CHAPTER 1
INTRODUCTION

1.0 Introduction

Battery plays an important role in a car system. Functioning similar to capacitor, battery holds the charge (power) when the engine is not running, and releases the charge when the car is ignited. Other than fuel, battery is another crucial power source to keep the engine running. As the market demand getting more sophisticated, development of technology of car is getting more competitive. Various types of improvements were made to add value of the car, and getting ready for any unwanted circumstances. Like airbag, ABS (anti-lock breaking system), and windshield heater, these features is not for everyday use, but as a back up, when the time comes. For battery, there is no back up system available that can help the driver to start the engine when the battery went dead. Current methods available are troublesome, expensive, and not convenient to be carried out.

1.1 Background of Study

There are cases where engine cannot be started because of the weak or dead battery. It commonly happens because of the headlights were not turned off after the vehicle parked. Lack of knowledge on maintaining the lead-acid battery or forget to check the battery condition at least once a month, also contributes to this case. In order to come out with a solution to solve this problem, research on the cranking system of the car, lead-acid batteries and procedure while jump-starting a car were conducted.

Basically, cranking system in the vehicles involved the main battery, key switch, solenoid, starter motor, and engine flywheel. When the key switch is turned on, the current will flow from the battery into the solenoid. The solenoid will act as the magnetic switch and allowing huge current (up to 300 ampere) into the starter motor [1]. The current induce the magnetic field and rotate the armature in the starter motor. This process makes the flywheel rotated through its pinion gear and starts the engine. The engine then rotates the V-belt which connects to the alternator which then charging up the main battery and generates direct current (DC) to run other accessories. Thus, when the main battery is weak, the starter motor could not have sufficient electric current to crank up the engine.

1.2 Problem Statement

It is always inconvenient when a car breaks down because of dead battery. A survey was conducted on the lectures and students in University Technology Petronas (UTP) and the survey shows that 86% among them has encountered dead battery situation before.

The common way to start the engine in this situation is by using a set of jumper cable to jump start the car. However, there are disadvantages of this method. Firstly, power source from another car is needed, and without proper knowledge to operate the jump start can expose the user to certain danger. Battery explosion, electric shock and inner circuit burnt such as stereo circuit might happen while performing jump starting without proper knowledge. The circuit burnt occurs because of the uncontrolled huge current, flowing into small wires which could not handle the current flow. Heat generated because of the overflow and the circuit will burn and causes system malfunctioned.

The idea of emergency startup system is similar to Uninterruptible Power Supply (UPS) used for computers, network servers and important device such as breathing assisting device inside hospital. With the primary battery unable to push the starter motor, the secondary battery will provide power just enough to start the car. The power needed by the engine to assist the moving of pistons before the spark plug can start the combustion. As the engine starts to burn fuel, and turning the alternator, the primary battery will be recharged by the alternator.

Studies and surveys have been done on choosing the energy source for the system and found that valve-regulated lead-acid (VRLA) is the most suitable to be use. These batteries have leak-resistant structure which prevent the acid from spill-out and thus can be placed in any form. VRLA batteries also generate no sulfuric acid mist or gasses unlike other conventional lead-acid batteries. The electrolyte in the VRLA batteries did not flow freely, and does not need an electrolyte check, this makes it a maintenance-free battery. Furthermore, the service life is longer than any ordinary lead-acid batteries due to its smaller self discharge rate compared to the ordinary lead-acid batteries. These batteries are also economical.

1.3 Objectives

Safety features of the emergency startup system needed improvement. The system is not fully assured that it runs steadily. The solenoid often heated during the operation, suspected to have current backflow of the system. To solve this problem, experiments and research need to be carry out to ensure the safety features of the emergency startup system. Because the system hooks to a system of more complex circuitry, experiment with “trial and error” method is the best way. Previously, solenoids and battery were located inside the car, exposing danger of unstable system to operate. For safety reason, stability and durability of the system must be studied thoroughly before the system can be implemented to normal cars.

Charging is very important for a battery as it could not generate its own power. For the emergency startup system, charging the battery after multiple time of use is very important. The solar panel proposed earlier is not feasible to recharge the secondary battery. Original battery charger will be modified to fit in the car, and charging thru the cigarette lighter power point. The potential of the current supplied is still in investigation. The other option is to take the current directly from the alternator as the primary battery does.

Design will be finalize according to the final decision. The are always change in design as the writer do not really know which part will have to be fix to make the system stable. There is no other way to achieve the best result other than trial and error.

1.4 Scope of study

The project goal is to design an emergency power supply system that will provide sufficient power to start a car when the battery of is flat or dead. There are a few aspects that needed to be considered in the design process. The price of the system have to be economical and affordable, convenient and user friendly. The conceptual design for the system was tested and able to start 1500cc car engine.

The concept of design of the device is to provide a built-in-device and consist of 2 main parts:

a. **Power Supply**

   The source of energy is a 12V and 7Ah Valve-Regulated Lead Acid (VRLA) Battery. VRLA Battery is a type of galvanic cell and is a most commonly used rechargeable battery. This battery is acted as a secondary power supply to the car starter when the car battery is weak or dead. Currently the system proposed to locate the battery inside the car and connected to the starter in such a way that it is parallel with the original starter circuit. A switch will be installed. Existing system uses 2 solenoids instead of one and located inside the car which can cause undesired threat to the driver. The solenoid often heated during the operation of the back up power supply. Further research will need to be carried on to overcome this problem. The proposed ways are; 1.Solenoid with 3 terminals (1 terminal to the starter,1 terminal to the primary battery, 1 terminal to back up power supply); 2.Locate the solenoid inside the engine and counter the root cause that make the heating of the solenoid.

b. Battery Recharge

In this part, solar energy will be used to recharge the VRLA Battery. A series of solar panels will be installed at the back windshield. Then, it will be connected to the battery through a set of solar circuit which will regulate the amount electricity converted by the series of solar panels. With this, the battery will be recharge automatically under the presence of light source. It will be very convenient because no charger were use and did not require replacing the battery. The condition of the battery do not require user to check for its status. Other method will also be considered if the solar energy is not feasible. The back up plan is to provide in-car charger that will take power from the car battery itself. The power will be taken from cigarette lighter to the battery.

CHAPTER 2
LITERATURE REVIEW AND THEORY

The diagram below shows the basic component of starting system in a vehicle. When the ignition switch is turn on, the current will flows from the battery into the magnetic switch (solenoid). This current will induces the magnetic field and rotates the armature core inside the starter motor. This action will then engages the armature pinion gear to the engine flywheel ring gear and initiate the operation of the engine. The battery then gets charged from the alternator, operated by the movements of the engine. This alternator uses the dynamo concepts to generate the electricity and charging the back battery.

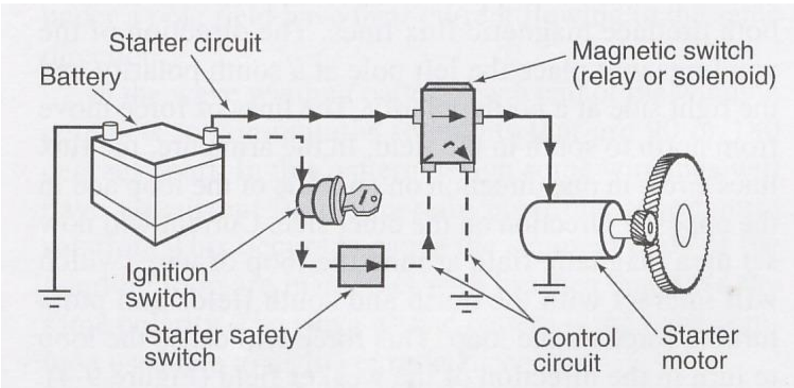

Figure 2-1: Major components of the starting system. [Bill and Jan Moeller, "*RV Electrical Systems-A Basic Guide to Troubleshooting, Repair and Improvement*", Ragged Mountain Press, 1995]

2.1 Energy Storage

For now a 12V and 7Ah Valve-Regulated Lead Acid (VRLA) Battery is used. VRLA battery is a type of galvanic cell and is a most commonly used as rechargeable battery. The advantage of this design is that the battery needs no water additions, can be operated in any position, and can be used in close proximity to people and sensitive equipment. The other additional benefits are maintenance-free, sealed no-leak design, higher cranking amps, lower self-discharge, greater vibration resistance, heavy duty and no-corrosion terminals. This battery is acted as a secondary power supply to the car starter when the car battery is weak or dead.

2.2 Solenoid

A solenoid is like a big relay or electric switch. It is mean to switch the starter motor which can draw up to 200A. It used a small DC current to switch a large DC current. The coil or a cylinder with 2 terminals on it will control the large DC current that flow in this circuit. Using the switch at the terminal, we can turn ON and turn OFF this circuit using this simple concept.

2.3 Indicator

This circuit is use to indicate the voltage level of the VRLA battery. At 12.65 volt and higher the battery is fully charged and at 11.89 volt is considered in weak condition. the indicator is adjusted in such a way that the green LED's indicate that the battery capacity is more than 50%, the yellow LED's indicate a capacity of 25%-50% and the red LED's less than 30%.

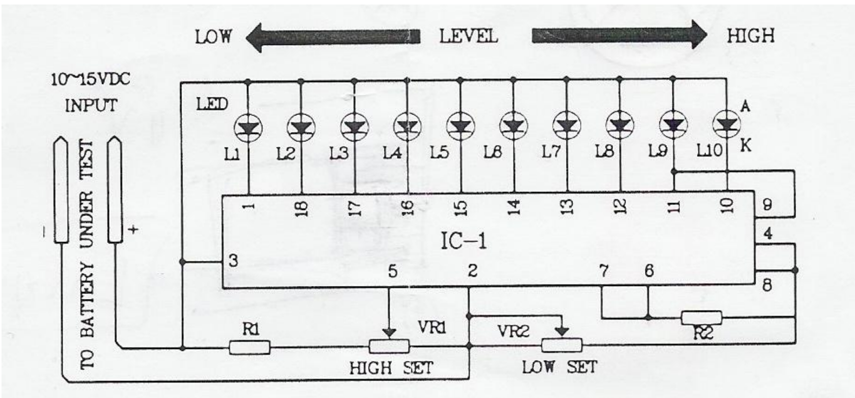

Figure 2-2: Components of the circuit diagram for indicator.

The open circuit voltage is measured when the engine is off. It can be approximately related to the charge of the battery:

Table 2-1: Open circuit Voltage.

Open Circuit Voltage	State-of-charge
12.65 V	100%
12.45 V	75%
12.24 V	50%
12.06 V	25%
11.89 V	0%

2.4 Starter

A starter is an electric powered motor that is used to assist cranking the car engine from stop position. From the car is idling, starter will get the power from the primary battery to crank the engine. Starter pinion will crank the engine until it runs at 200 R.P.M (revolution per minutes) before the combustion of the fuel take over the engine cranking system [3]. A starter consists of the very powerful DC electric motor and starter solenoid that is attached to the motor. A starter motor requires very high current to crank the engine. The negative (ground) cable connects "-" battery terminal to the engine block close to the starter. The positive cable connects "+" battery terminal to the starter solenoid. The starter solenoid works as an electric switch - when actuated, it closes the circuit and connects the starter motor to the battery. At the same time, it pushes the starter gear forward to mesh with the engine's flywheel.

Figure 2-3: Starter motor consist of two parts, top part (cylinder-like) is the starter solenoid. Lower part (bigger part) is the motor that will drive the pinion to start the car engine.

2.5 Solar Panels

Solar energy is a very large, inexhaustible source of energy. The energy supply from the sun is truly enormous: on average, the earth's surface receives about 2.3x10^7 W of solar power [7]. In principle, solar energy could supply all the present and future energy needs of the world on continuing basis [8]. Solar energy is an environmentally clean source of the energy. It is free and available in almost all parts of the world. Solar power is readily available, especially in region with 30 degree of the equator with desert like climates [9]. However there are many problems associated with the usage of solar power. The main problem is that the solar is a dilute source of energy. Solar radiation flux available rarely exceeds 1 kWh/m^2 and the total radiation is at best about 7 kWh/m^2 [8]. The value is small and not enough for technology application.

Another problem is the availability of solar power is varies with time. This is because of the season and day night cycle. Variations also occur at certain location because of change in weather condition. Due to this uncertainty, good storage system has to be developed so that energy collected during sunshine can be stored for use during unavailability periods.

According to Jabatan Kajicuaca Malaysia, being a maritime country close to equator, Malaysia naturally has abundant sunshine and thus solar radiation. However, it is extremely rare to have full day with completely clear sky, even in periods of severe drought. The clouds cover cut off a substantial amount of sunshine and thus solar radiation. On the average, Malaysia receives about 6 hours of sunshine per day. There are, however, seasoned and spatial variations in the amount of sunshine received.

CHAPTER 3

Methodology & Project Work

3.1 METHODOLOGY

Step 1: Identify need

A survey was conducted among the students and lecturer in UTP and the need of an economical and practical device that allows user to start the cat when the batter is weak or dead was identified.

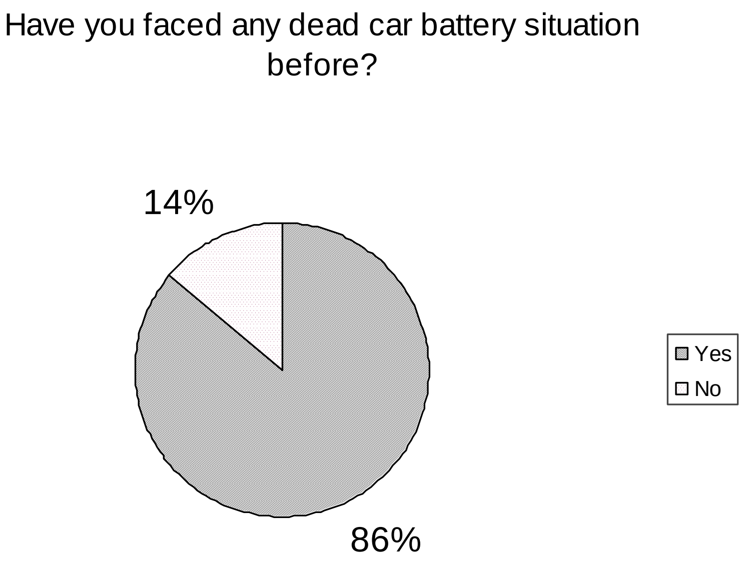

Figure 3-1: Survey result of individual faced dead battery problem.

Sep 2: Define Problem

There are 3 major problems that need to be solved in this project. The first problem is the heating of the solenoid while operating the emergency startup system. The temperature of the solenoid can be up to 90 degree Celsius when operated in a long period of time (5 minutes approximately). It is suspected that the backward current has contributed to this heating problem. Second problem is the number of solenoid uses in the system. Starter motor readily uses one solenoid that attached to the starter motor [Figure 2-3], and the emergency startup system uses another solenoid to control the secondary battery. This is costly and can bring danger to the driver, as the second solenoid located inside the car. The third problem is the charger for the secondary battery. Secondary battery will lose its power when operated. Unlike the primary battery getting charged thru the alternator, secondary battery needs another charging device to fill up. Built in charger, solar panels and outside charger is the proposed solution for the problem. The most effective, convenient, and economical will be use for the charging method and applied to the emergency startup system.

Step 3: Research

Research of the solenoids working principle and further understanding to modified the current solenoid to match the Emergency Startup System. Experiments are crucial as the projects deal with complex system of car circuitry. To maintain car system stability and avoid undesired effect, various source of reference are taken into consideration. The reference book and personnel is the main source of information. Books are chosen to best match the topic and the problem faced. Personnel from UTP become the best way to get information and discussion. Input from the technician really helpful and straight to the point. Vehicles operating manual also referred to avoid mistakes and to further understand the circuitry and precautions of the car engine. Workshop personnel also contribute to the general information of current trends and problem faced by the driver. Workshop personnel also become the evaluator for the system, whether the system is fully functional or not.

Step 4: Set Criteria

The system must be working and safe to be use in every car. It must not affect the stability of the current system. The charging method also has to be low cost and easy to maintain and still consider safety as the main point. For the solar panels, the size must not be too big to fit in to a car. Size of the panels will depends on the efficiency of the panels, the intensity of the sun light, and the power needed to be generated from the solar energy.

Step 5: Analysis

All pros and cons of the solution are considered .Alternative solutions are analyzed as a replacement if problems occur in the future. Analysis will be dividing into 2 parts; experiments, and real world application. Experiments conducted inside the lab, using facilities provided by UTP. The internal combustion lab will be the main station to do all the experiments. After all the uncertainties are known, the system will be tested onto real car, with full system running on, plus the emergency startup system.

Step 6: Decision

A final solution is selected based on the research and analysis. The decision will be inducted from the experiment result. The best solution will be justified to be the final solution for design and fabrication. The final decision will considering the 3 factors which are; safety, convenient, and economy.

Step 7 Design and fabrication

The best design will be drawn and fabricate. Design will base on the experiments result and the circuitry need. Design and fabricating will consider all the material selection, stability and durability of the product. With the aid of software, the design will be simulate for testing. This is done to make sure that the design able to withstand any circumstance that it might undergo.

Step 8: Finalize

The final design and system will be recheck and retest and applied to vehicle. Objective of the project will be checked again and make sure it is fulfilled. The objectives have to be fulfilled before ending this project. Any recommendation will be state clearly. Final product has to be proven, in terms of technicality, mechanical aspect, electrical aspect, and fundamental calculation, and simulation.

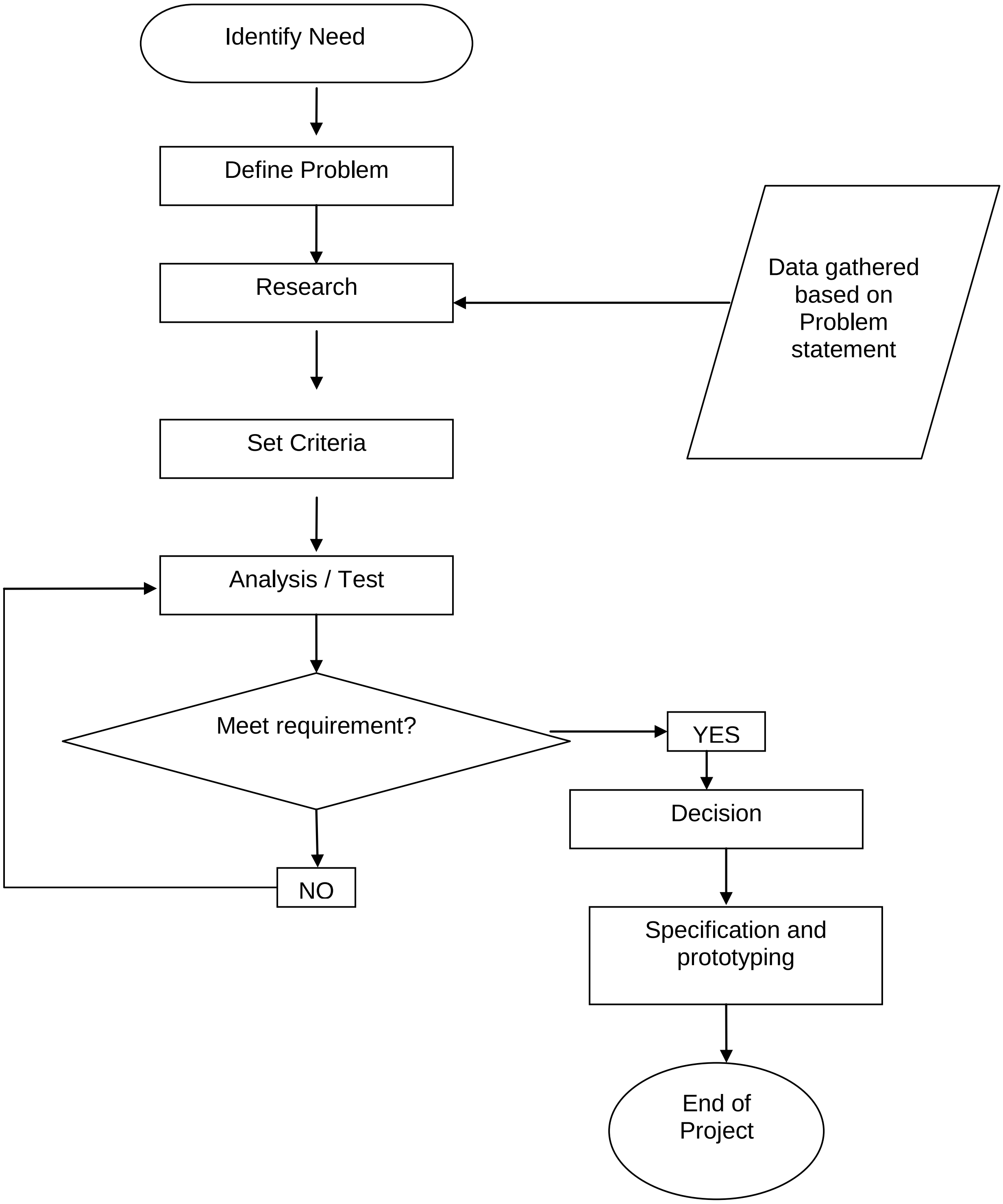

Figure 3-2: Schematic Flow Process.

3.2 Project Work

3.2.1 Experiments and Set up

There are several experiment that need to be done to complete the analysis before proceed to designing process. Project will focus on justification of the system stability of the startup system and also the solar panel's power and its size.

The first experiment will be the experiment of the current flow of the system. The objective is to determine current flow and backward flow of each connection for emergency power supply. The hypothesis of the experiment would be no backward current flow during operation of startup system. Am meter (clamps type), and thermometer will be use to achieve the experiment result. Theory behind the experiments is that, the project consist of two power sources, the flow of the current must be investigate, whether it flows to desired direction, or the opposite. The opposite direction will cause unwanted drawback mainly on the system durability. The method that will be use for this experiment is, by connecting the circuit as it was originally proposed. The system will be operated, and the current flow reading will be collected thru the clamp meter. Negative reading of the current flow will indicate backward current. If this happen, a new connection should be proposed. The new connection will surely affect all other connection and a new device such as relay; will be added to the system.

The second experiment is to investigate the charging capability of the solar panels. The objective would be, to determine charging rate of VRLA battery. The hypothesis of the experiment is that the charging rate is ~7.0 Ampere at 12 V and can be charge using solar panels. To assist the experiment, solar panels, Weak VRLA battery, Battery indicator, source of light (sun), and Ammeter will be used. The theory for this experiment is that, in idle condition (not contact with devices), VRLA battery rating is 7 Ampere (open connection). For charging, factor of 2 is needed to make the current flow onto the battery and recharge the battery. For VRLA 7*2 is 14.0

Ampere [5]. The method of the experiment is that, the solar panels will be connected to the battery and indicator. Solar panels will be exposed to the sun, and the indicator is observed. Indicator will indicate charging if the solar panels, supplying power to the battery. Ammeter will be use to measure the current value and current flow. Catalogues from internet will also be considered to assist the calculation to determine the size of the solar panels to charge the battery. Besides testing using available solar panels, theoretical calculation will also be conducted to make sure the best solution is achieved.

Third experiment is to investigate the capability of the car cigarette lighter to charge the weak VRLA battery. Because of the VRLA will be loosing power after usage, a charging method is crucial. Charging method must also be convenient for the user. The objective is to determine capability of car cigarette lighter to charge the battery. The hypothesis is that, the car cigarette lighter can push the current from primary battery to charger and charge the weak VRLA battery. The equipments to help assist this experiment is a working car engine, modified charger, ammeter, and indicator of the charger .Theory behind this experiment is that, after operating the startup system, the car cigarette lighter can be the charger because of the car engine is running and the alternator producing the electricity. It produces 12V, and the ampere is unknown. If applicable, extra fuse will be add to channel more current to the car cigarette lighter power point. The method of the experiment is that, to modify a normal charger of VRLA battery to fit in the car cigarette lighter. Run the car engine, and the battery connected to the charger. The indicator and ammeter is used to determine the current. Alternative for this option is to directly connect the secondary battery to the car alternator. The feasibility of this option will be known after some experiments by connecting the secondary battery to the alternator. The primary battery will be monitored so that the primary battery is also recharged fully during the operation of charging the secondary battery. Secondary battery will not be charged as often as the primary battery. Secondary battery will only need to be charge when the power is low, after 2-3 times of usage. A switch will be put into the connection to prevent the car alternator charging the secondary battery continuously.

After all these 3 experiments were carried out, the design will be decided and fabricated. After that it will be tested to real car system and stability will be monitored. Other experiments might follow if the experiment fails to prove the hypothesis. The third experiment however, will be carried out if the second experiment is not successful or not economical. Third experiment is made, to compare and get the best solution for charging method.

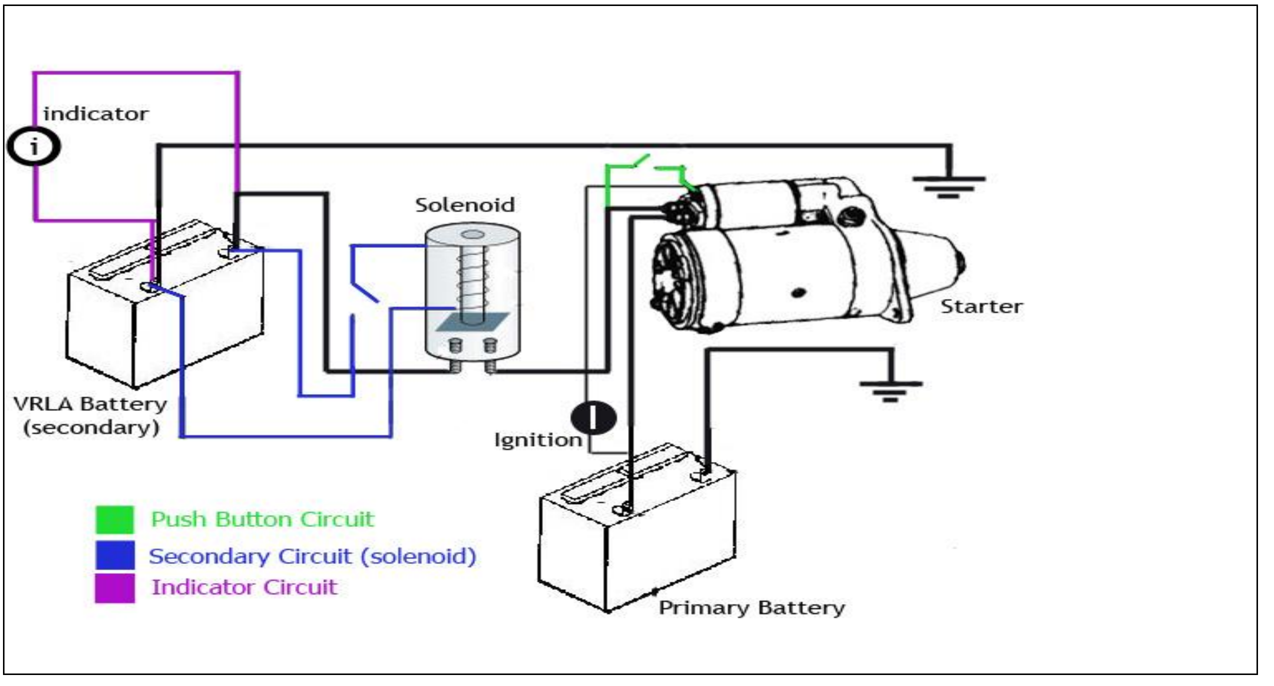

Figure 3-3: Circuitry diagram of Emergency startup system.

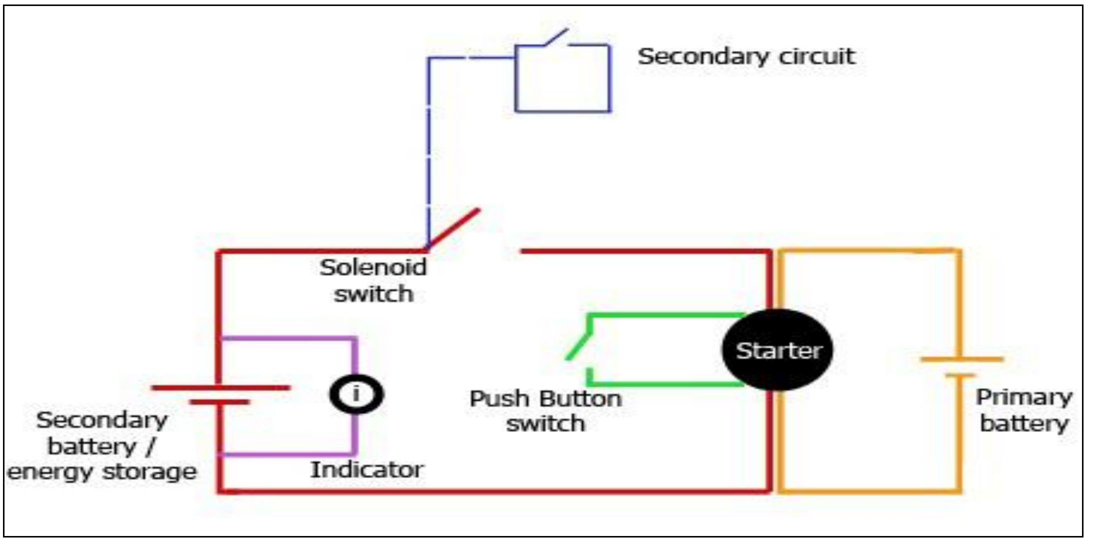

Figure 3-4: Simplified Circuitry diagram of Emergency startup system.

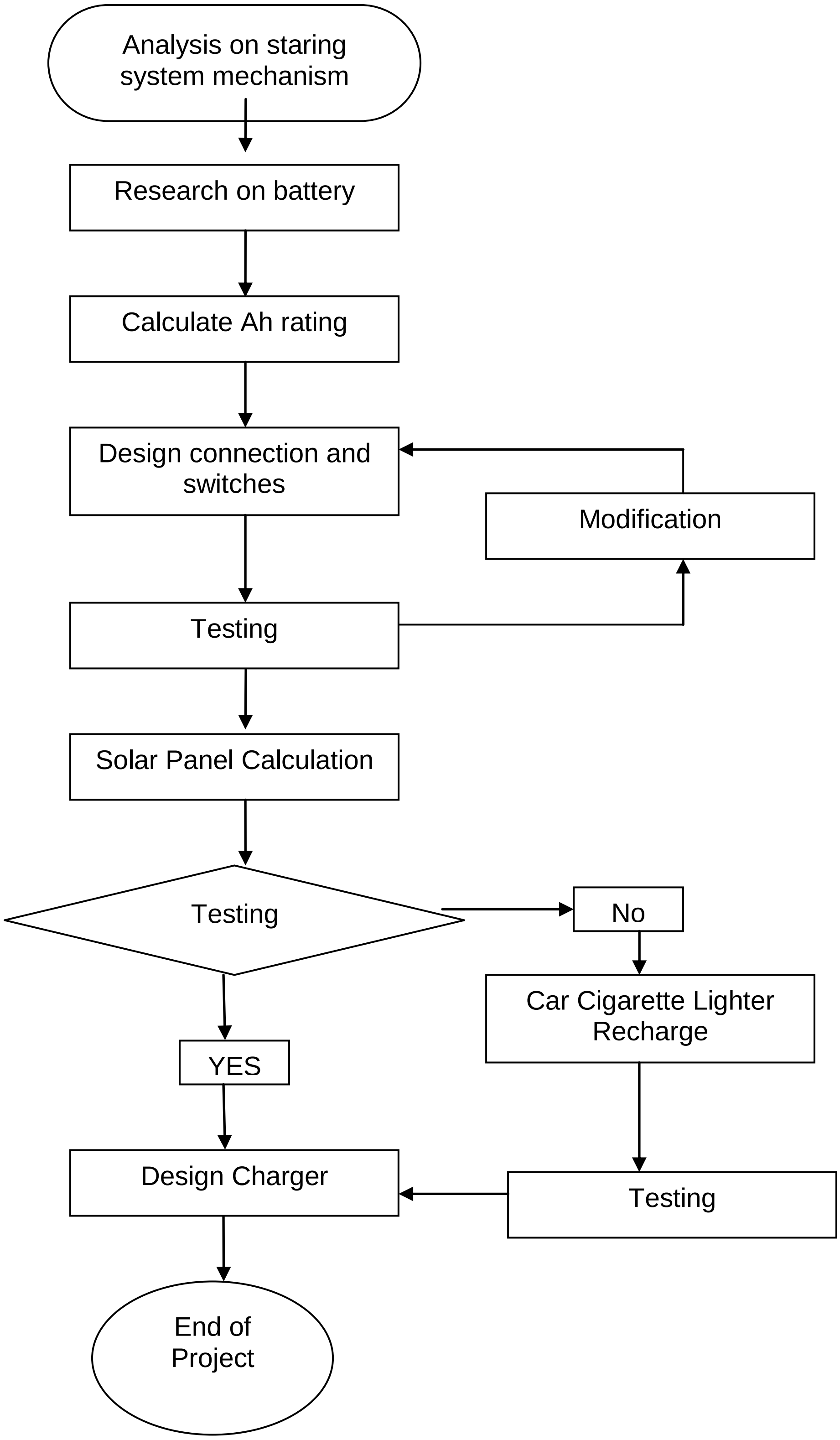

Figure 3-5: Schematic Flow of Project Work.

3.2.2 Battery details

a) Battery

A car battery is a type of rechargeable battery that supplies electric energy to an automobile. Usually this refers to a SLI battery (Starting - Lighting - Ignition) to power the starter motor, the lights and the ignition system of a vehicle's engine. This also may describe a traction battery used for the main power source of an electric vehicle.

Automotive starter batteries (usually of lead-acid type) provide a nominal 12-volt potential difference by connecting six galvanic cells in series. Since the cells naturally produce about 2.1 V, the actual voltage is roughly 12.6 V. Lead-acid batteries are made up of plates of lead and lead oxide, which are submerged into an electrolyte solution of 35% sulfuric acid and 65% water. This causes a chemical reaction that releases electrons, allowing them to flow through conductors to produce electricity. As the battery discharges, the acid of the electrolyte reacts with the materials of the plates, changing their surface to lead sulphate. When the battery is recharged, the chemical reaction is reversed: the lead sulphate reforms into lead oxide and lead. With the plates restored to their original condition, the process may now be repeated.

b) Fluid level

Many automobile batteries have low maintenance requirements. Many today do not provide for opening the caps to check water levels or add water; they are intended not to require this service. If the battery has easily detachable caps then a top up may be required from time to time. Prolonged overcharging or charging at excessively high voltage causes some of the water in the electrolyte to be broken up into hydrogen and oxygen gases, which escape from the cells. If the liquid level drops too low, the plates are exposed to air, lose capacity and are damaged. In this case the caps are simply removed and the cells topped up with distilled or de-ionized water just above the visible plates. *Tap or root water should never be used as they both can contain high levels of minerals, which will impair a battery's performance* [6].

c) Charge and discharge

In normal automotive service the vehicle's engine-driven alternator powers the vehicle's electrical systems and restores charge used from the battery during engine cranking. When installing a new battery or recharging a battery that has been accidentally discharged completely, one of several different methods can be used to charge it. The most gentle of these is called trickle charging. Other methods include slow-charging and quick-charging, the latter being the harshest.

d) Changing a battery

In most modern automobiles, the grounding is provided by connecting the body of the car to the negative electrode of the battery, a system called 'negative ground'. In the past this was different, some cars had 'positive ground', but such vehicles were found to suffer worse body corrosion and, sometimes, blocked radiators due to deposition of metal sludge. Care should be taken when first filling the battery with acid, as acids are highly corrosive and can damage human skin and mucous membranes. When removing a car battery, the ground connection should be removed first and the other connection second. This ensures that a short circuit will not occur by a wrench touching grounded engine parts while disconnecting the other terminal. When connecting a battery, live connection must be connected before grounded ones.

e) Corrosion

Corrosion at the battery terminals can prevent a car from starting. Regularly clean the terminals with a wire brush, and/or dissolve corrosion with mixed water and baking soda as needed. Also, anti-corrosion pads from an auto-parts store can be placed on each battery terminal to minimize corrosion. Another method to inhibit corrosion is to grease the terminals with dielectric grease, such as the grease used inside spark plug boots or then you can put some battery conditioner in the battery but making sure not to overfill it.

3.2.3 Processes inside battery

Lead-acid car batteries for a '12 volt' system consist of six cells of 2.1 V nominal voltage Each cell contains (in the charged state) electrodes of lead metal (Pb) and lead (IV) oxide (PbO_2) in an electrolyte of about 37% (or 6-12M) w/w sulfuric acid (H_2SO_4). In the discharged state both electrodes turn into lead (II) sulfate ($PbSO_4$) and the electrolyte loses its dissolved sulfuric acid and becomes primarily water. The chemical reactions are (charged to discharge) [4]:

- ***Anode*** **(oxidation):**

  $$\mathrm{Pb}(s) + \mathrm{SO}_4^{2-}(aq) \leftrightarrow \mathrm{PbSO}_4(s) + 2e^- \quad \epsilon^o = 0.356V$$

- ***Cathode*** **(reduction):**

  $$\mathrm{PbO}_2(s) + \mathrm{SO}_4^{2-}(aq) + 4\mathrm{H}^+ + 2e^- \leftrightarrow \mathrm{PbSO}_4(s) + 2\mathrm{H}_2\mathrm{O}(l) \quad \epsilon^o = 1.685V$$

Because of the open cells with liquid electrolyte in most lead-acid batteries, overcharging with excessive charging voltages will generate oxygen and hydrogen gas by electrolysis of water, forming an extremely explosive mix. This should be avoided. Caution must also be observed because of the extremely corrosive nature of sulfuric acid.

3.3 Procedures for jump-starting a car:

To prove that the current jump start is not convenient, the steps of the process were included below. Safety features normally neglected by the operator who conduct the jump start. This is happens because of lack of knowledge. Even though we rarely heard of car battery accident in Malaysia, but there are some cases reported. A 1994 study by the National Highway Traffic Safety Association estimated that in 1994 more than 2000 people were injured in the United States while working with automobile batteries.

Firstly, make sure the owner manual is read, as it will describe any peculiarities involved in jump-starting your vehicle. A car is pulled with a charged battery next to the car with the dead battery, situating the two batteries as close as possible without allowing the two cars to touch. Both engines are turned off; the keys are pulled out, put both cars in park (or in first gear if they have stick shifts), engage the emergency brakes and open the hoods. Attach a red-handled/positive jumper cable clamp to the positive terminal (the one with the plus sign) of the charged battery and connect the other red-handled clamp to the positive terminal of the dead battery. Attach the neighboring black/negative cable to the negative battery terminal on the charged battery. Finally, attach the other end of the negative cable to an unpainted metal surface on the engine of the car with dead battery. Find an unpainted bolt or bracket that is as far from the dead battery as possible. This will provide a solid ground while further reduce the possibility of igniting any hydrogen gas. Attempt to start the car that has the dead battery. Once the dead car is running, remove the clamps one at a time in reverse order that they were connected. Allow the jump-started car to run for half an hour in order to charge the battery. It will charge whether driving or idling.

CHAPTER 4
RESULTS AND DISCUSSIONS

4.1 Working Mechanism of the Emergency Startup System

When the primary battery is weak and cannot crank the engine, emergency startup system will play its roll as emergency power to crank the engine by supplying power directly to the starter motor inside the car engine. The process starts with the energy storage, the VRLA battery. With the rating of 7 Ah, the battery can supply enough power to start the engine. Current from the battery will flow inside the cable (high current) and ends at the solenoid terminal. Solenoid cuts off the circuit. This solenoid prevents the power from VRLA to constantly flow to the starter and wasting its energy. When the user switches on the emergency startup system main switch, VRLA battery will supply current (low current) to the solenoid. When this solenoid is powered up, it will magnetize the coil and push the element inside solenoid to touch the solenoid terminals. Initially, these terminals separate the cable of primary circuit. When the 2 terminals connected, the circuit of high current will then complete until the starter.

User then turn the car ignition key to ON (notice that car switch have 4 position: OFF (initial), ACC (accessories), ON, and START). This step is to activate all the power needed to start the car, such as spark plug, ECU, and car starter relay. It also acts as a safety measure, so that people who do not have the car key cannot start the car. When the push button on the ESS is pressed, the built-in solenoid inside the starter will magnetize and complete the circuit. It is a closed circuit now. Solenoid element also pushes the plunger out when the car is starting, and draws back after the push button is released. Starter will draw 150-200 A of 12V to start the engine. Starter cranks the engine to 200 RPM and starts the car. Once the car gets started, the engine will turn the alternator and charge the primary battery. It is Recommended that user keep the engine run for at least 15minutes.After that, the primary battery will be able to start the car again, as usual.

4.2 Result of Experiments

The project is base on the ETP findings. A series of experiments were done during the ETP to select the available power source that can crank the car engine. The first experiments were to determine the current flow from the battery when starting the engine. The battery was connected to the starter alone, and the current reading is taken. For this experiments, the starter motor was not connected the engine. The pinion has no resistance to spin, because it is not connected to the engine. The current reading was 20 Ampere. 20 Ampere is considered a big value of current. Some of the option for the energy source for the project is now seems to have no potential of cranking the option. Thermo couple, fuel cell, compressed air and a turbine; these options were considered as no potential to generated 20 Ampere currents. 12 Volt of electrical potential is quite easy to generate, a dynamo that used for a bicycle can create 12 Volt of electrical potential but the ampere is so small and the current is fluctuated. Electrical expertise was referred. A circuit of amplifier to amplify the current was suggested. After thorough research for the circuit, the result is a negative. There were amplifier but to step up to the factor of 100 is seems impossible. There are limits for everything. Even to step up the current to the factor of ten consist of complex circuitry and use parts that is unavailable in Malaysia.

At first, solar panels potential for starting the vehicles seems unfeasible. The current generated also in small value. Hence, a storage unit for the power is suggested. Many types of the battery were evaluated, Lead Acid, SLA battery, battery used in a motorcycle, and many more. VRLA is the best candidate for this, because it is maintenance free, lower discharge rate, and small in size. The battery is used to try to start a car. The primary battery was taken out from PERODUA KANCIL car, and replaced with the VRLA battery 7 Ah. The testing is a success. The car started, and the engine running like using normal battery. 7Ah battery is capable of starting small capacity engine, 660cc with carburetor engine.

Another engine is used to try the capability of the 7 ah VRLA battery. MITSUBISHI MIVEC engine, 1600 cc with fuel injection engine was tested. The battery manages to start the engine for once. For the second attempt, the power seems to drain up and unable to start the engine. The MITSUBISHI engine uses more power to start compared to the PERODUA KANCIL engine. A bigger rating of VRLA battery is used to start the MITSUBISHI engine. The 7Ah VRLA battery replaced with 18Ah battery. The engine started and run perfectly. After 4 attempts, the battery still has the power to crank the engine. The 18Ah battery size is a lot bigger in size. It is 3 times bigger than the 7Ah battery. After the experiments, the writer is convinced that the VRLA is capable of starting the car engine. The rating of the VRLA battery depends on the size of the engine and the electronic parts. For fuel injection engine, it uses a lot more power than the carburetor engine. Fuel injection uses current for the injector, and ECU (engine control unit).

The source of the power is now known, however the connection is another problem. Since the project uses 2 batteries, it is important that both batteries do not drain each other, and the power must not come from both sources. The connection is either in series or parallel to the starter. There must be only one battery is used at a time. The secondary battery also has to be separated from the car circuitry when the emergency system is not activated. The only way the connection can meet all the criteria is by using a switch. There are a lot of switches available in the market. However, a switch that can stand high current is rare. To use electronic switch is impossible because it could not stand current more than 40 Ampere. Things get harder after the experiments of determining the current of the starter when connected to the engine.

Table 4-1: Current flow from the battery

Current Flow from Battery to the Starter Motor	Current (Ampere)
First attempt	194 Ampere
Second attempt	155 Ampere
Third attempt	181 Ampere
Fourth attempt	177 Ampere

From the table, we can see that the current is not constant for each attempt. The first attempt used more currents because the engine is still in cold condition. Therefore, it used more current to start. Second attempt is made right after the first attempt. The engine just stopped and the second attempt was carried out, and it used lower current. For the third and fourth attempt, the current has less different in value. It was carried out a moment after the second attempt. The engine is not cold as the first attempt. The third and fourth reading is taken as the reference.

The problem with the switch gets worst. To find a switch than can withstand the 170 Ampere of 12 Volts is quite hard. Many personnel were referred pertaining to the problem. Some feedback suggests the writer to use contactor. However, contactor works for AC (Alternating Current) current only. The car system used DC current, so was the VRLA battery and primary battery. Electrical relay is another good suggestion. However, it can only withstand 100 Ampere of current. Other suggestion is stepping down the current, and uses a normal switch and then step up the current again. Stepping huge current will uses a lot of expensive material and took a lot of space. After the discussion over a forum on the internet, a solenoid is suggested. Solenoid can operate huge current (up to 300 Ampere). It acts like a switch and controls the flow. Solenoid is then selected as the switch to control the flow of the two batteries, the primary battery and the secondary VRLA battery.

After many attempts, the circuit for both batteries is complete. It can operate as desired and start the engine when the primary battery is weak. However, there are some flaws in the design. The solenoid was heated during the operation of secondary start up. The charging method of the battery is also crucial because of the secondary battery has no power input. For the primary battery, it gets its power from the alternator that charging when the car engine is running. Experiments are carried out again to make sure that the system is stable and counter the heating problem. It was suspected that the backflow of the current causes the heating. The experiments were carried out as follow,

Experiment 1: Current flow of the system. The objective is to determine current flow and backward flow of each connection for emergency startup system. For the experiment, Ammeter (clamp type) used to investigate the current flow. Negative sign will indicate, back ward flow. All connection involved were tested. For the experiment, a drained primary battery is connected to the system. This is done to make sure that only current from secondary battery is used to crank the system. After that, the Am meter is connected to the desired connection to determine the amount of current, flows through the connection. The experiment conducted 3 times for every connection. The primary battery gets charged when the engine is started; the writer has to drain the primary battery again before attempting for the next connection.

The results of experiments are showed below:

Table 4-2: Current flow of the connections

Connection	Current (Ampere)
Secondary battery-Solenoid connection	155A to 218A
Solenoid-Starter Motor connection	155A to 218A
Secondary startup switch	13.3A to 13.8A
Primary Battery-Starter Motor	25 A to 43 A

From the result, we know that for every attempt to crank the engine, the power needed by the starter motor is varies. It depends on the engine condition. First attempt, the current value is the highest as the engine is at the “cold” state. Second and third attempt uses less current because of the engine is already in “warm” state. The result of the first attempt will be use as the writer guidance for follow up. This is because, in real situation, people that facing the problem of weak battery condition, could not start the engine from the “cold” state. For this experiment, 218 Ampere is the best result to show the current flow through the connection.

From the last reading, the expected result is 0 ampere. However, through the experiment, it is known that there is current flow from the primary battery to the starter motor. Although the current supplied is consider as low, but this current has the potential to be the reason of solenoid heating. Suspecting that the solenoid used in the experiment is not efficient. Two more solenoids are used to replace the existing solenoid. The solenoids used are taken from "Perodua Kancil" spare part, and "Proton Saga" spares part. The solenoid is connected as the connection proposed and the temperature is recorded.

Table 4-3: Table for temperature of solenoid.

Solenoid used	Temperature (Celsius)
Used Solenoid (unknown)	112˚ Celsius
Perodua Kancil Solenoid	62˚ Celsius
Proton Saga Solenoid	41˚ Celsius

From the result, we can see that, the solenoid taken from Proton Saga spare part gives the lowest reading of temperature. This is because of the size of the solenoid, and meant for 1500 cc engine. The Perodua Kancil Solenoid gives higher value because it is meant for 650 cc engine. Note that the car that used for the testing is Proton Iswara 1500 cc engine. The heating is considered as acceptable. Discussion with technician and lecturer, it is agreed that the heating is because of the extra current supplied by the primary battery is not being used by the starter motor and heating the solenoid instead. 41˚ Celsius will not bring any harm and will less likely to bring any threat of danger to the system. The solenoid itself is fully made of steel and can easily withstand the temperature.

Experiment 2: The second experiment is to investigate the charging capability of the solar panels. The objective would be, to determine charging rate of VRLA battery. The hypothesis of the experiment is that the charging rate is ~7.0 Ampere and can be charge using solar panels. There are many types of solar panels available in the market. The PV panel is selected as solar panel for the experiment. PV (photovoltaic) panel is some kind of instrument that is capable of capturing energy from sunlight. The energy is then being converted to electrical power. This electrical power can be use to charge the VRLA after usage of cracking up the engine. To assist the experiment PV panel, Weak VRLA battery, Battery indicator, source of light (sun), and Ammeter used. After the calculation, the solar panel required for charging the battery is 700 cm x 2340 cm of PV panel is required. The table acquired from a vendor from the internet.

Table 4-4: Solar panels model from Plastecs Ltd.

Cell #	Vdc (oc)	mA	size in mm	Price (USD)
WB-15	**0.4-0.55**	**60**	**20 x 20**	**$0.62**
WB-16	0.4-0.56	100	15 x 35	$0.85
WB-17A	0.4-0.56	125	18 x 35	$0.76
WB-17A	0.4-0.57	130	27 x 27	$1.23
WB-18	0.4-0.58	140	20 x 40	$1.27
WB-19	0.4-0.59	150	30 x 30	$1.31
WB-19A	0.4-0.60	175	20 x 50	$1.34
WB-20	0.4-0.61	200	35 x 35	$1.44
WB-21A	0.4-0.62	225	30 x 38	$1.67
WB-22	0.4-0.63	350	38 x 35	$2.55
WB-23	0.4-0.64	400	50 x 50	$2.95

Battery to charge: 12V (13.8 V), 7 Ah

Expected Voltage supplied from solar = 14V

Charge Rate = 7A per hour

PV Cell used = WB 15 (0.4V, 60 mA, 20x20mm)

Number of cells required to supply 14V

=14/0.4 = 35 panels

Number of panels required to supply 7A

= 7000/60 = 116.67 = 117 panels

Total cells required

= 35 x 117 = 4095 panels

= 0.7 meter x 2.34 meter = 1.638 m^2

After the theoretical calculation done base on data from the internet, the experiment is conducted by the author to investigate the actual power supplied by the solar energy. Solar energy depends on the intensity of the light. To get the actual reading, the experiment conducted at UTP, to determine how much power the solar panels can give. The capability of the power to recharge the battery is also experimented. The data given in the table below is taken from the experiment at UTP. The PV plates are located inside the lab, and under direct sunlight. This is done to determine the difference of the power output of the solar panels under different condition.

Table 4-5: Table of solar panels experiment readings

Time	Location	Volt	Current (mA)
9.33 am	Direct Sunlight	9.28	80
	Inside Lab	2.65	22
10.05 am	Direct Sunlight	9.50	82
	Inside Lab	2.61	22
12.44	Direct Sunlight	9.65	83
	Inside Lab	2.71	23

From the experiments carried out, the solar panels able to charge the battery. However, the solar panels can only charge the battery at the stable state, not to fully charge. The reason is that the current needed to fully charge the battery is higher. For that matter, a system which consists of more efficient PV cells and bigger size of panels is required. Since the cost is another constraint in this project. It is not feasible to continue on solar panels. The direction to the sun and the light intensity must be at optimum level in order to fully charge the battery. Detail calculation will follow.

Experiment 3: Third experiment is to investigate the capability of the car cigarette lighter to charge the weak VRLA battery. Because of the VRLA will be loosing power after usage, a charging method is crucial. Charging method must also be convenient for the user. The objective is to determine capability of car cigarette lighter to charge the battery. The hypothesis is that, the car cigarette lighter can push the current from primary battery to charger and charge the weak VRLA battery. If this method is not feasible, other method will be use. Directly connect to the car alternator is the final choice. Since the battery is located inside the engine, it is possible to tap the power to charge the battery from the alternator (previously known as dynamo. The charger of the battery, socket for cigarette lighter is needed to set up the experiment. Due to time constraint, the writer made the decision to tap the power directly from the alternator. The alternator can supply power to the primary 70Ah battery. However, the alternator still has some excess power to supply the current for the secondary battery. The idea is to charge the battery when the secondary battery is weak. An indicator will show the user whether the battery charge is full, or partial (weak). The secondary battery will not be connected to the alternator all the time; hence it will not ‘steal’ the power produce by the alternator to the primary battery. It uses a switch, to connect the secondary battery to the alternator. This switch will only need to be turned on, whenever the secondary battery is weak. The concept is more like ‘symbioses’ rather than ‘parasitic’ process. Secondary battery is idling and storing its power, whiles the primary battery and other system inside car, running as usual. When the time comes, the primary battery is weak; the secondary battery will give its power to crank the engine. When engine successfully started, the alternator will charge the primary battery. After the car functioning as usual, user can recharge the battery by switching on the secondary battery recharge circuit. At this moment, engine will let to run in idle, to give the power from the alternator to the secondary battery. The charging of the secondary battery can be done at any time. Not necessarily right after the usage of secondary start up.

For the final design, the system uses 2 solenoids, and charging using the power from the alternator. The idea of the 3 terminals solenoids is not possible because of the connection problem. With 3 terminals, one of the connection will always connected and closed the circuit, which means, the battery will drain each other. The weaker battery will take the power from the battery with higher charge. This will lead to power drain and can cause bad battery lifetime. To fit in 4 terminals for solenoid is also impossible. The size of the solenoid is too small to fit in 4 terminals. So, the design will still use two solenoids. Since the solenoid is no longer heated while operating the secondary start up, it is not a problem to use two solenoids. Charging the secondary battery using the power from the alternator is chosen. Many will think that it is like stealing the power from primary battery. Actually it is not. The primary battery uses the power for all the accessories inside the car, the air condition, car stereo, wiper, heater, and other devices. If we close all these accessories, the alternator will have no problem to charge not just one secondary battery, but more than that. The alternator is now functioning as small generator inside the car. It uses the fuel, run the pistons, turn the alternator, and produce electricity. This electrical power uses to charge the batteries.

CHAPTER 5
CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The objectives of the project are fulfilled. The safety of the emergency starts up in now better. The heating problem caused by the power overflow through incompatible solenoid. By providing on par solenoid, it improves significantly and less heat is observed at the solenoid. The 3 terminals solenoid is not feasible because of the short circuit problem. Since the two solenoids are already stable, the design can be use for the system. Charging of the secondary battery using solar is almost feasible. However, the size of the panels is too big to fit in to a car. As the solar panels technology is still developing, higher power and efficiency will surely be introduced. In 5 years, the solar charger could be feasible. Charging using the power from the car alternator is selected. The secondary battery will be charged whenever the secondary battery is weak. At most of the time, the battery is completely isolated from any system of the car. This is done to prevent any unwanted short circuit or power drainage when the system is not in use. The project starts with the power source selection, to consider all the energy that can be use to produce electricity. After the source is justified, the storage for the energy generated is selected. VRLA is used because of the low maintenance, and can store the charge for longer time compare to other rechargeable battery. The switch to separate the two batteries uses another car solenoid. Car solenoid is the only switch that can withstand huge current. When the system to start the engine is complete, the charging for secondary system follows. Solar panels were chosen. It can produce the desired power, but the size is slightly bigger than the car roof, which is hard to be implemented. The car cigarette lighter charging is not feasible because of the current supplied by the power point is 12.5V while the power needed is 13.8V. The project is successfully done and working properly when tested to a PROTON ISWARA 1500cc engine.

5.1 Recommendations

The project is now can be implemented inside a car, and can start the car engine when the battery is flat. However, there are rooms for improvement and further work as the technology developed and create an opening for project improvement. Further study on solar panels can be carried out. Solar panels and its development are rather slow. Improvement of the efficiency of the solar panels can make the solar charging possible. Recently, a new type of solar panels was introduced by Plastecs Ltd. with higher current compared to panels that available in the market. Since the Plastecs Ltd only announce their new product after the project has completed, further study cannot be carried out because of the time constraint.

The system has successfully started the 1.5 liter engine of automatic transmission car. The capability of the system to start a car with more complex system and bigger engine capacity is unproven. Testing the ability of the secondary startup system to bigger and more complex engine system such as Honda CR-V 2000cc can be carried out. A higher rating of Ah for the VRLA battery might be necessary as the system needs more power to crank the engine. The secondary startup system is much needed by new bred, complex car as their system run on Electronic Control. They could not afford to lose electrical power as the engine store the memory of the engine valve opening, the fuel need to be injected and many more. By having the secondary startup system, electronic memory of a car Engine Control Unit can be protected and prevent from memory lost.

The amount of Ah for the car is now depending on the available VRLA battery rating in the market. For example, Perodua Kancil and Proton Iswara, both are using 7Ah battery for startup. For Mitsubishi Mivec 1.6 liter engine, 18Ah battery is used. For Mitsubishi Mivec engine, smaller Ah rating might be enough to crank the engine, but bigger than 7Ah. However, in the market, there are only 7Ah, 18Ah, and 32Ah available. The rating is not based on the design of the engine. More specific rating for each type is engine is proposed. This is to avoid the car carrying much bigger battery than it needs, or not having sufficient power to start the engine.

The correct method to jump start a car, and its risk has to be exposed to the public. Many of the car users, practice the wrong method of jump starting a car and exposing them to certain danger. Circuit burnt, and permanent damage to the host battery always occurred to those who practice the jump start wrongly. Battery explosion, and visual impairment from the acid can turn a helpful hand to a miserable accident. Many car users assume that they know how to jump start. Basic electrical knowledge, or just using logic is not appropriate to deal with electrical power, especially with very high current such as start up mechanism. The exposure can be done either by providing more clear operation manual with every set of jumper cables, or a diagram of the right connection at the battery itself.

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