DESIGN OF BLUETOOTH CONTROLLER FOR SOLAR GRASS TRIMMER

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DESIGN OF BLUETOOTH CONTROLLER FOR SOLAR GRASS TRIMMER

SITI RAUDHAH BINTI RADUAN

Thesis submitted in fulfilment of the requirements
for the award of the degree of
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ABSTRACT

Solar energy is that the heat and light-weight radiations received from the Sun. It is one among the foremost galore types of non-conventional, renewable energy supply found on the world. It is without delay on the market, freed from value and is pollution free. Solar energy is controlled to be become electricity and power by the utilization of devices like star panels that consists of electrical phenomenon cells. Solar system receiving more attention through this year because of its advantages compare to other renewable energy. Solar power is one of the suitable renewable green energy to be used in Malaysia as located in tropical regions and situated near to the equator. Besides, Malaysia is able to receive enough radiation of the light energy from the sunlight to generate electricity. The demand and request for green energy technology produced by renewable energy sources has increased. The objective of this project is to control all the movement and the direction of the trimmer by using an application in the PlayStore. Therefore, the application needs to connect with a Bluetooth device that connected with all the electrical components in the electrical box. So, it will be come up with the trimmer that is transportable, durable, easy to operate and maintain. The advantage of powering a grass trimmer by solar instead of by fuel is principally ecological. It additionally aims to style an Android-hopped-up trimmer of electrical source which a conductor electric grass lawn tool. The heart of the machine may be a battery hopped-up DC motor. It is additionally helpful technique for our grass trimmer. The present technology usually used for trimming the grass is by exploitation the manually handle device. The Bluetooth-driven the machine for trimming the grass is applied. The device consists of blade that is operated with the assistance of the motor. The battery will then be charge by the solar. Meanwhile, the solar grass trimmer can be operated anywhere within the Bluetooth signal range by the mobile phone of the owner.

ABSTRAK

Tenaga solar ialah radiasi panas dan cahaya yang diterima dari Matahari. Ia adalah salah satu daripada pelbagai jenis bekalan tenaga yang tidak boleh diperbaharui secara konvensional di dunia. Tenaga solar adalah sejenis sumber yang tiada dijumpai di pasaran, malah ia dikeluarkan dalam sebuah nilai dan bebas dari pencemaran. Tenaga solar dikawal untuk menjadi tenaga elektrik dan kuasa oleh penggunaan peranti seperti panel bintang yang terdiri daripada sel-sel fenomena elektrik. Sistem solar mendapat lebih banyak perhatian sepanjang tahun ini kerana kelebihannya berbanding dengan tenaga boleh diperbaharui yang lain. Kuasa solar adalah salah satu tenaga hijau yang boleh diperbaharui yang akan digunakan di Malaysia yang terletak di kawasan tropika dan terletak berhampiran dengan Khatulistiwa. Selain itu, Malaysia mampu menerima sinaran matahari yang cukup untuk menghasilkan tenaga elektrik. Permintaan untuk teknologi tenaga hijau yang dihasilkan oleh sumber tenaga boleh diperbaharui telah meningkat. Objektif projek ini adalah untuk mengawal semua pergerakan dan arah mesin dengan menggunakan aplikasi di PlayStore. Oleh itu, aplikasi ini perlu membuat sambungan dengan peranti Bluetooth bagi memastikan mesin berjalan dengan lancar. Oleh itu, ia akan menghasilkan mesin rumput yang mudah dibawa kemana-mana, tahan lama, mudah dikendalikan dan juga diselenggara. Kelebihan untuk memelihara mesin rumput yang terdiri daripada tenaga solar adalah lebih ekologi. Ia juga bertujuan untuk gaya kebergantungan mesin rumput Android ini yang terdiri daripada sumber elektrik konduktor. Nadi utama mesin daripada motor DC akan disambung terus dengan bateri. Ia juga merupakan teknik tambahan untuk mesin rumput kami. Teknologi sekarang yang biasa digunakan untuk memangkas rumput adalah dengan mengeksploitasi peranti pengendalian secara manual. Oleh itu, Bluetooth digunakan untuk memotong rumput sekaligus menggerakkan mesin. Peranti ini terdiri daripada bilah yang digerakkan dengan bantuan motor. Bateri akan dicas semula oleh solar. Sementara itu, mesin rumput solar ini boleh dikendalikan di mana-mana sahaja asalkan masih di dalam jarak isyarat yang ditetapkan bagi Bluetooth dengan telefon bimbit pemilik.

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LIST OF SYMBOLS

Ah	Ampere hour
A	Ampere
cm	Centi meter
E	Back electromotive force
e^-	Electron
g	Gram
HP	Horse power
I	Current
kW	Kilowatt
kHz	Kilo Hertz
m	Meter
P	Power
R	Resistance
V	Volt
°C	Degree Celsius
Ω	Ohm
η	Efficiency
ω	Speed

LIST OF ABBREVIATION

AC	Alternating Current
AGM	Absorbent Glass Mat
ARM	Advanced RISC Machines
AVR	Advanced Virtual RISC
CC	Constant Current
CdTe	Cadmium Telluride
CIGS	Copper Indium Gallium Selenide
CV	Constant Voltage
DC	Direct Current
DIR	Direction control
EMF	Electro Motive Forces
FF	Fill Factor
GND	Ground
IC	Integrated Circuit
I_{SC}	Current Short Circuit
MD30C	Motor Driver 30 Current
PIC	Peripheral Interface Controller
PWM	Pulse Width Modulation
RPM	Revolutions Per Minute
Rx	Receiver pin
SLA	Sealed Lead-Acid
SOC	State Of Charge
TCO	Transparent Conductive Oxide
Tx	Transmitter pin
Vcc	Voltage input

Vin	Voltage input
Voc	Voltage Open Circuit

CHAPTER 1

INTRODUCTION

1.1 Project Background

In the time where technology is merging with environmental awareness, consumers are looking for ways to contribute to the environment by using devices with eco-friendly technology to decrease the pollution and protect the nature. Pollution is manmade and can be seen in our own daily lives, more specifically in our own homes. Mostly, gas powered lawn mower are one of devices that contribute to the pollution especially air pollution. If using electrical powered, for sure it consumes large amount of energy for the working to move the cutting blades and the wheels. Nowadays, all the creation and new devices going under automation so our team tried to reduce the human effort for the trimming job.

The design objective is to come up with a grass trimmer that is portable, durable, easy to operate and maintain. It also aims to design a self-powered trimmer of electrical source which is a cordless electric grass trimmer. The heart of the machine is a battery-powered DC electric motor. The use of cable ties as blade makes the design unique such that less energy is needed for the motor to spin the blade. Thus, the machine is considered highly efficient as it uses no human effort and is readily adaptable for cutting conditions.

The system uses 12V batteries to power the vehicle movement motors as well as the grass cutter motor. We also use a solar panel to charge the battery so that there is no need of charging it externally. The grass trimmer and vehicle motors are interfaced to a microcontroller that controls the working of all the motors. The microcontroller moves the vehicle motors in forward direction in case if the owner give an instruction in forward. Meanwhile, the microcontroller stops the grass trimmer motor if the owner gives the instruction to do so. Thus this system allows a Bluetooth controlled grass trimming system with only one human needed.

1.2 Problem Statement

Nowadays, most of the activities which included human efforts are either replaced or automated by the use of machines or other kinds of equipment. The present technology commonly used for cutting the grass is by using the manually handle device which inconvenience due to heavy machines to carry and required human effort for proper handle. Bluetooth solar grass trimmer is one of the machines for a public appliance to reduce human effort for trimming job.

In the time where technology is merging with environmental awareness, consumers are looking for ways to contribute for reducing the cause of pollution. By switching to modern technology from traditionally aspect, the implementation of solar trimmer devices is more environmental friendly compared to old cutting devices which can contributes to air pollution due to the internal combustion of engine. Therefore, solar grass trimmer devices are more preferable where the energy can be supplied from sunlight that absorbed by the solar panel to generate electricity.

Besides, the traditional lawn mower will consume engine oil in their fuel combustion to generate energy which generally creates byproducts and harmful pollutants. Thus, the energy efficiency can be achieved with the help of motor by using the solar energy. The grass trimmer device is solar powered which the battery can be charge manually from main supply. Hence, the energy consumption can be reduced and carbon emission can be minimized.

In response to this problem, the project purpose is to improve design on several options for traditional grass cutter devices into Bluetooth solar grass trimmer devices that can increase the energy efficiency and reduce pollution. The usage of solar panel and the microcontroller (Arduino) as well as Bluetooth device as the main controller will provide some change in energy consume by solar grass trimmer.

Bluetooth Solar Grass Trimmer is chosen for our project because of the nowadays technology which commonly using the manually handle device for trimming the grass. The trimmers sold on market in this day needs manual handle from the users. Our team decided to upgrade those manually handle grass trimmer to the Bluetooth solar grass trimmer which use solar energy.

This proposal was written to put into words about our project entitled Bluetooth Solar Grass Trimmer. This machine is a controlled grass trimmer which used to trim the

grass such as cow grass at the house compound or other suitable places by using a Bluetooth device. The device consists of cable ties which are operated with the help of the motor and the power supply for the motor is from the battery. The battery can be charge by using the solar panel with the help of solar charge controller.

This project may explore the new investigation field as a team to build this Bluetooth solar grass trimmer as our Senior Design Project. At the end of the project, we expected to build a portable size of Bluetooth solar grass trimmer with its solar charger. Our aim is to fabricate a grass trimming machine system which runs with the help of motor by using the solar energy.

1.3 Research Objectives

The objectives of the project are as follows:

- To fabricate a Bluetooth solar grass trimmer that easy to handle.
- To program a Bluetooth solar grass trimmer which can driven by the motor driver and be able to communicate with the Bluetooth HC-05.
- To power the Bluetooth solar grass trimmer with the solar panel system.

1.4 Scopes Of Study

This project is proposed to improve the controller by designing the Bluetooth module in the electrical circuit. In order to achieve the objectives, the following scopes of works are proposed.

i. Select the best controller in terms of its power rating, cost and efficiency.
ii. Identify the best controller supporting equipment's such as battery, motor driver, motor, inverter based on the price, size, efficiency and safety.
iii. Design the controller circuit for the solar grass trimmer using the selected Arduino Uno R3, 12VDC motor, MD30C motor driver, DC to AC inverter and HC-05 Bluetooth module.

iv. Build a programming code for Arduino to control the movement and direction of the solar grass trimmer.

CHAPTER 2

LITERATURE REVIEW

2.0 Literature Review

This section reviews the different main parts and characteristic that is needed to make the Bluetooth solar grass trimmer. Hence, we would to highlight on four main parts of solar grass trimmer which includes body design and material, motor, battery and solar panel.

2.1 Body Design

2.1.1 Body Deck Design

Plastic is generally cheaper and so often found on budget, entry-level machines. Some of premium lawn mowers models such as Honda mowers use plastic for its deck. It is corrosion and weather resistant and relatively lightweight. It can also be very tough and some impact resistant polymers can even rival metals for strength.

As for steel, it is a traditional and tough steel deck which is mainly found on petrol machines, their strength suiting the more vigorous demands of larger lawns and tougher mowing tasks. Some stamped steel decks can be quite thin but thicker steel is a prestige material that is durable and tends to be favoured by high-end manufacturers. Steel decks are usually treated with powder paint that helps protect the deck and fight corrosion. Steel decks are generally impact resistant and will absorb impact damage fairly well.

For aluminium alloy decks, it is the arguably the premium choice material of the three. They have advantages of both the others, featuring the strength and quality of steel and the corrosion resistance of composite plastics. Aluminium alloy decks where used on many top mowers and it is long-lasting and hard wearing. Aluminium, is a little more brittle than steel and does not have the same impact resistance as steel, but is usually a premium product and likely to be made from premium quality components.

2.1.2 Wheels

A standard-sized wheel may have difficulty rolling over rutted or uneven ground. Smaller wheels follow the curves more closely than larger wheels. It could cause the mower deck to bottom out and scalp the lawn. Larger diameter wheels are a better match for ruts, grooves, depressions and rolling terrain. The larger diameter is more likely to span uneven ground, resulting in a lower likelihood of damaging the lawn while mowing. Most in the markets nowadays sold this kind of mowers which use small diameter on front wheels and larger diameter on back wheels as shown in Figure 2.1.2 for the stability of the mowers.

Figure 2.1.2: Different diameter of grass trimmer wheels

2.1.3 Cutting Head

Cutting head used in grass trimmer nowadays were mostly use aluminium head. This item is made of made of solid aluminium, ensuring the durability. It can handle small vibration, durable and wear well. Aluminium head fit for most lawn mower, lawn trimmer and universal use. With practical and compact, it is a great accessory for grass brush cutter. For the lawn mower cutting head, nylon cable ties and traditional cutting blades were used. Nylon cable ties is flexible, affordable, lighter and easily replaceable but the line breaks easily if not used correctly, turns small rocks into projectiles and cannot handle brush or thicker weed stems. As for cutting blades, it is versatile use with different blade attachments and powerful enough to cut brush and small trees. Although it is powerful but the cutting blade is cumbersome for large areas and can throw materials back at the user.

Figure 2.1.3.1: Aluminium cutting head

Figure 2.1.3.2: Cutting blades and nylon cable ties

2.2 Motor

For designing a grass trimmer, selecting a suitable electric motor is important criteria since the motor is the one that drives the generated torque to the cutting head to trim the grass and lead the grass trimmer to move the grass trimmer's wheels. Moreover, the size of the motor shall be suitable enough so that it will fit in perfectly inside the grass trimmer to move the cutting head and the wheels. Most of the electrical motors that ar obtainable within the markets ar costly and enormous in size. In addition, these motors ar used for serious duty field mowers since the cutting blades need an oversized quantity of power unit and move speed. A BLDC motor will be used since the cutting head will be using strings instead of cutting blades (Sivagurunathan, Sivagurunathan, & Jun Hao, 2017). If using string or cable ties trimmer, it only requires minimum rotational speed of 17000 RPM and estimated operating voltage is 15V-21V.

Figure 2.2:BLDC4244 motor

2.2.1 Motor Performance

There are a few parameters that can measure a motor's performance, including motor speed, RPM, and power. The theory and calculation of these parameters are discussed below.

2.2.2 Torque & Rpm

Torque is a measure of how much force acting on an object causes that object to rotate. A revolution per Minute (RPM) is a measure of the frequency of rotation around a fixed axis in one minute. It is used as a measure of rotational speed of a mechanical component. Higher RPM motors tend to generate less torque.

2.2.3 Motor Speed

In a motor, whenever there is relative motion between magnets and coils, a back electromotive force (EMF) is induced in the coils. Back EMF is proportional to the rotational speed of motor,

$$E=KV*\omega$$

Where E is back-emf, KV (Volts/RPM) is the back-emf constant and ω is the speed. In a basic circuit analysis, where resistor and back-emf is in series, we get,

$$V=R*I+E$$

$$=(R*I)+(KV*\omega)$$

$$\omega=\frac{V-R*I}{KV}$$

Where V is the DC supplied voltage, R (Ω) is resistor, I (A) is current. From the equation above, we can see that the speed of DC motor is equal to the applied voltage minus voltage drop due to resistance and current in the motor. As the current in the motor increases, the speed of the motor decreases. Current is proportional to torque, which also means that when torque of motor increases, the speed decreases.

2.2.4 Power

Power is the rate at which energy is generated or consumed. The more wattage the motor have, the more power on demand it has. Power used for an hour/Watt hour calculation is very important for building the trimmer because we can control the duration time and capacity needed to run it.

The formula that we use to calculate watt hour calculation is:

$$P = V \times I$$

Where P = Power, V = Voltage, I = Current, 1HP= 0.7457kW

For example, the grass trimmer estimated motor rated with 3/4HP and 53A with full load running (Jeremy James 2014).Therefore, the voltage that we need is 10.55V. So, we can determine the suitable battery which is at 12V for supply voltage.

2.3 Battery

Firstly, sealed lead-acid (SLA) is the battery that constructed with vents or valves to automatically relieve pressure from gas build up to avoid any discharged or overcharged. The sealed battery contains less amount of electrolyte as compared to the flooded type. Rather than submerging the plates in a liquid, the electrolyte is impregnated into moistened separators which enable the batteries to operate in any physical orientation without any leakage. The most significant advantages of sealed acid

is the ability to combine oxygen and hydrogen which occurs at moderate pressure of 0.14 bar (2psi) to create water and prevent dry out during cycling.

There are several types of sealed lead-acid with difference in technology which are absorbent glass mat (AGM) and gel cell. The AGM suspends the electrolyte in a specially design glass mat. This offers several advantages to lead acid systems, including faster charging and instant high load currents on demand. AGM works best as a mid-range battery with capacities of 30 to 100Ah which typically suitable use as starter batteries for electronic vehicles. In addition, the sealed lead acid battery is design with a low-over-voltage potential to prevent the battery from excess charging which lead to potential gas generating, venting and subsequent water depletion and dry out during charging.

In gel cell, the sulfuric acid in AGM battery is mixing with silica gel agent which converts liquid electrolyte into a semi-stiff paste to make the gel maintenance free. The gel separator is function as to move the heat whereas the absorbent glass mat of the AGM acts as insulator. This will improve the heat transfer to the outside of the battery and allows the battery to stay high performance range. However, gel cells required appropriate charge and float voltage because it too sensitive when over charging occurs.

The common type of lithium-ion batteries that is used in most of the portable electric transportation in the market is Lithium-Ion Phosphate (LiFePO4) Battery. Lithium-ion uses a cathode as positive electrode and anode as negative electrode as well as electrolyte as conductor. The cathode is metal oxide and the anode consists of porous carbon. During discharge, the ions flow from the anode to the cathode through the electrolyte and separator which is charge in reverse direction and the ion flow from the cathode to the anode. Li-phosphate batteries is suitable for electronic vehicles because its can maintain the topping charge which is can maintain at full charge level and prevent the sulfation on the batteries. Li-phosphate is more tolerant to full charge conditions and is less stressed than other lithium-ion systems if kept at high voltage for a prolonged time. As a trade-off, its lower nominal voltage of 3.2V/cell reduces the specific energy below that of cobalt-blended lithium-ion. In addition, Li-phosphate is suitable to replace the lead acid starter battery. For example, four cells of Li-phosphate connected in series can produce 12.80V has similar voltage to six 2V of lead acid cell connected in series (Types of Lithium-ion Batteries – Battery University 2017).

2.3.1 Battery Charging System

The lead acid battery uses the constant current constant voltage (CC/CV) charge method. A regulated current raises the terminal voltage until the upper charge voltage limit is reached, at which point the current drops due to saturation. The charge time is 12–16 hours and up to 36–48 hours for large stationary batteries. With higher charge currents and multi-stage charge methods, the charge time can be reduced to 8–10 hours. However, without full topping charge the lead acid battery is sluggish and cannot be charged as quickly as other battery systems. Lead acid batteries should be charged in three stages, which are constant-current charge, topping charge and float charge.

Stage 1: Constant-current charge

During the constant-current charge, the battery charges to about 70 percent in 5–8 hours which the remaining 30 percent is filled with the slower topping charge that lasts another 7–10 hours.

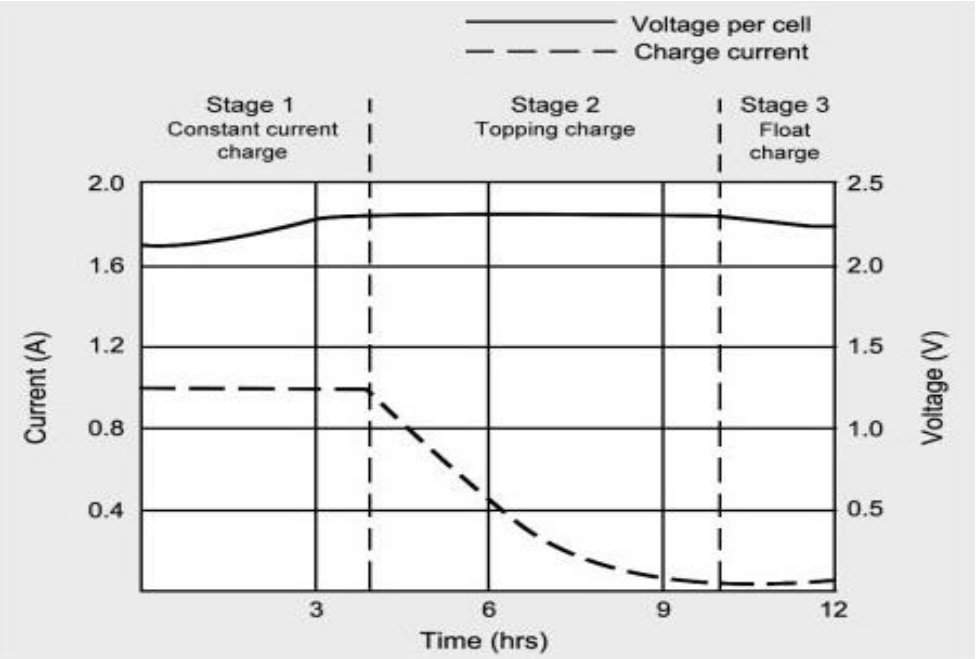
Stage 2: Topping charge

The topping charge continues at a lower charge current and provides saturation. If continually deprived, the battery will eventually lose the ability to accept a full charge and the performance will decrease due to sulfation.

Stage 3: Float charge

The float charge in the third stage maintains the battery at full charge.

Figure 2.3.1: Charges stages for lead acid battery



2.4 Microcontroller

Software Program commonly defined as a set of instructions, modules or procedures that allow for a certain type of computer operation. Most of the solar grass trimmer is a program under Arduino whereas on microcontroller board which is open source electronics platform based on easy-to-use hardware and software. This system needs a controller that can be programmed to control all the movements on the circuit such as sensors, motor drivers, relay and etc. In fact, microcontrollers is an embedded application software that contains programmable input and output peripherals while microprocessor usually used in personal computers that consists of several chips.

A microcontroller is more economical to fix all the instructions compared to other devices that designed in separated memory, microcontroller board, the chips and their input/output pins. Several microcontrollers may use four-bit words and operates at clock rate frequencies as low as 4-kHz, for low power consumption. It has the ability to

retain the functionality for such events such as timers, interrupts or even analog to digital converter.

The hardware integrated with one application as an embedded design is implemented using the 12C bus to interface different sensors and motor drivers to the ATMEL microcontroller chip (AVR Atmega32). There are many advantages in developing microcontroller based circuits and incorporating new sensor technology into agricultural applications. Microcontrollers and solid-state sensors can be found in many consumer applications even in the factory.

There are a lot of microcontrollers that exists in this world such as 8051, PIC, ARM, and AVR. A very common use for the consumer nowadays is the Arduino Uno. Arduino Uno usually comes with a set of a board of Atmega328. In shorts, Arduino Uno consists of 14 digital input/output pins(in Figure 2.4) and combines with the application software such as Proteus and AVR. Moreover, to control and communicate with all the progress of the functions, the Arduino programming software(AVR) must be connected together with the hardware board that consists of our electrical circuit. Arduino software consists of some libraries that can provide extra functionality in sketches and will be uploaded by our own creativity.

Figure 2.4: Arduino Uno board.

2.5 Solar System

Solar energy is the best alternative for producing electricity due to industrialization for various industrial applications and electrical gadgets. Solar energy emits less of pollution or greenhouse gasses effect. The variety of solar power technologies available run on a scale of efficiency, price, durability, and flexibility which depending upon the need of project. Solar photovoltaic (PV) systems are highly modular and making it's suitable for use on the demand side of electricity consumptions. PV solar technology generates power because substances like silicon generate an electrical current with the absorption of sunlight called photovoltaic effect. The solar photovoltaic effect can be observed in almost any junction material that has different electrical characteristics base on the material of their junction. The device used to utilize the photovoltaic effect is the solar cell.

In solar system, sunlight is directly absorbed by semi-conductor materials on the solar panel by hitting the photons. Semiconductor is the materials that have tendency to absorb sunlight and deliver a portion of the energy through the electron and hole which is absorbed by the photons to carries the electric current. A solar cell is simply semiconductor diodes which separates and collect the carries and conduct the generated electrical current conversely in a specified direction. The energy of light is directly converted into electricity through the photovoltaic effect. The photovoltaic effect is the creation of voltage or electric current in a material upon exposure to light. The figure below show the energy from the sunlight is directly absorbed into the solar cells through photovoltaic effect.

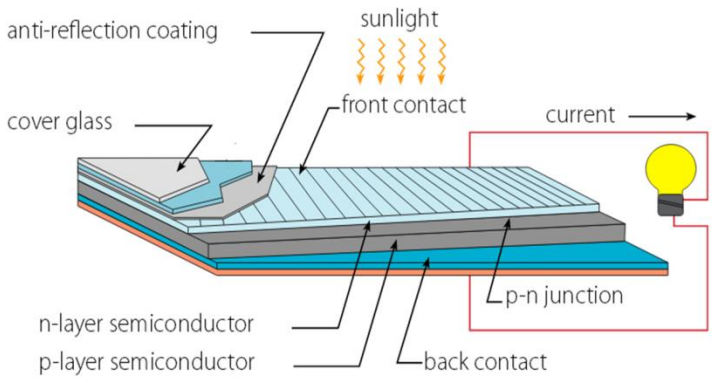


Figure 2.5.1: The solar cell structure

Solar cells consist of two layer which is p-type silicon and n-type silicon layer (Figure 2.5.1). The sunlight is composed of photons or particles of solar energy that contain various amount of energy corresponding to the different wavelengths of the solar spectrum. The electrons present in the valence band absorb energy which is in the excited state and jump into the conduction band and become free. These highly excited electrons are accelerated into a different material by a built-in potential. Thus, electromotive forces are produces by some of the light energy is converted into electric energy.

The operation of a solar cells is occurs when sunlight is falls on silicon metal cell by which the photon energy allows the electrons from the n-layer to move to the n-layer as show on Figure 2.5.2 below. The movement of electrons on the layer will create an electric potential difference on the semiconductor borders. When these borders are connected to a load by conductive wires, there will be a flow of electric current. The process will repeated when the electron is getting back to the p-layer. Generally, a photovoltaic cell has low current and voltage level which approximately about 3A and 0.7V respectively (Photovoltaic Panel Converts Sunlight into Electricity 2010).

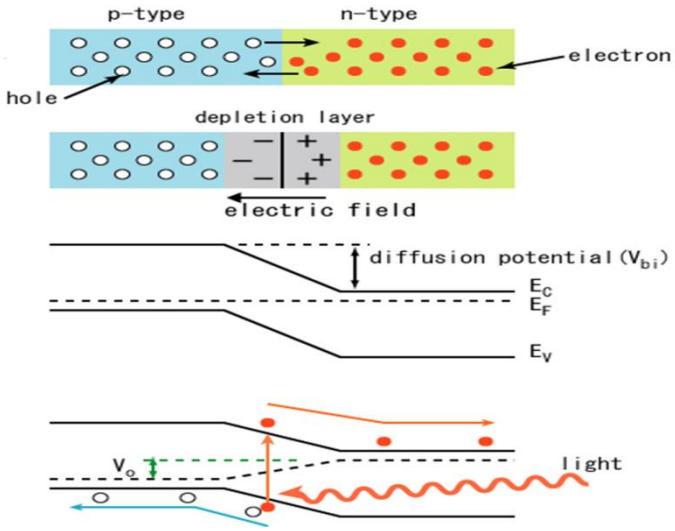


Figure 2.5.2: Operation of solar cells

2.6 Solar Panel

For most applications, the types of solar PV module usually the best option use in industrial are polycrystalline silicon solar cells, monocrystalline silicon solar cells, and thin film solar cells. These technologies generally provide the right balance of price,

efficiency, and reliability. Most solar panels range in efficiencies of 13% to 16%, though some high-end model modules can reach percentages as high as 20% (Solar Photovoltaic Cell Basics | Department of Energy n.d.).

2.6.1 Mono-Crystalline Silicon Solar Cell

Solar cells made of monocrystalline silicon (mono-Si), also called single-crystalline silicon (single-crystal-Si), and are indicating with high purity of silicon. Monocrystalline solar panels have the highest efficiency rates since they are made out of the highest-grade silicon. The efficiency rates for monocrystalline solar panels are typically between 15% - 20%. Generally, monocrystalline silicon solar PV is made up of single crystal which are cylindrical in shape. The shape of the panels is cut into the distinctive patterns that give them their recognizable appearance which is the sliced silicon cells expose the missing corners in the grid-like structure. Every each of the partition on the grid of the solar panel for monocrystalline design is rectangular shape with no rounded cutting edges that differences compare to other type of PV cells. The crystal framework in a monocrystalline is even and producing a steady blue colour with no grain marks as it can give the higher purity to achieve the higher efficiency.Monocrystalline solar panels tend to perform better than similarly rated polycrystalline at low-light intensity. This is due to space-efficient which requires least amount of space to yield the power outputs as its can produce up to four times amount of electricity. In terms of prices, the cost of producing monocrystalline is significantly higher compared to polycrystalline and thin film. Monocrystalline solar panels accounted for 38 percent of all modules produced in 2017, up from 25 percent in 2015 (Monocrystalline Cells vs. Polycrystalline Cells | CivicSolar n.d.). In addition, monocrystalline solar panels also live the longest. Most of the manufactures put in the range of 25 years warranty for monocrystalline solar panel.

2.6.2 Polycrystalline Silicon Solar Cell

The first solar panels based on polycrystalline silicon, which also known as poly-silicon (p-Si) and multi-crystalline silicon (mc-Si) that was introduced at the market in 1981. Unlike Monocrystalline-based solar panels, polycrystalline solar panels do not require the Czochralski process. Raw silicon is melted and poured into a square

mold, which is cooled and cut into perfectly square wafers. Instead of using a single crystal of silicon, wafers are also formed through the melting process together with many fragments of silicon. The efficiency of the polycrystalline solar panel is typically 14%-16%. This is because of lower silicon purity due to many crystals in each cell that cause less freedom for electrons to move. As result, polycrystalline solar panels have lower efficiency ratings and not quite efficient compared to monocrystalline panels. However, polycrystalline solar panels tend to have slightly lower heat tolerance than monocrystalline solar panels. Polycrystalline solar panels will tend to have a higher temperature coefficient than solar modules which made with mono cells. This means that as heat increased output for this type of cell will fall less which will be losing it efficiency more quickly as the temperature is rise.Polycrystalline modules are easily distinguished by their blue cells that resemble a camouflage of molten silicon. In terms of prices, the cost of producing and selling of polycrystalline solar panels is much lower than monocrystalline. Adding to that, the estimated life of this solar panel is about 25 years same as monocrystalline.

2.6.3 Thin Film Silicon Solar Cell

Thin film solar panels are made of solar cells that have light absorbing layers about 350 times smaller than that of a standard silicon panel. The different types of thin-film solar cells can be categorized by which photovoltaic material that varies and combined onto this substrate:

- Amorphous silicon (a-Si)

  It is the non-crystalline form of silicon. The cell structure has a single sequence of p-i-n layers. When exposed to the sun, their power output is significantly decreased. The A-Si type thin film is manufactured in 6 steps. First, the glass substrate is coated with a TCO for transparent conductive oxide layer as front contact, followed by P1 laser scribing. Then a layer of a-Si is deposited followed by P2 laser scribing. Then a metal conductive layer is placed as back contact with the relative P3 laser scribing.

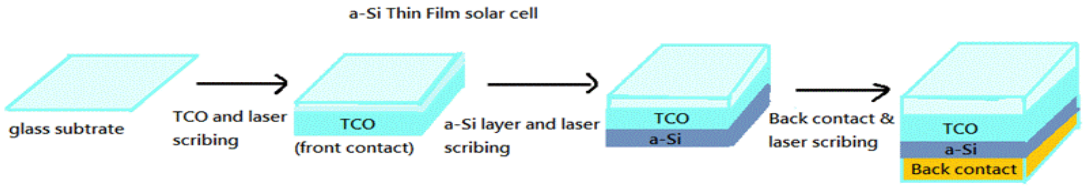


Figure 2.6.3.1: Composition of A-Si thin film

- Cadmium telluride (CdTe)

  It is formed from cadmium and tellurium. It is usually combined together with cadmium sulfide to form a p-n junction PV cell. The composition is similar to the a-Si solar cell with an additional Cds layer for buffer.

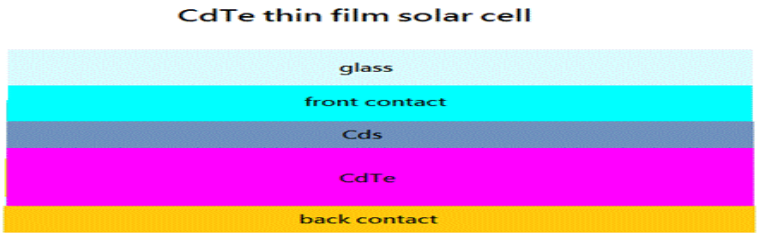


Figure 2.6.3.2: Composition of Cadmium telluride (CdTe) thin film

- Copper indium gallium selenide (CIS/CIGS)

  It is the semiconductor material composed of copper, indium, selenium, and/or gallium. In thin film technology, CIGS has the highest PV conversion efficiency. CIGS/CIS has similar manufacturing process as a-Si thin films. However, as opposed to a-Si thin film, the glass substrate on CIGS/CIS is at the rear instead of the front. In addition, Cds is applied as a buffer layer.

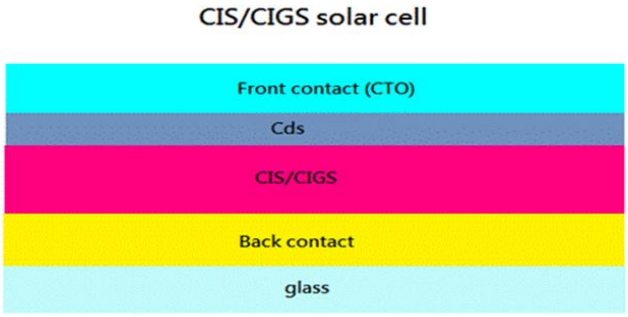


Figure 2.6.3.3: Composition of CIS/CIGS thin film

Thin-film solar cells has reached efficiencies between 7%-13% and production modulates operate at about 9% (Andrew Sendy, 2016) which is the lowest efficiency compared to types of silicon solar panels. In term of price and production, thin film solar panel is the lowest prices compared to polycrystalline and mono-crystalline solar panel. Since thin film solar panels are the cheapest panels to produce because of the low material costs for the thin film they are quickly becoming the more economically efficient panel types.Thin film solar panels have great advantages compared to other silicon solar panel because it is not affected by shade and high temperatures. The maintenance for thin film solar panels is not required periodically because of the photovoltaic materials used are able to absorb quite bit sunlight even if they are covered by shade. Additionally, because they are better able to resist high temperatures, these panels may be able to once and for all solve the problem of ambient heat in relation to solar panel output.

2.6.4 Solar Efficiency

Efficiency of a solar cell can be defined as the ratio of energy output from the solar cell to input energy from the sun. The efficiency is the parameter that used to compare the performance of one solar cell with other solar cell. Adding to that, the efficiency of a solar cell is depends on the spectrum, the intensity of the incident sunlight on the panel surface and the temperature of the solar cell. Thus, the conditions under which efficiency is measured must be carefully controlled in order to compare the performance of one device to another.

The efficiency of a solar cell is determined as the fraction of incident power which is converted to electricity and is defined as:

$$P_{max} = V_{oc} I_{sc} FF$$

$$\eta = \frac{v_{oc} I_{sc} FF}{p_{in}}$$

Where:

V_{oc} is the open-circuit voltage

I_{sc} is the short-circuit current

FF is the fill factor

η is the efficiency

The input power for efficiency calculations is 1 kW/m^2 or 100 mW/cm^2.

2.7 Bluetooth

Bluetooth could be a low value, low power, short-range radio technologies supposed to switch the cable connections between hand phones, PDAs and alternative transportable devices. Ericsson Mobile Communication started developing their Bluetooth system in 1994, searching for a replacement to the cables connecting their hand phones and their accessories. The first Bluetooth devices hit market around 1999. The Bluetooth SIG is liable for the any development of the Bluetooth normal. Sony Ericsson, Intel, IBM, Toshiba, Nokia, Microsoft and Motorola square measure a number of the businesses concerned within the SIG. The composition of the Bluetooth SIG is one amongst the foremost strength of the Bluetooth technology. The mixture of each software package and hardware provider collaborating within the any development of the Bluetooth technology ensures that Bluetooth product square measure created obtainable to finish users. Microsoft support Bluetooth in their Microsoft Windows software. Bluetooth software package is formed obtainable to the overwhelming majority of the desktop software package market. Due to the ad-hoc nature of Bluetooth networks, remote Bluetooth devices can move in and out of vary oft. Bluetooth devices should thus have the flexibility to get near Bluetooth devices. When a brand new Bluetooth device is discovered, a service discovery could also be initiated so as to work out that services the device is providing.

Microsoft is one of the companies who prefers bluetooth device in their PC gamers. As some laptop gamers have grownup to simply accept, and even embrace, the idea of playing a computer game with a gamepad, the options for those players have blossomed. Microsoft's switch to Bluetooth Xbox One controllers is a lot of important than simply improved vary with its new Xbox One S console. While the software maker has only mentioned compatibility with Windows 10 for the new Bluetooth-enabled controllers, it is clear that Microsoft has greater ambitions to bring Xbox One games to platforms other than just Windows [Brian Crecente et al. 2016]. The advantages of using Bluetooth are Bluetooth chips have lower power consumption which less drain on battery. Bluetooth devices "advertise" their capabilities to others, and a single device can be connected up to seven other devices at the same time. This makes it easy to find and connect to the device you are looking for or to switch between devices. Meanwhile, bluetooth has lower distance range up to 100m only and its generally lower speed in data transfer.

It can be concluded from the above literature survey that bluetooth as a controller is found to be more effective than other device such as Wi-fi because bluetooth technology is growing fast and a new version is already proposed by the Bluetooth SIG group. Moreover, the objective of this project is to control the direction of the solar grass trimmer. With the improvement and modification, it is expected that the bluetooth is support with other electrical components with their own specifications.

CHAPTER 3

METHODOLOGY

3.1 Introduction

The methodology of this project is discussed based on the parts of this project. Based on the topic of 'Bluetooth solar grass trimmer', this project is about how to develop or design a grass trimmer and Bluetooth system with solar powered energy in order to charge the power source (battery) and maintain the efficiency of the solar panel. In addition, the solar panel must be clean from any dirt or dust so that the solar panel could get the best radiation from the sunlight. This methodology will focus on wiring system and modification of the coding for the Bluetooth solar grass trimmer.

3.2 Circuit Designing Process

For the program code of the system, the coding was made using the Arduino software. Next, simulation of hardware for the whole system circuit was constructed using the Fritzing software since the basic software which is Proteus was not applicable for the motor driver MD30C. After that, all the electrical components such as motor driver, Bluetooth and relay module was tested first with some coding to know their capability to work for the grass trimmer. Then, the circuit was built on the breadboard and all the coding was combined together so that the trimmer can work successfully. Thereafter, the whole circuit on the breadboard was going to be transferred to the donut board. Then, the voltage regulator was added into the board for the safety of the Arduino Uno R3. All the components need to be soldered by using the solder iron. To make it easier while handling with the multi core wire, the solder flux paste was put on the core of wire to ensure that the solder flux melt easily and follow the wire core perhaps for a better connection on the Donut board. After finish soldering all the components on the board, the path of connection must be checked by using the digital multimeter to prevent it from the short circuit. Other than that, it was important to check the connections for all the components because if there is any residue of the solder lead fall into another pathway of connection, the wire will melt or can be exploded somehow

can make damage to the components. Lastly, the circuit was undergoing some troubleshooting for several times to ensure that the performances of the circuit in a good condition before transferring into the controller box. The Figure 3.2 shows the flow process of the circuit fabrication or design.

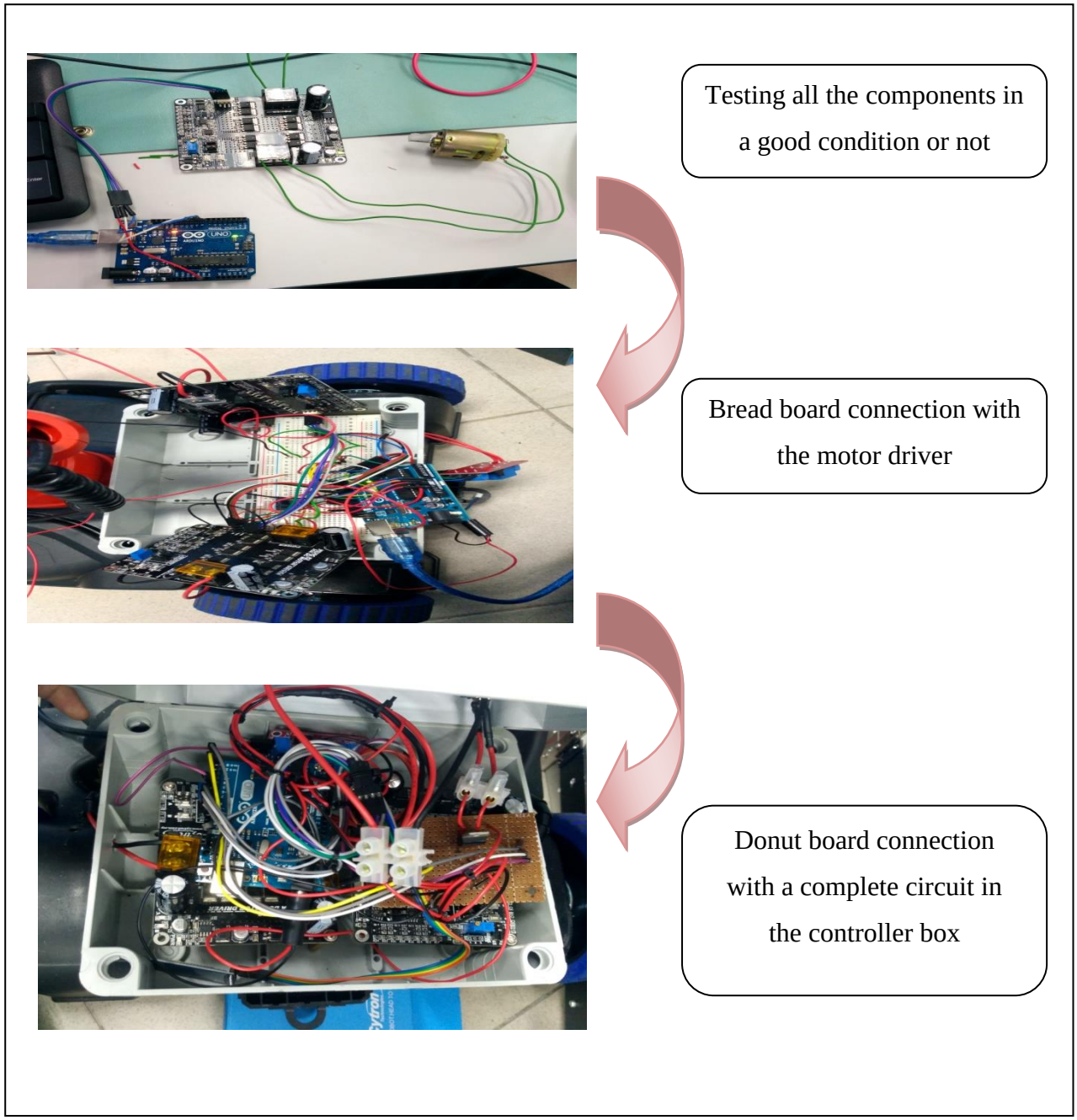


Figure 3.2: Process of circuit design

3.3 Bluetooth Solar Grass Trimmer (Controller Part)

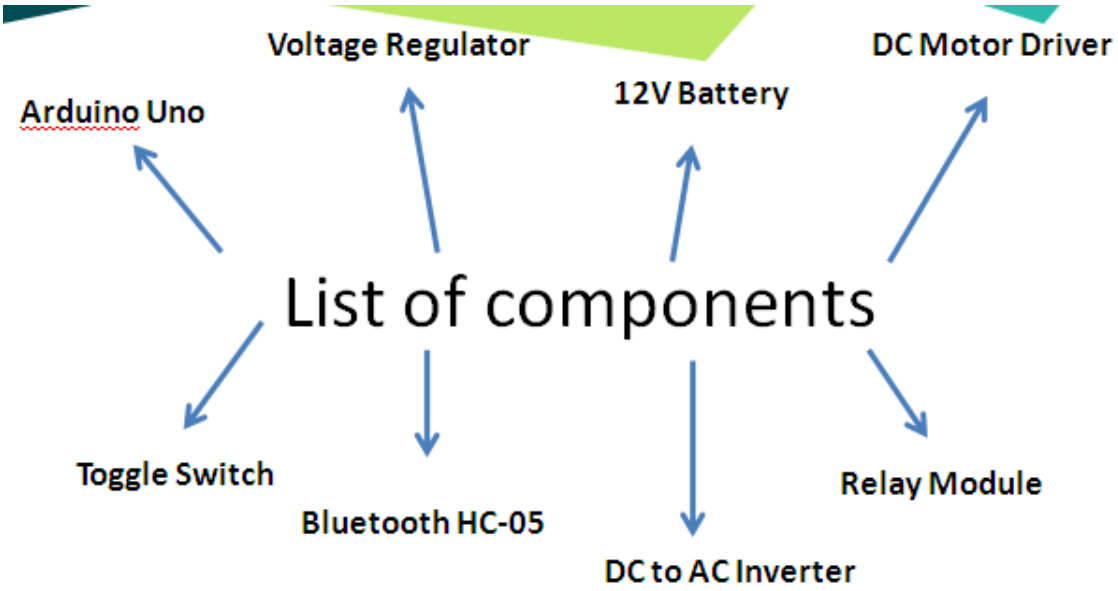


Figure 3.3: List of components for Bluetooth solar grass trimmer.

The Figure 3.3 above shows the electrical components that are needed in producing the controller part for Bluetooth solar grass trimmer. The main part for the controller is Arduino Uno R3 which acts as the brain or the central processing unit of all the electrical connections. The input of the machine is the Bluetooth HC-05. When the Arduino Uno R3 receive the input data from the Bluetooth HC-05, it will interpret the data and give out an instruction to become an output. So, the output will be controlled according to the program coding that had been uploaded into the Arduino Uno R3.

3.3.1 Block Diagram of the Trimmer

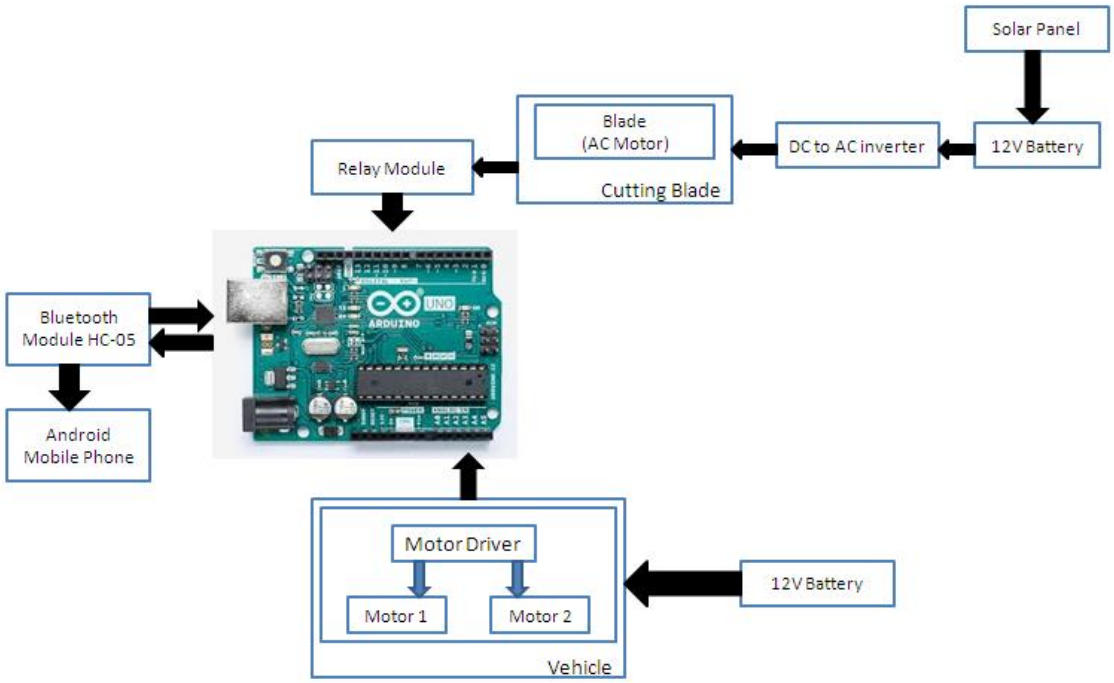


Figure 3.3.1: Block diagram of the trimmer.

3.3.2 Flow Chart of the trimmer

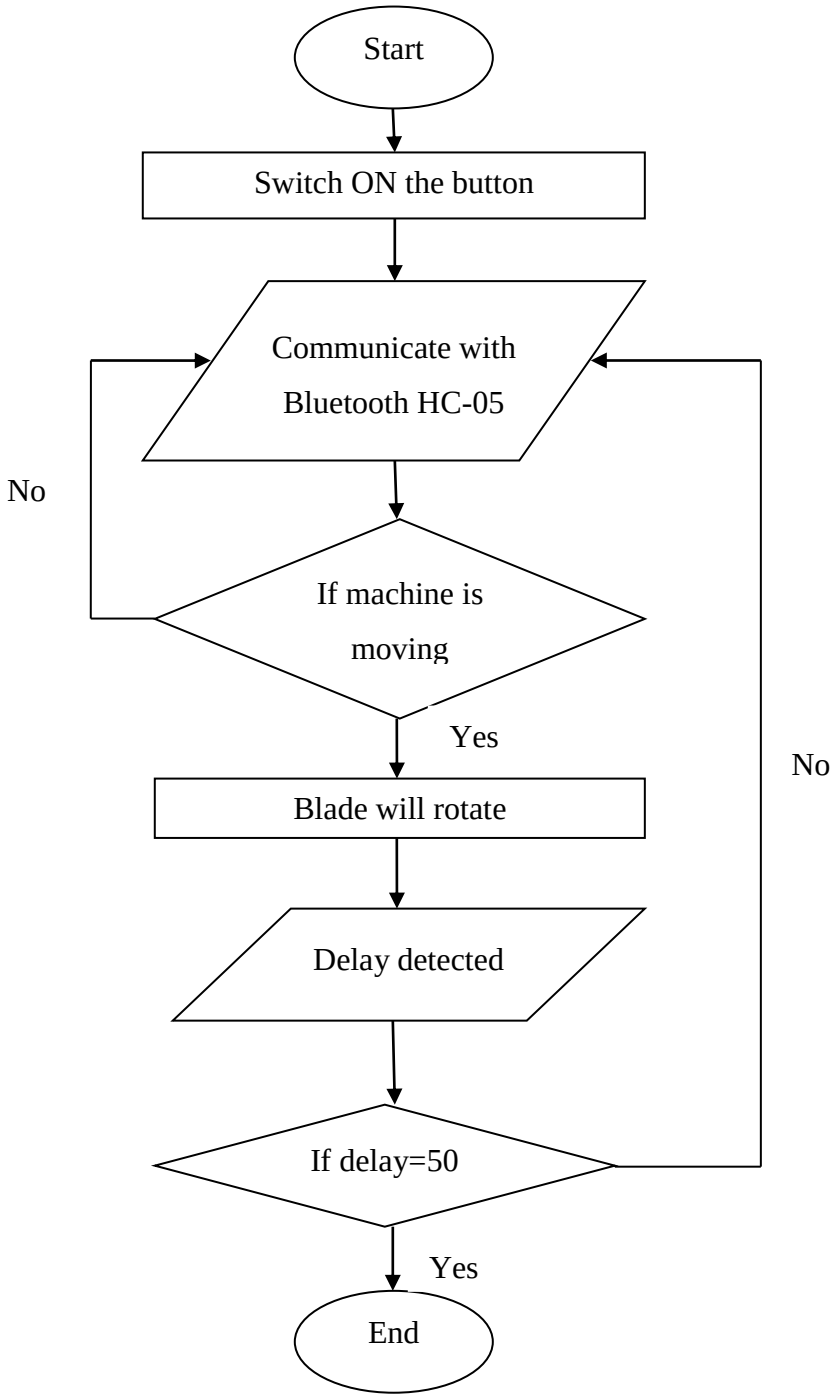


Figure 3.3.2.1: Flow Chart of the Operation system.

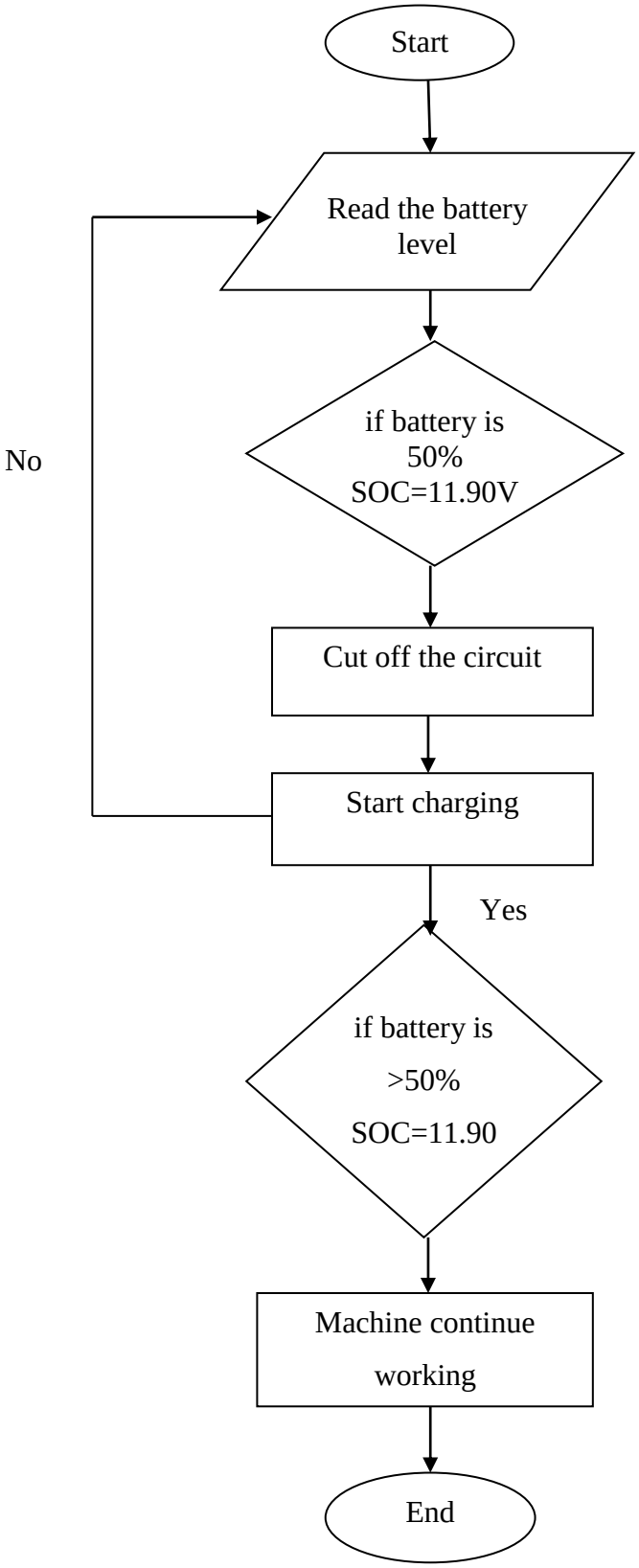


Figure 3.3.2.2: Flow Chart of the charging system.

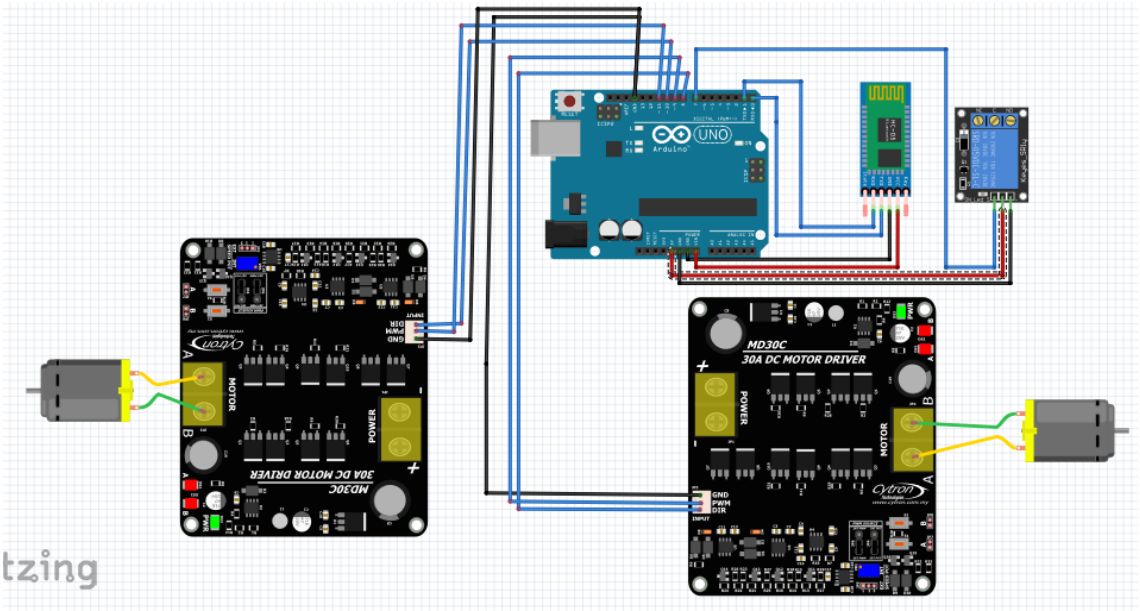


Figure 3.3.2.3: Schematic circuit connection for the controller

Figure 3.3.2.3 shows the design for the controller part system with Arduino Uno R3, 12V 7.2Ah Lead-acid battery, MD30C motor driver, 12VDC motor and Bluetooth module HC-05. The process flow of all the components illustrated in the block diagram at Figure 3.3.1 while the flow chart for both operation and charging system in Figure 3.3.2.1and Figure 3.3.2.2. Arduino Uno R3 will regulate the voltage supplied to the Bluetooth HC-05 despite controlling the speed of the 12VDC motor. Furthermore, to drive the 12VDC motor, a MD30C motor driver are needed to drive and control the speed and direction of the motor. This machine has a toggle switch to ON or OFF the trimmer. So, this trimmer may ease the users to cut off the circuit immediately to prevent it from broken or explode. The source for the central processing unit which is Arduino board is from the 12V lead-acid battery and it will come up with the voltage regulator before reach the board. This safety precaution is to prevent the voltage regulator on the Arduino board from getting burns. In addition, Arduino Uno R3 board recommended input voltage just from 7V to 12V.

The reason for choosing the same source for Arduino is to reduce the weight for the trimmer. Other than that, switch is also made for ON and OFF the Arduino board and the trimmer besides for the safety of the Arduino board if any short circuit and wrong connection occur.

Firstly, the Bluetooth module HC-05 is connected directly to the Arduino board. It communicates with the Arduino called Serial Communication. The bluetooth module usually can be powered from 3.6V to 6V. However, the logic voltage level of the data pins is 3.3V. On the other hand, the TX (Transfer pin) and RX (Receiver pin) should be connected in a cross state because to avoid the parallax reading error during connection with the application on the mobile phones. Other than that, the Vcc and GND pin is connected directly to the GND and Vin port in the Arduino board. This is because both pins give the power source for the Bluetooth module to turns on and communicate each other with the Arduino board and application on the Android mobile phones.

Next, the L293D H-bridge motor driver is replaced with the MD30C motor driver. The main reason to change the motor driver is the MD30C can withstand the current quite high up to 30 Ampere. The next reason is to avoid the motor driver burns quickly due to the high pressure from the blade that comes from the high amount of grass. The two motor driver is use because it just consist of one channel motor and power source that can connected with one motor only. The motor driver works as a driven to the motor for the tyre. The PWM (pin 9 and 11) and the DIR (pin 8 and 10) of Arduino board is connected with the pin PWM and pin DIR for each of the motor driver as shown in the Figure 3.3.2.3. The GND pin from the Arduino board is connected to the pin GND for both motor driver MD30C for the reference point. Then, the 12V battery and 12VDC motor is connected with the POWER and SOURCE pin terminal.

Voltage regulator is made for the safety to the whole circuit and the most important component is Arduino Uno R3 board besides being a medium from the 12V 7.2 Ah lead-acid battery. For the safety of the circuit on the Arduino board, the switch is connected to the voltage regulator in order to secure the circuit from any leaking voltage and current through the Donut board connection.

3.3.3 Arduino Uno R3

Figure 3.3.3: Arduino Uno R3

Type of Microcontroller	Arduino Uno	Arduino Mega
Chip used	Atmega 328	Atmega1280
Input voltage	7-12V	7-12V
Digital I/O pins	14 pins (6 PWM output)	54 pins (15 PWM output)
Analog input	Pins 6	Pins 16
Memory	32KB	128 KB

Table 3.1: Comparison of Arduino (Source: http://www.cytron.com.my)

Arduino Uno R3 (Figure 3.3.3) is a microcontroller board based on the Atmega328. The Arduino Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it has 14 digital input and output pins (which 6 pins can be used as PWM outputs), 6 analog inputs, a 16MHz crystal oscillator, a USB connection, a power jack, an ICSP header and a RSET button. It contains everything needed to support the microcontroller and the Arduino Uno can be powered via the USB connection or with an external power supply. The adapter can be connected by plugging a 2.1 mm center-positive plug into board's power jack.

The board can operate on an external supply of 6V to 20V. If the supply less than 7V, the 5V pin may supply less than 5V and the board will unstable. If the 12V and above is used, the voltage regulator can overheat and damage the board. The recommend range if 7V to 12V. Arduino board can connect with many of electrical components such as GPS, buttons, LEDs and etc. However, this flexibility combined with the fact that Arduino software is easy to use, free and the hardware is pretty cheap.

The Arduino board has several different kinds of pins and yet they have different functions.

- **GND**: Short for "Ground". There are many GND pins on the Arduino Uno board, any of them can be used to ground the circuit.
- **5V and 3.3V**: The 5V pin supplies 5 volts of power source while the 3.3V pin supplies 3.3 volts of power source. Most of the Arduino component can connected to the 5V or 3.3V.
- **ANALOG IN**: This area of pins labelled A0 till A5 are Analog In pins. It can read the signal from an analog sensor and convert it into a digital value.
- **DIGITAL**: Across from the analog pins are digital pins (0 through pin 13 on Arduino board). These pins can be used for both digital input (like telling if button is pushed) and digital output (powering an LED).
- **PWM**: The tilde (~) next to some of digital pins such as pin 3,5,9,10 and 11. These pins act as normal digital pins, but can also be used for something called Pulse-Width Modulation (PWM).
- **AREF**: Stands for Analog Reference. It is sometimes used to set an external reference voltage (between 0V to 5V) as the upper limit for the analog pins.
- **Reset Button**: Pushing the Reset button will temporarily connect the reset pin to ground and restart any code that is loaded on the Arduino. This can be very useful if the code doesn't repeat if wanted to test it multiple times.
- **Power LED Indicator**: Just beneath and to the right of the word "UNO" on the circuit board, there's a tiny LED next to the word 'ON'. This LED should light up whenever Arduino is plugged with a power source. If the LED is not lights up means that there is problem in the circuit connection with the Arduino.
- **TX RX LEDs**:TX short for transmit while RX is short for receive. These markings appear quite a bit in electronics to indicate the pins responsible for the

serial communication. The indicator LEDs will lights up whenever Arduino is receiving or transmitting data (like when loading a new pogram onto the board). However, the pins TX and RX cannot connect directly with (Bluetooth HC-05 as example) TX and RX pins because it can give a parallax error.

- Main IC: The black component with all the metal legs is an IC (Integrated Circuit). Think of it as the brains for the Arduino. The main IC on the Arduino board is slightly different from board type but usually it comes from Atmega line of IC's from the ATMEL company.
- Voltage Regulator: It is not actually something that can interact with on the Arduino board. The voltage regulator work to control the amount of voltage that comes in the Arduino board. It will turn away an extra voltage or else the Arduino board will burns and cannot use anymore.

The Arduino Uno is chosen to control the operation of the trimmer and the speed of the tyre besides communicate with the Bluetooth HC-05 to control the direction of the trimmer with "Bluetooth RC Controller" application in the Android mobile phones (Play Store). Besides that, Arduino Uno is an open-source physical computing platform based on a simple input or output board and a development environment that implements the processing or wiring language. Arduino Uno can be used to develop stand-alone interactive objects or can be connected to software on the computer.

3.3.4 Bluetooth HC-05.

Figure 3.3.4.1: Bluetooth HC-05.

Bluetooth HC-05 is one of the types of serial communication. It designed for a transparent wireless serial connection communication setup. The port that comes from the module is fully qualified by the Bluetooth V2.0+EDR (Enhanced Data Rate) 3Mbps modulation with 2.4GHz radio transceiver and baseband. The module works just only by AT COMMANDS and it cannot connect with other Bluetooth devices but can accept only the connections. The sensitivity for the module is -80dBm while it can transmit the RF power up to +4dBm. The input voltage for the module is around 3.3V to 5V and it connected to the Vin on the Arduino board for this trimmer.

Bluetooth HC-05 module consists of 6 pins which has their own functionality.

- **EN**: Short from 'ENABLE'. The module fails to connect with the Arduino and application software if it is pulled LOW while if it is connected to 3.3V, the module will enabled and the communication can runs smoothly.
- **Vcc**: The supply voltage for this module is 3.3V to 5V and it can simply connected to the Arduino board to make it ON.
- **GND**: Stands for the 'Ground' and connected to the pin GND on the Arduino board.
- **TXD and RXD**:TX short for transmit while RX is short for receive. These markings appear quite a bit in electronics to indicate the pins responsible for the serial communication. Both pins acts as an UART interface for communication.
- **STATE:** State acts as a status indicator. When it goes to HIGH, the LEDs will blinks with a 2s delay while when it goes to LOW, the LEDs will blinks for a long time and it indicates that the bluetooth is on paired.

This is some steps on how to connect Bluetooth HC-05 via mobile phones.

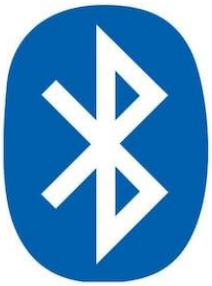


Figure 3.3.4.2: Bluetooth symbol.

Firstly, connect the Bluetooth symbol in own user's phone. Then, it will ask for the password. The password for this Bluetooth HC-05 is '1234' or '0000' and it will pair each other. Continue connect (ON) the Bluetooth symbol.

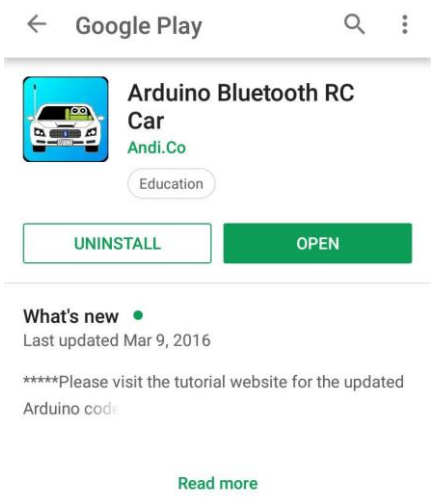


Figure 3.3.4.3: Application software.

Next, search for the application 'Arduino Bluetooth RC Car' in 'Play Store'. However, this application is not applicable for the iPhone users. If the iPhone users want to connect this application, they need to buy an Android phone or they cannot use the trimmer.

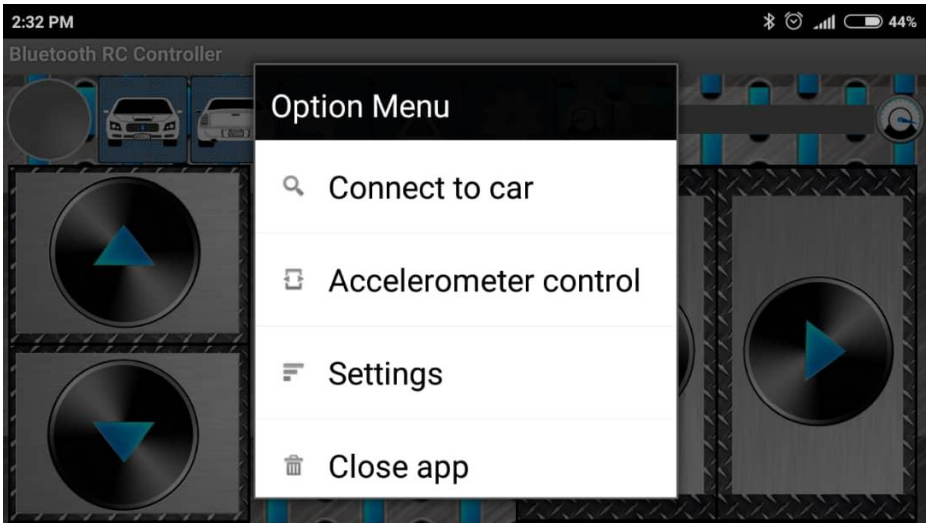


Figure 3.3.4.4: Setting menu.

Proceed with the setting menu in the application. The Option Menu will be pop-up, and choose for the Connect to car in the first row and the user will find the device. For the information, user still need to connect with the 'HC-05' as in the Figure 3.3.4.4 to drive the trimmer or else user cannot control the trimmer or even move the trimmer and the blade. Finally, user can control the trimmer at the range of 10m.

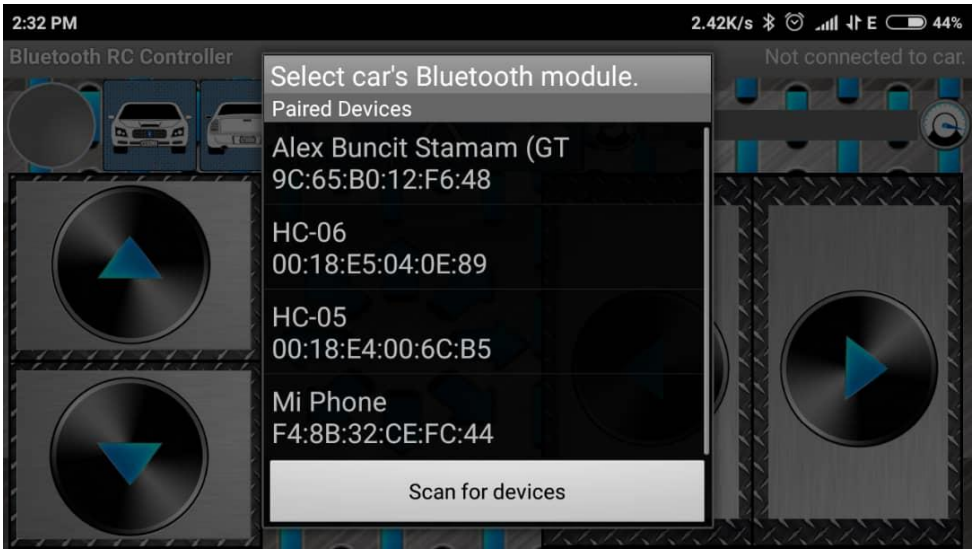


Figure 3.3.4.5: Scan for devices.

3.3.5 DC Motor Driver

Figure 3.3.5: MD30C motor driver.

A motor driver acts as a current converter whereas it will convert a low-current signal to be a high-current signal so that it can drive the motor. There are many specifications for choosing the motor drivers such as the maximum supply voltage, load voltage, maximum output current, and rated power dissipation and so on.

MD30C is a one channel of bi-directional control for one brushed DC motor. In its common mode of operation, only one DC motors can be driven simultaneously both forward and reverse direction. MD30C can be supplied up to 30V motor voltage and 80A current peak in one second. This motor driver is suitable for 12V DC motor used in this project. MD30C motor driver is designed to drive high current brushed DC motor up to 30A continuously. The NMOS design is more efficient and provides the faster switching time hence user friendly features such as onboard PWM generator without a host controller and reverse polarity protection. It is compatible with two types of PWM operation, which are sign-magnitude and locked-anti-phase.

For this project, the sign-magnitude PWM operation was implemented. PWM is feed to the PWM pin to control the speed while DIR pin is connected to control the direction of the motor.

Below is the description of the MD30C:

- Terminal Block: The terminal block is used to connect the MD30C to the motor and power source.
- Red LED A: This LED will turns ON when the output A is high and output B is low. It indicates the current flows from output A to B.
- Red LED B: This LED will ON when the output A is low and output B is high. It indicates the current flows from output B to A.
- Test Button A: The current will flows from output A to B when this button is pressed and the motor will turn clock wise (or counter clock wise depending on the connection).
- Test Button B: The current will flows from output B to A when this button is pressed and the motor will turn counter clock wise (or clock wise depending on the connection).
- Green Power LED: This is the indicator for power input from power source into MD30C. It should be lights up when the board is powered ON.

Pin No	Pin Name	Description
1	GND	Ground
2	PWM	PWM input for speed control
3	DIR	Direction input

Table 3.2: Input pin detail of MD30C (http://www.cytron.com.my/p-md30c)

Moreover, this motor driver consists of two modes namely manual and automatic mode. In manual mode, user can test this motor driver by using the button. Meanwhile, in automatic mode, user can control it by inserting a coding (Arduino).

3.3.6 Relay Module.

Figure 3.3.6: Relay

A relay is a primary protection that works to open or close the circuits as well as to control the process of voltage or current from one circuit to switch another circuit. The relay can be a protection for the electrical circuit or it also applicable for monitoring the process on the board. Protective relays will monitor the currents, voltages, and power of an electrical circuit by setting the limits to protect the motors.

Basically, for operating a low voltages relay, the maximum current can be charged up to 100mA for the relay coil. Most relays act as a circuit breaker to take care other electrical pieces of equipment such as the IC's, resistor or even the transistor. In addition, to prevent the damage on the electrical circuit or other equipment around the relays during the breaking down the circuit, a protection diode must be applied on it. The advantages for choosing a relay rather than a transistor because of the relays can switch either AC(alternating current) or DC(direct current) while transistor only can switch the DC.

For the implementation of our project, we choose relays due to the switching high voltages with a huge current and it is more applicable to use relays because it can have many contacts at once. At first, we just choose the temperature sensor for the safety of the motor in our robot; meanwhile, due to the climate season of a quite same temperature range, we agreed to choose relays to protect our circuit and also other electrical equipment. The idea is when the motor rotates too fast it will produce heat which causes the circuit breakdowns.

3.3.7 Theory of Inverter

To start this Senior Design Project, we needed to find the components of the machine are viable options to change in order to reach our ultimate goal of 15,000 RPM blade speeding. The main components that can be improve to achieve the blade speeding are inverter and relay module. The first two factors to be tested are inverter and relay.

Many of the electrical components are designed to work in AC but with the small scale power generators can produce a DC. That means, to run the AC powered blade from a DC battery, an inverter is used to convert the DC operation to the AC for moving the blade smoothly. Most machines application derives the power from the 12V battery. It is important to use the same voltage rating of the inverter and the battery. Meanwhile, battery is a direct current (DC). This means the current flows continuously from negative terminal of the battery and then completes the circuit by then move to the positive terminal of the battery. The flow of the electron in one path direction is called the direct current. Inverter works to increase the DC voltage and changed it to AC before turn to output to power on the machine. Many inverters in electrical stores used electromagnetic switch that gives the square-wave output whereas the current flows in one way that flick on and off at high speed to vice versa the current direction.

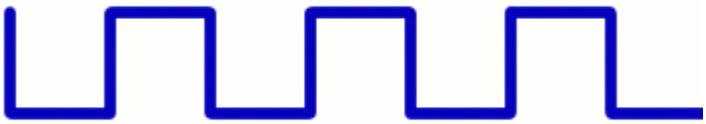


Figure 3.3.7.1: Square-wave output

Meanwhile, a normal AC power will provides a sine-wave pattern so that the current can gradually swaps from one to another.

Figure 3.3.7.2: Sine-wave output

Electronic inverters usually will produce a smoothly varying AC output from the DC input. In addition, inductors and capacitors is used to make the current ups and downs more gradually than on off switching square wave output. The inverters also presence with the transformer so that it can conserve more energy and some energy will be lost as heat. That means, many inverters are come out with the fans so that it can cool down the inverter hence the efficiency will up to 90%.

A relay is a primary protection that works to open or close the circuits as well as to control the process of voltage or current from one circuit to switch another circuit. The relay can be a protection for the electrical circuit or it also applicable for monitoring the process on the board. Protective relays will monitor the currents, voltages, and power of an electrical circuit by setting the limits to protect the motors.

Basically, for operating a low voltages relay, the maximum current can be charged up to 100mA for the relay coil. Most relays act as a circuit breaker to take care other electrical pieces of equipment such as the IC's, resistor or even the transistor. In addition, to prevent the damage on the electrical circuit or other equipment around the relays during the breaking down the circuit, a protection diode must be applied on it. The advantages for choosing a relay rather than a transistor because of the relays can switch either AC(alternating current) or DC(direct current) while transistor only can switch the DC.

3.4 Gantt Chart

Activities	Week													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Preparation of the letter for material purchasing														
Build up the design														
Create a coding														
Test and modify the design														
Robot successfully built														
Analysis the data/ Tabulation of data														
Writing a report														
Final thesis report submission														

Table 3.3: Project Timeline Senior Project Design 2

3.5 Milestones For SDP2

Week 1 : Prepare the letter for material purchasing.

Week 2 -8 : Build up the body design for the "Bluetooth Solar Grass Trimmer". Create a suitable coding to control the movements of the machine and run the test on it.

Week 8-11 : Run the test on the machine simultaneously until get the finals result.

Week 9-11 : Analyze the data obtained by using theoretical analysis method.

Week 10-13 : Writing a report from the collected data.

Week 13-14 : Prepare the presentation and submit the final thesis of report.

3.6 Cost Analysis

Budget per student= RM500

Amount of students= 3

Total budget= RM500x3= RM1500

Total of savings= RM 354.60

No	Materials	Costs (RM)	Quantities (units)	Total Cost (RM)
1	Arduino Compatible Atmel DIP ATmega328P UNO R3 + USB B type cable	31.10	1	31.10
2	MD30C motor driver	125.00	2	250.00
3	5V 1 Channel Relay	5.00	1	5.00
4	Toggle Switch	2.00	1	2.00
5	Bluetooth Serial Transceiver HC-05	15.90	1	15.90
6	12V 7.2Ah Battery	42.00	2	84.00
7	Controller Box (medium)	9.50	1	9.50
8	Controller Box (big)	13.50	1	13.50
9	Solar Charge Controller	90.00	1	90.00
10	PCB stands	0.80	8	6.40
11	Voltage Regulator +24V	1.00	1	1.00
12	OPS 20A PVC Connector	2.00	1	2.00
13	30W Solar Panel	145.00	1	145.00
14	Black & Decker Body Trimmer	300.00	1	300.00
15	Acrylic (Black)	30.00	1	30.00
16	Tire + Coupling Hub	80.00	2	160.00
	TOTAL (RM)			**1145.40**

Table 3.4: Cost Analysis.

3.7 Ethical Consideration

In order to complete the project there are several work ethics should be follow. The priority was safety precaution while project making process. Safety is the most important for student to follow and ensure that there will be no accident in workplace. Wiring installation is complicated and needs to be check often the wiring diagram for missing wire installation. During the wiring of the circuit, soldering tools need to be used with some caution while the process is ongoing. Open circuit also constituted a problem because some of the wires to be soldered did not make proper contact with the straight board. Rules and regulation while working in machine room need to be obeying for the own safety. Safety measure needs to be taken into account at the workplace are likes wearing safety boots, jackets, google and mask all the time when handling tools and machine. Machinist should not wear watch, jewelry and other accessories as well as loose clothes that can cause trouble when handling the machine. Every different type of operations on machine likes milling machine and turning machine including drilling, cutting using seasaw must be conducted follow by the correct procedure and tools to avoid accident happen in the machine room. The floor must be always dry to avoid slippery and the table must be clean repeteadly. Lastly, plagiarisms is strictly prohibited in this project and writing a report. It is because it will lead to not to think out of the box and creatively.

CHAPTER 4

RESULT AND DISCUSSION

4.1 PWM Overcharge and Discharge Protection

In a 12 V battery system, the voltage is varying between 11.90 volts and 14.4 volts. In this project, an experimental on analyzing the time taken for battery to fully charging by a 30W solar PV was conducted. The value of the current produces is varying depending on the solar irradiances. Overcharge may occurs when the battery is charging, while deep discharging may happen when load are connected into the system as the Bluetooth solar grass trimmer is running.

4.1.1 Overcharge Protection

The battery voltage is depends on the actual state of charge of the battery, charge current, discharge current, type and age of the battery. When a normal full loaded battery and no charging or discharging current is flowing than the battery voltage is about 12.4 volts to 12.7 volts. When charging current is start flowing, the voltages will jumped to a higher level value in a period of time. When the loads are switched on, it will causing the voltage to drops down to a lower level which in the range of 12.0V to 11.50V. Meanwhile, the PV module produces energy and current for battery charging which will cause the battery voltage to rise in a period of time until the battery voltage reached at maximum level. Then, the charge controller will switch off the charging current or reduced it by pulse width modulation (PWM) to avoid from overcharging occurs.

4.1.2 Deep discharge Protection

When we deep discharge the battery repeatedly, loss of capacity and shortened of battery life will eventually occur. To protect battery from deep discharge, the PWM charge controllers will disconnect the system loads once the battery reaches a low voltage or low state of charge condition. If the voltage of the system falls below 11.5 V for a period of a few second, then the charge controller will be switched off. All the loads which are connected in the system to the controller are switched off. In addition, if

the battery voltage increases above 11.5V, the charge controller will be switched on the loads to operate as well as for charging the battery.

4.2 Battery State of Charge

The Figure 4.2 below shows the relationship between thestate of charge against battery voltage during the constant charging current with no load condition.

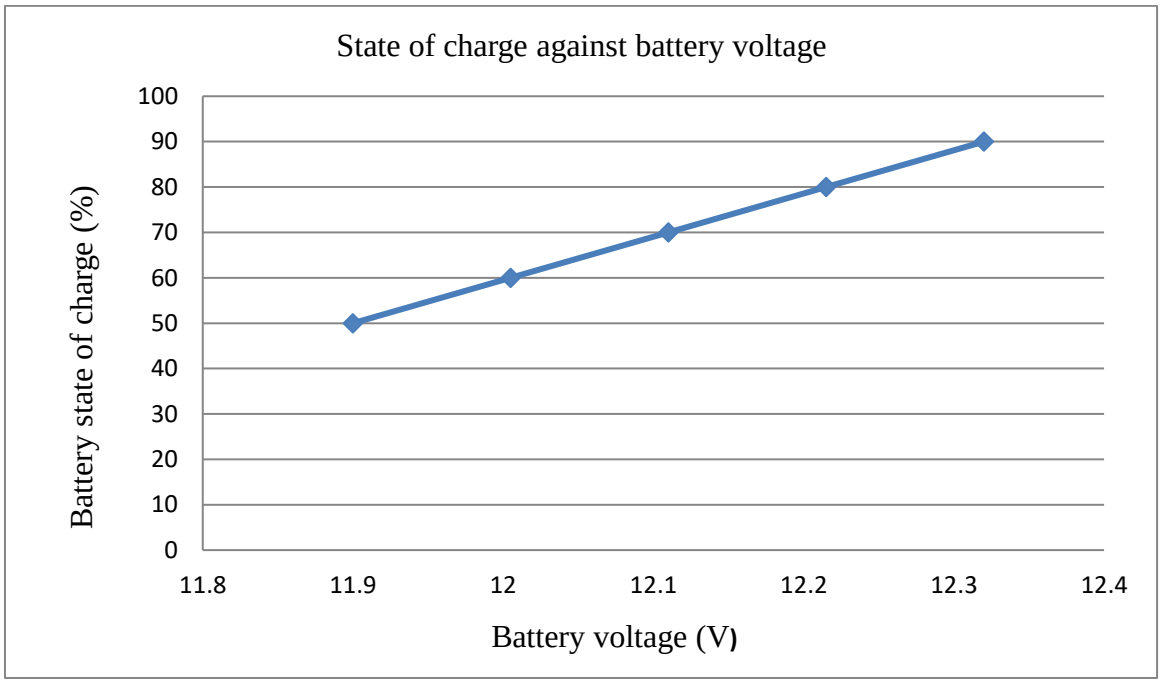


Figure 4.2: State of charge against battery voltage

From the result obtained in Appendix B1, the graph of state of charge against battery voltage was set up. It indicates that the battery voltage is directly proportional to the state of charge (Murnane, n.d.). It can be seen that, during the charging time interval, the battery voltage is increase due to the battery state of charge increase. If longer the charging time interval, the battery voltage will increase until it reached a threshold as well as the state of charge that can be achieved until hundred percent of state of charge (Gabler et al, 1995). Additionally, if the battery voltage is below the minimum level which at 11.90V, indicating the battery is in discharging condition. However, the batter voltage is more significantly affected by the battery current due to the battery's electrochemical kinetics, irradiances and temperature (Armstrong et al, 2008).

4.3 PV module Analysis

Firstly, all the system parameter such as output PV current, voltage and irradiances was initialized in Appendix C1. As to analyze the power input produces from the 30Watt solar panel, the graph of power input against voltage with varying in irradiance was set up.

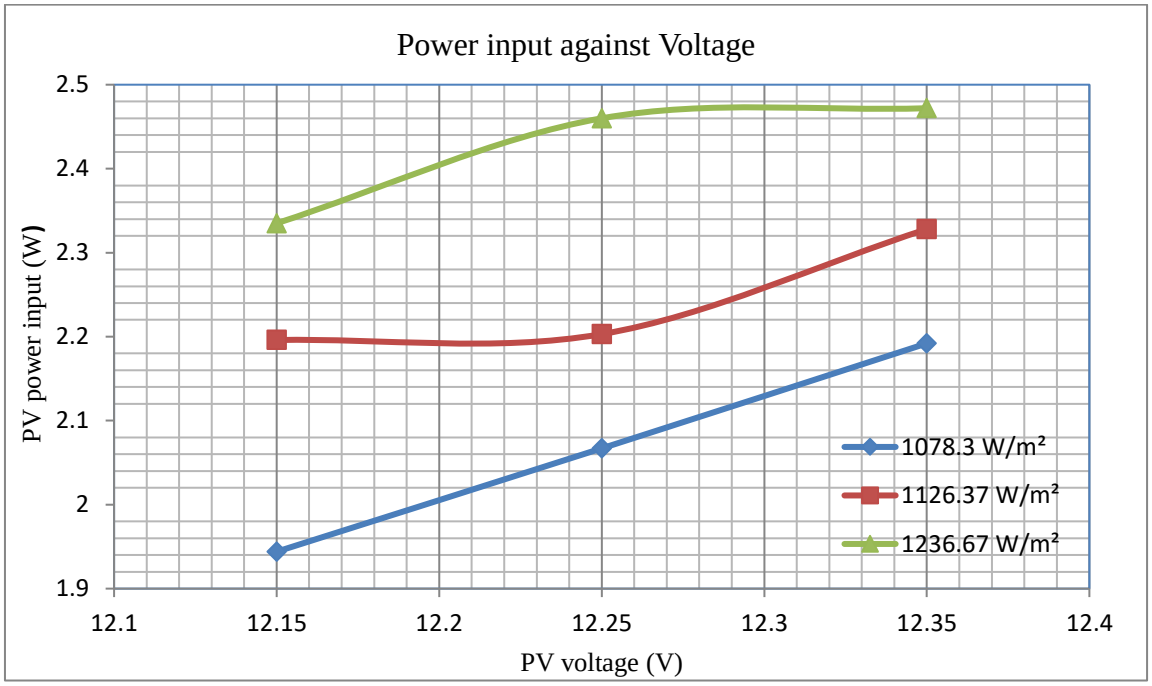


Figure 4.3: Power input against Voltage

From the result obtained, the voltage and current produces by the PV module at differences average of irradiances. The power input is obtained from the calculation by using current and voltage value produces by the PV module for a period of time. In an open circuit voltage, when the irradiances is constant for a 10 minutes period, the current produces will constant but the voltage produces by the PV is increase. The current produces through the PV module was affected by the solar irradiances (Abu Eldahab et al, 2016). It can be seen that, when the solar irradiance is higher, the current produces is increase resulting the higher power input produces (Florida Solar Energy Center, n.d.).

4.4 Battery charging profile at constant average irradiance

Figure 4.4 shows the battery charging profile under load and no load condition. The result of the testing was recorded in Appendix A1 and A2.The irradiances was measured for average of three reading during the 1 hour period charging time, while the

battery voltages were measured at every 10 minutes for both under load and no load condition.

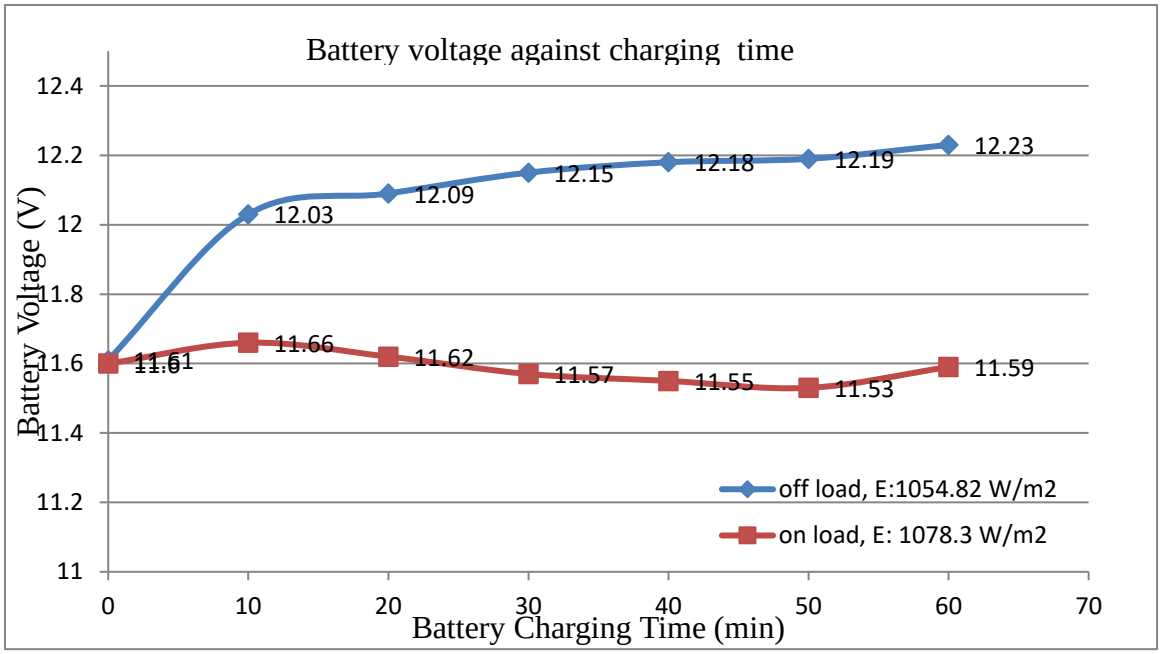


Figure 4.4: Battery charging profile

It is seen that, during the bulk charge phase, for no load charging condition, the PV source is directly connected to the battery with addition of PWM charge controller until the battery voltage rise to 12.23V for one hour period under 1054.82W/m^2 (Dunlop, n.d.). During the charging time under no load condition, the actual charging current is allowed to be equal to or less than maximum current which is the battery-charging current depends on the PV power production and varies according to the irradiance conditions (Chowdhury et al., 2008). The flow of current produces from the PV will cause the battery voltage to rise (Perez, 1993). However, during the time interval of 20 until 50 minutes charging time of under load condition, the voltage value was drop steadily depending on the charge rate which varies due to irradiances and also the current from loads consumption. As the battery is to be discharged, the discharging current causes the battery's voltage to drop. If the battery voltage below the LVD set point, the load will disconnect through PWM charge controller to prevent from over discharge.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

In summary, the main aim of this project is to ensure the “Bluetooth Solar Grass Trimmer” is able to carry out smoothly. Moreover, the trimmer would be able to deliver the documentation in a proper way by considering resistant factors such as weight, stability, design, and materials. For a development of control system in brushless DC motor, rechargeable battery, microcontroller, blades and solar panel are used. Arduino software as programming software is used to develop the program in a microcontroller of Bluetooth Solar Grass Trimmer. As an expected outcome, Bluetooth Solar Grass Trimmer is the success to carry out and it is going well in a cow grass. In addition, this low cost of Bluetooth solar powered grass trimmer will meet the challenge in environmental production since there is no cost of fueling and free air pollution. This Bluetooth Solar Grass Trimmer has been developed for the residences to keep their home environment stay clean.

5.2 Recommendation

End of this development, after testing the Bluetooth Solar Grass Trimmer, there are some improvement required to achieve the convenient for the user. The improvements are stated as follow:

1. Consume large battery capacity from 12V to 24V to increase the life span of the trimmer and increase the efficiency of cutting blade.
2. From Bluetooth to automated by using the sensor where the trimmer becomes fully automated.
3. Use DC Motor as the cutting blade motor for more efficiency.
4. Use bigger size for the wheels to get better grip and movement.
5. Build an adjustable height grass trimmer so that it can be use to trim any type and height of grass.
6. Use an application that is also available to the IPhone users as this trimmer only can be controlled by using Android devices.

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APPENDIX A1

ARDUINO UNO R3 DATASHEET

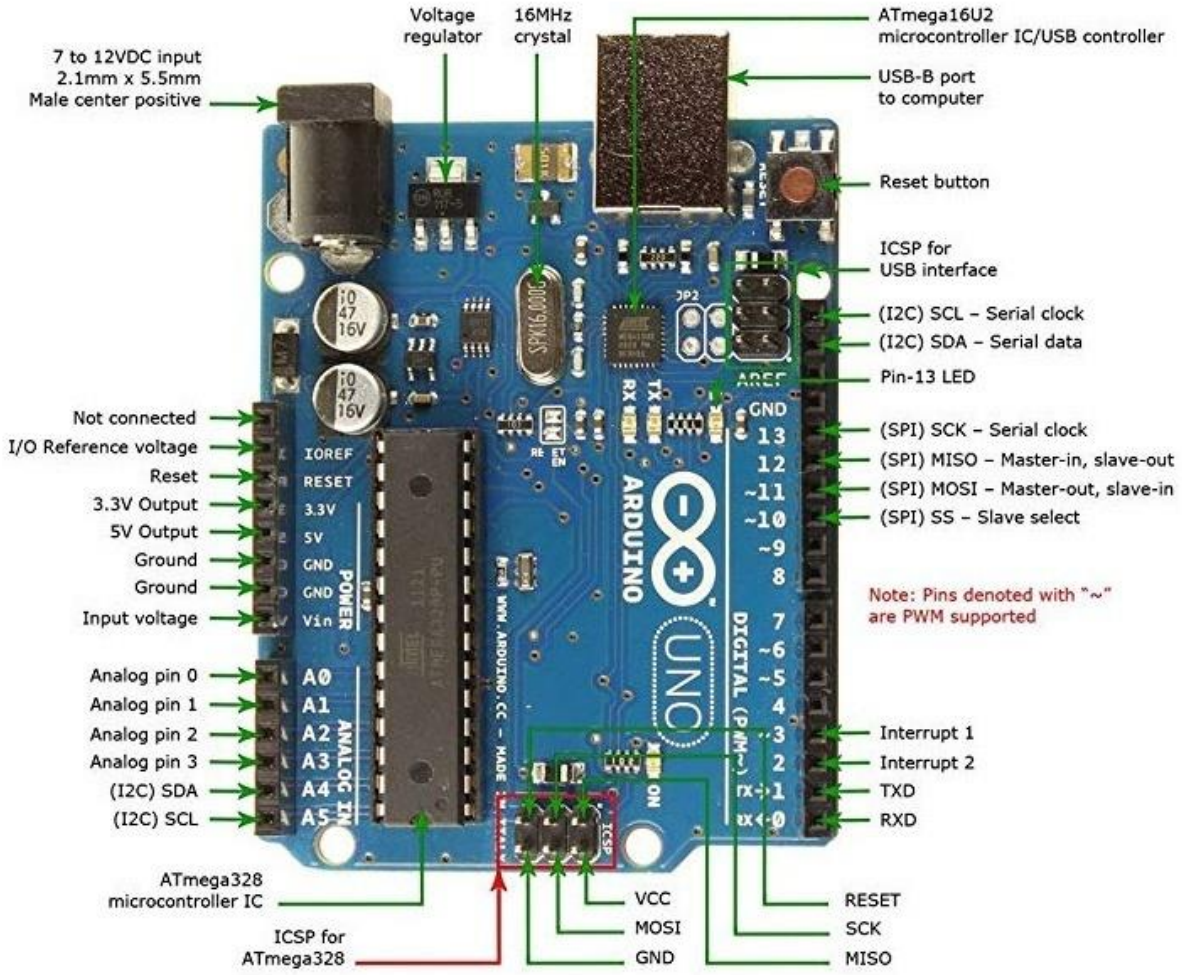

Figure 1: Arduino Uno R3

The Arduino Uno is a microcontroller board based on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, aUSB 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 Atmega8U2 programmed as a USB-to-serial converter. "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.

Microcontroller	ATmega328
Operating Voltage	5V
Supply Voltage (recommended)	7-12V
Maximum supply voltage (not recommended)	20V
Digital I/O Pins	14 (of which 6 provide PWM output)
Analog Input Pins	6
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB (ATmega328) of which 0.5 KB used by bootloader
SRAM	2 KB (ATmega328)
EEPROM	1 KB (ATmega328)
Clock Speed	16 MHz

Figure 1: Technical Specifications of Arduino Uno R3

APPENDIX A2

BLUETOOTH HC-05 DATASHEET

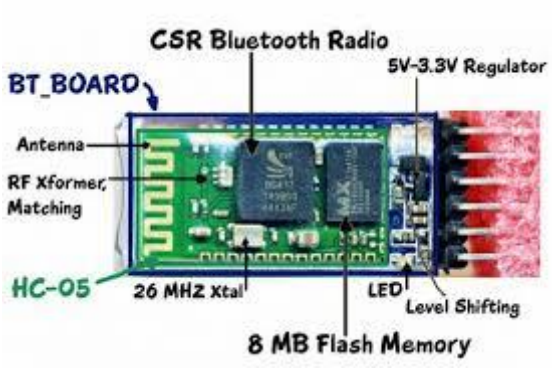

Figure 2: Bluetooth Module HC-05

Bluetooth is a technology for wireless communication. It is designed to replace cable connections.It uses serial communication to communicate with devices. It communicates with microcontroller using serial port (USART). Usually, it connects small devices like mobile phones, PDAs and TVs using a short-range wireless connection to exchange documents. It uses the 2.45GHz frequency band. The connection can be point-to-point or multi-point where the maximum range is 10 meters. The transfer rate of the data is 1Mbps.HC-05 Bluetooth module provides switching mode between master and slave mode which means it able to use neither receiving nor transmitting data.

The module specifications as below:

- Bluetooth protocol: Bluetooth Specification v2.0+EDR
- Frequency: 2.4GHz ISM band
- Modulation: GFSK(Gaussian Frequency Shift Keying)
- Emission power: ≤4dBm, Class 2
- Sensitivity: ≤-84dBm at 0.1% BER
- Speed: Asynchronous: 2.1Mbps(Max) / 160 kbps, Synchronous: 1Mbps/1Mbps
- Security: Authentication and encryption
- Profiles: Bluetooth serial port
- Power supply: +3.3VDC 50mA
- Working temperature: -20 ~ +75Centigrade

- Dimension: 26.9mm x 13mm x 2.2 mm
- It is IEEE 802.15.1 standardized protocol, through which one can build wireless Personal Area Network (PAN). It uses frequency-hopping spread spectrum (FHSS) radio technology to send data over air.

APPENDIX A3

MD30C MOTOR DRIVER DATASHEET

Figure 3: MD30C Motor Driver

The 30A 5-30V Single Brushed DC Motor Driver is designed to drive medium to high power brushed DC motor with current capacity up to 80A peak and 30A continuously. Fully NMOS design not only provides faster switching time, it is also more efficient and no heat sink or fan is required. Besides that, it also incorporates some user friendly features such as reverse polarity protection and onboard PWM generator which allows it to operate without a host controller. The motor can simply be controlled with the onboard switches and speed potentiometer. External switches and potentiometer can also be used. The 30A 5-30V Single Brushed DC Motor Driver also incorporates some user friendly features such as reverse polarity protection and onboard PWM generator which allows it to operate without a host controller. The motor can simply be controlled with the onboard switches and speed potentiometer. External switches and potentiometer can also be used.

Features:

- Bi-directional control for 1 brushed DC motor
- Maximum current: 80A peak (1 second), 30A continuously
- Motor voltage: 5V - 30V
- 3.3V and 5V logic level input
- Fully NMOS H-Bridge for better efficiency and no heat sink is required
- Speed control PWM frequency up to 20KHz
- Onboard PWM generator with switches and potentiometer for standalone operation
- Support both locked-antiphase and sign-magnitude for external PWM operation

APPENDIX A4

5V RELAY MODULE

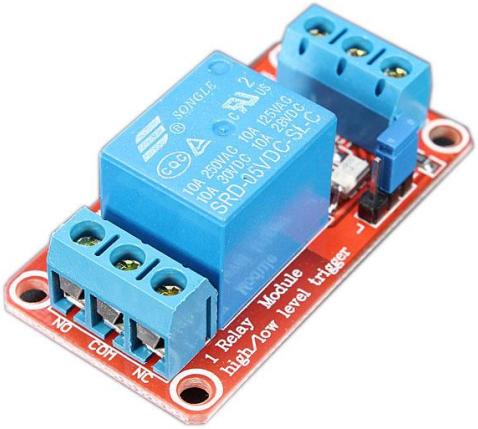

FIGURE 4: 5V 1 channel level trigger optocoupler relay module

Specifications:

- The module uses genuine quality relay, normally open interfaces.
- Using SMD optocoupler isolation, driving ability, stable performance.
- The module can be high or low by a jumper setting trigger.
- Fault-tolerant design, even if the control line is broken, the relay will not operate.
- The power indicator (green), the relay status indicator (red).
- The interface design of human nature, all interfaces are available through a direct connection terminal leads, very convenient.

Features:

- Maximum load: AC 250V/10A, DC 30V/10A.
- Trigger current: 5mA.
- Working voltage: 5V.
- Module size: 50 x 26 x 18.5mm (L x W x H).
- Four mounting bolts holes, diameter 3.1mm.
- DC+: positive power supply (VCC).
- DC-: negative power supply (GND).
- IN: can be high or low level control relay.
- NO: normally open relay interface.
- COM: Common Interface Relays.
- NC: normally closed relay interface.

APPENDIX A5

500W DC TO AC POWER INVERTER

Figure 5: DC to AC Power Inverter.

Description:

- Output Voltage: AC220V 50HZInput Voltage: DC10-15V.
- This has an alternate power source, a cigarette lighter adapter and battery clamps, the battery clamps are required for your heavy usage.
- The newly-added USB output socket (5v Global Standards) can be directly used to charge multiple additional devices from a single DV charge.
- Buit-in cooling fan to avoid overheating, so that can extended Using life of inverter. Input & Output fully isolation, Continuous power output.
- The side of the device has an universal/international plug , which can be used in many countries. with The overload protection and under voltage protection function.

Features:

- Durative output power: 500W.
- Twinkling maximum power: 1000W (This is the momentary boot power, not the rated real power).
- Output voltage:110V~130V,Requency:60+/-2HZ,Wavefrom:Modifiled sine wave.
- Output voltage:220V~240V,Requency:50+/-2HZ,Wavefrom:Modifiled sine wave.
- Input Voltage:10~15V/22~25V.
- Built-in fuse:35A.
- Undervoltage alarm:10.4~11.0V.
- Off low pressure:9.7~103V.
- Shutdown over-voltage:14.5~15.5V.
- No-load consumption:12V input.
- No-load Current: <0.3A90% .
- Continuous output power:300W.
- 30 minutes of continuous.
- Volume:128x95x55(mm).
- Weight:800g.

APPENDIX B

CODING OF THE BLUETOOTH SOLAR GRASS TRIMMER

```
#define m1_dir 8
#define m2_dir 10
#define pwm1 9
#define pwm2 11
#define RELAY1  6
intbuttonState = 0;
constintledPin=  13;
char data = 0;                    // Add library

void setup()
{
PinMode (m1_dir,OUTPUT);
pinMode (m2_dir,OUTPUT);
pinMode (pwm1,OUTPUT);
pinMode (pwm2,OUTPUT);
pinMode (ledPin, OUTPUT);
pinMode (RELAY1, OUTPUT);
Serial.begin (9600);          //Sets the baud for serial data transmission
}
void loop()
{
DigitalWrite (RELAY1,LOW);
  if (Serial.available() > 0)      // Send data only when you receive data:
   {
DigitalWrite (RELAY1,HIGH);
data = Serial.read();        //Read the incoming data & store into data
Serial.print(data);          //Print Value inside data in Serial monitor
Serial.print("\n");
switch(data)
```

```
{
 case 'F':       //forward
digitalWrite (RELAY1,HIGH);
digitalWrite (m1_dir,HIGH);
digitalWrite (m2_dir,LOW);
analogWrite (pwm1,120);
analogWrite (pwm2,120);
delay (20);
break;

case 'B':  //reverse
digitalWrite (RELAY1,HIGH);
digitalWrite (m1_dir,LOW);
digitalWrite (m2_dir,HIGH);
analogWrite (pwm1,120);
analogWrite (pwm2,120);
delay (20);
break;

case 'R':               //right
digitalWrite (RELAY1,HIGH);
digitalWrite (m1_dir,HIGH);
digitalWrite (m2_dir,LOW);
analogWrite (pwm1,200);
analogWrite (pwm2,0);
delay (20);
break;
```

```
case 'L' :              //left

digitalWrite (RELAY1,HIGH);
digitalWrite (m1_dir,HIGH);
digitalWrite (m2_dir,LOW);
analogWrite (pwm1,0);
analogWrite (pwm2,200);
delay (20);
break;

case 'S' :              //stop
digitalWrite (RELAY1,HIGH);
digitalWrite (m1_dir,LOW);
digitalWrite (m2_dir,LOW);
analogWrite (pwm1,0);
analogWrite (pwm2,0);

digitalWrite (ledPin, HIGH);
default:
break;
    }
  }
}
```

APPENDIX C

DESIGN FOR THE BLUETOOTH SOLAR GRASS TRIMMER