-Based Charging Optimization With Building Integrated Wind Energy," IEEE Trans. Automation Science and Engineering, vol. 16, no. 3, pp. 1002-1017, July 2019 34

[14] W. Mo, Y. Chao, C. Xin, L. Kangjie, D. Shuaiqi, "Optimal Charging Navigation Strategy Design for Rapid Charging Electric Vehicles", Energies, vol. 12, no.6, pp. 962, 2019