# BATTERY INDICATION SYSTEM FOR GENERATOR SET

By

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Dissertation submitted in partial fulfillment of

the requirements for the

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(Electrical & Electronics Engineering)

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# CERTIFICATION OF APPROVAL

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A project dissertation submitted to

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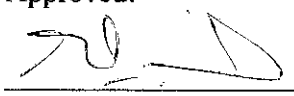

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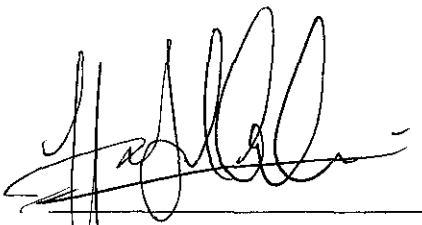
TRONOH, PERAK

SEPTEMBER 2011

## CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.



HAFIZULLAH BIN JAMALUDIN

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Last but not least, I offer my regards to those who support me especially all my friends and Telekom Staffs for contributing their assistance and ideas for this project.

# ABSTRACT

The standby generator is important in order to back up the main power supply failure. The function of standby generator is crucial in order to maintain the capability of equipment and devices operation. When main failure occurs, the system will switch from main to standby generator to get the power supply. The start-up of generator set will use batteries for engine cranking. The batteries will be used as supplied power to starter motor to give initial move to engine flywheel. Batteries are used to power up the starter motor to rotate the engine flywheel. Without batteries, the electric starter motor cannot be used, thus generator set cannot be start up. The aim of this project is to build a system to identify undervolatage and overvoltage at battery used in generator set. The system then will give indication upon the detected voltage limit. This system will reduce the failure of generator to start as backup while there is no main power supply. This project will use Direct Current (DC) voltage sensor to determine the low and high voltage present during battery charging and the battery voltage itself.

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# CHAPTER 1

# INTRODUCTION

## 1.1 Background of study

Generators are machines that are designed to produce electricity. However, some large generators , especially those used high load demand purposes, require a small amount of power to start their operation.

This is where generator batteries come in. They deliver a high starting current in order to start a generator. They use an electrolyte which contains sulfuric acid. The interaction between the electrolyte and lead inside the battery causes a chemical reaction which, in turn, produces electrical energy. Generator batteries can be flooded plate types, gel cell types or absorbed glass matt batteries.

Flooded type generator batteries are the most common type. Usually, the cells are not sealed so the user can refill the electrolyte fluid in this type of battery. The electrolyte can be replenished by pouring it into small ½ inch holes on top of the battery casing [1].

One example of battery used for generator set application is lead-acid battery. Lead acid battery is a type of battery which store energy using a reversible chemical reaction between lead plates and dilute sulphuric acid (electrolyte). Three basic types of lead acid battery which are starter batteries: used to start engines in cars, generator and others, deep-cycle batteries: used in renewable energy applications and camping, and marine batteries: used both for starting and for deep cycle applications [2].

## 1.2 Problem statement

A standby generator is a great device for providing back up electrical power for any situation where power is lacking. For homes and businesses, a standby generator is ideal for many situations where electrical power maybe lost including rolling blackouts, emergency blackouts, or just electrical problems. A standby generator will produce electricity to buildings, equipment, and appliances whenever power is lost which can save time, money, businesses, and even lives. People who have faced emergency situations where electrical power has been lost, the importance of standby generators can easily be seen.

The current system is only detecting the weak voltage of battery as indication. This will be as threat to the generator set where engine cannot be cranking without enough voltage supplied. Failure to crank engine will lead to failure to rotate the shaft connected to alternator, thus alternator cannot be rotated. When this problem occurs, the operational system will be down due to failure of the generator set to supply power.

Besides that, batteries are exposed to overcharging in the case where battery charger is not well function. This will reduce the lifespan of batteries, even damaging them. When batteries are damage, the voltage supplied to starter motor is less than minimum requirement for engine cranking. As result, generator set is failed to start. Failing to start generator set will bring a big lost to the electrical & electronic system.

## 1.3 Objectives

Upon completion of the project, some objectives set and satisfy the scopes of study that have been underlined, which are relevant to the requirement of the project. The objectives of this project are as follows:

1. To design an Indication System of Battery for Generator Set application. The system will use sensor as the main devices to detect the under voltage and overvoltage of the battery.
2. To design indication system where people can know the failure of battery even at home or far away from the generator battery.
3. To give indication or alert to people by mobile phone.
4. To eliminate failure of generator set to start due to the damage or low voltage of battery. Since the system can give early indication, the battery lifespan can be saved thus can reduce the maintenance cost.

## 1.4 Scope of study

While the scope of study will consists of two major parts which are:

1. Research and survey on the sensor unit and relay. The research is to give some ideas and relevant solutions to create and improve new identification system application.
2. The experimental work is data gathering and identifying the processes and disturbance model of the application.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Voltage Sensor

Cell voltage sensor senses the voltage across individual, series-connected cells to provide a high cell voltage signal proportional to the highest voltage across any of the cells and a low cell voltage signal proportional to the lowest voltage across any of the cells. In one embodiment, the high cell voltage signal is substantially equal to the highest voltage across any cell and the low cell voltage signal is substantially equal to the lowest voltage across any cell.

A battery charger or monitor, including the cell voltage sensor, is provided for charging the series-connected cells in response to the high and low cell voltage signals and for monitoring the voltage across the cells to provide protection from overvoltage and/or undervoltage conditions. The charger further includes a controller generating a control signal in response to the high and low cell voltage signals for adjusting a charge current supplied by a current regulator to the cells during a first portion of a charge mode and for maintaining the voltage across the cell charged to the highest voltage substantially constant during a second portion of the charge mode.Figure 1 in the next page shows the example of voltage sensor [3].


**Figure 1 : Example of Voltage Sensor**

As a safeguard against unexpected battery failure caused by some of the non-fault conditions just mentioned, the "battery monitor" is often recommended. Several makes are now available. In general, these include a small local sensor that is installed at each cell or small group of cells. The sensors are wired to one or more electronic monitoring units that generate alarm or relaying signals based on cell condition such as under voltage, changes in connection resistance, or even low electrolyte level. Condition alarms may be local or remote.

Sensors themselves typically respond directly to cell voltage. If an inter cell connector is open, so that neither charging nor load current can flow, cell voltage will change. Similar changes occur if cell sulfation takes place. Monitoring circuits are self-checking so that a monitor defect itself is translated into a condition alarm [4].

## 2.2 Relay Switch

An electric current through a conductor will produce a magnetic field at right angles to the direction of electron flow. If that conductor is wrapped into a coil shape, the magnetic field produced will be oriented along the length of the coil. The greater the current, the greater the strength of the magnetic field, all other factors being equal. Looking at Figure 2 below,batteries will supply current.The current will move and passing through the coil which will create magnetic fiel around the coil.Thus, the coil will become temporary magnet.

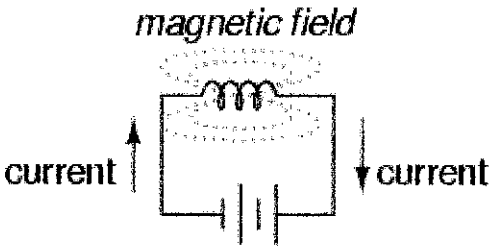


**Figure 2: Example of Circuit Diagram inside Relay**

Inductors react against changes in current because of the energy stored in this magnetic field. When we construct a transformer from two inductor coils around a common iron core, we use this field to transfer energy from one coil to the other. However, there are simpler and more direct uses for electromagnetic fields than the applications we have seen with inductors and transformers. The magnetic field produced by a coil of current-carrying wire can be used to exert a mechanical force on any magnetic object, just as we can use a permanent magnet to attract magnetic objects, except that this magnet (formed by the coil) can be turned on or off by switching the current on or off through the coil.The circuit diagram of the relay can be referred in Figure 3 below.

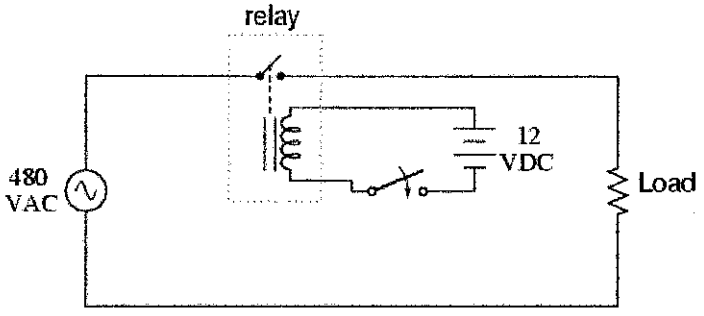


**Figure 3 : Example of Relay Circuit**

If we place a magnetic object near such a coil for the purpose of making that object move when we energize the coil with electric current, we have what is called a *solenoid*. The movable magnetic object is called an *armature*, and most armatures can be moved with either direct current (DC) or alternating current (AC) energizing the coil. The polarity of the magnetic field is irrelevant for the purpose of attracting an iron armature. Solenoids can be used to electrically open door latches, open or shut valves, move robotic limbs, and even actuate electric switch mechanisms. However, if a solenoid is used to actuate a set of switch contacts, we have a device so called the *relay* [5].

## 2.3 Generator Set Battery

Starter batteries are used to crank most emergency generator sets. The prime mover uses either a 12- or 24- volt starter motor. Battery failure is one of the most common reasons emergency generator sets fail to start. In a standby application, the generator set is stationary most of the time, running only for exercise periods or during a power outage. The engine-mounted charging alternator on a standby set normally will not run sufficiently to ensure the starter batteries are charged for rapid and reliable starting. To ensure the battery is adequately charged while the generator set is stationary, a separate static battery charging system is recommended [6].

The commonly used battery for generator set is lead acid battery. The lead acid battery is made up of a series of identical cells each containing sets of positive and negative plates. In semi traction cells flat plate construction is used. Each positive plate is a cast metallic frame which contains the lead dioxide active material.The negative plates contain spongy lead active material. Within the similar frame , both plates usually have the same surface areas. In practice a typical cell is constructed with many more plates than just twoin order to get the current output. All positive plates are connected together as well as the negatives. Each positive plate is always positioned between two negative plates,there is always one or more negative plate than positive.The illustration of the battery and the inside view of it can be seen in Figure 4 and Figure 5 respectively [7].

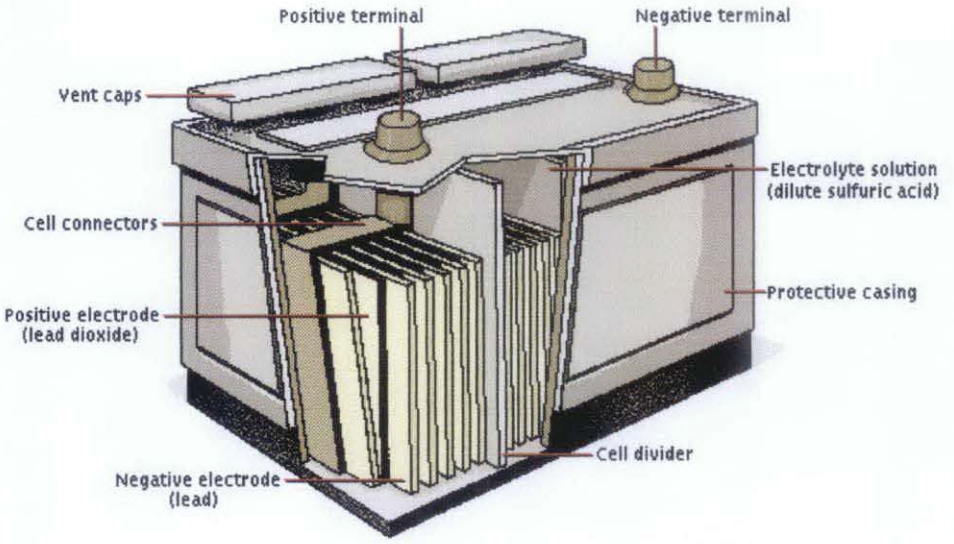


**Figure 4 : The lead acid battery [8]**

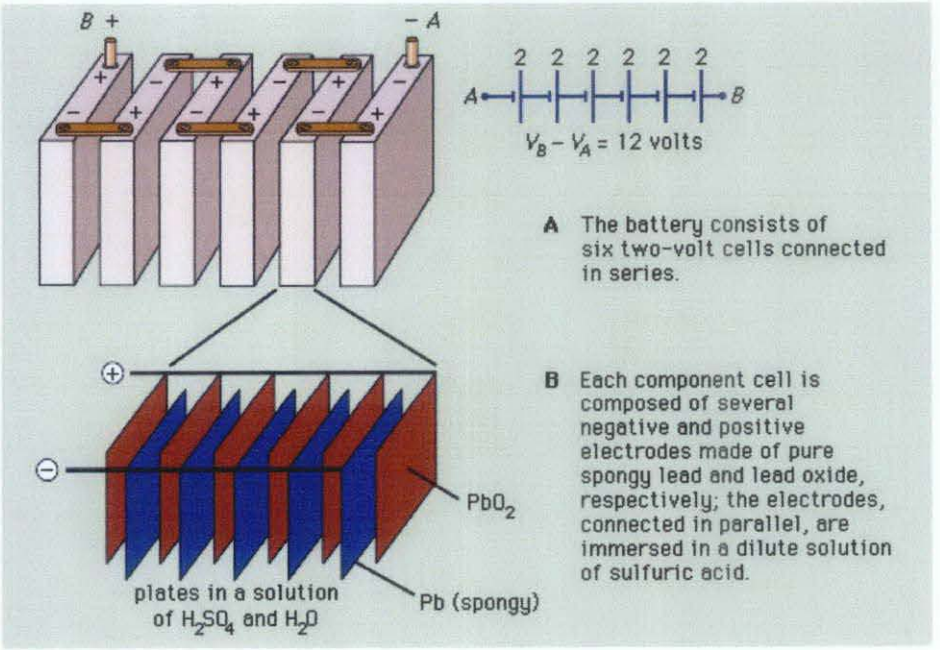


**Figure 5 : Inside view of Lead Acid Battery [9]**

## 2.4 Wireless Battery Monitor

The system is to predict and prevent battery failure and support operation of the critical equipment. It is a battery management program that identifies and predicts battery failure and reduces battery maintenance and battery replacement cost. The system is the best way to ensure the integrity of the complete backup power system [10]. The present invention relates to storage battery. More specifically, the present invention relates to battery monitors of the type used to monitor individual storage batteries or banks of storage batteries.

Individual storage batteries and bank storage batteries are used in various applications including backup power supply applications. In order to act as backup, the batteries must be ensured have not degraded and capable maintaining a desired amount of charge [11]. This method will detect the voltage of batteries and transmit data through wireless medium.

## 2.5 Battery Monitoring System

Battery monitoring system will be acting as a 'fuel gauge' for battery banks to ensure there is sufficient capacity to operate systems for the designated time in the event of a power failure. Besides that, it is going to identify faults and weaknesses in the battery bank early so preventive maintenance and replacement can be undertaken in safe and orderly manner. The system also will ensure that the battery bank is maintained in an optimum environment to maximise its performance and life [12].

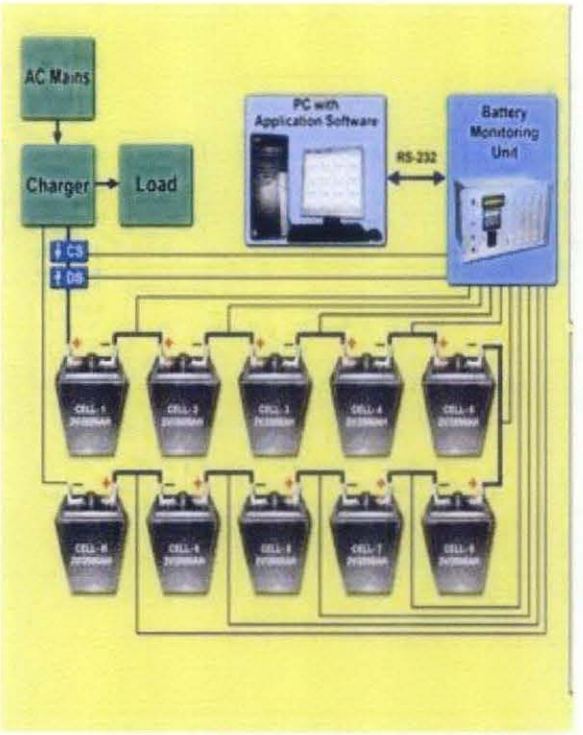


**Figure 6 : Battery Monitoring System [13]**

Figure 6 above shows the battery monitoring system used to monitor the performance and the condition of batteries. The system is commonly applied when batteries are used as backup power system to the main power supply. In figure 6 above, AC mains is the main power supply to the load. These AC mains also will be used to provide voltage to charge batteries through battery charger. Battery monitoring unit will monitor all batteries condition, so that the batteries will remains function to back up power system when main supply is fail.

## 2.6 Short Messaging (Mobile)

The short message service (SMS) is the technology that allows sending and receiving text message to and from mobile telephones, Personal Digital assistants (PDA) and personal computer (PC). Using this technique, we could send the message to mobile phone as the indication for the battery. In order to allow message to be sent, we need to follow the global system for mobile (GSM).

GSM is a digital system which allows short message service (SMS) feature to exist. GSM uses a variation of time division multiple access (TDMA) and is the most widely used of the three digital wireless telephony technologies (TDMA, GSM, and CDMA). GSM digitizes and compresses data, then sends it down a channel with two other streams of user data, each in its own time slot. It operates at either the 900 MHz or 1800 MHz frequency band [14].

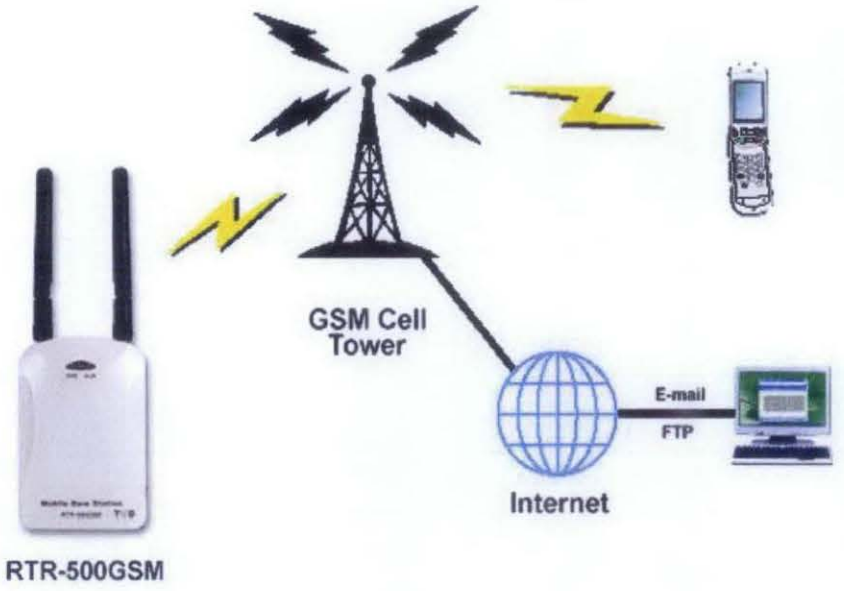


**Figure 7 : Global System for Mobile (GSM) [15]**

Figure 7 above shows the GSM tower and the application of GSM in a digital system. GSM which stand for global system for mobile is used widely around the world. It is used to connect from one device to another like mobile phone to mobile phone.RTR-500GSM is a GSM module which can send message or voice signal to mobile phone or to email via internet and vice versa. The signal is send to GSM tower before transmitted to receiver like mobile phone or internet server. The applications of GSM make data transfer become easier through wireless medium.

# CHAPTER 3

# METHODOLOGY

## 3.1 Procedure identification

Figure 8 shows the flow of procedure identification through two semester period.

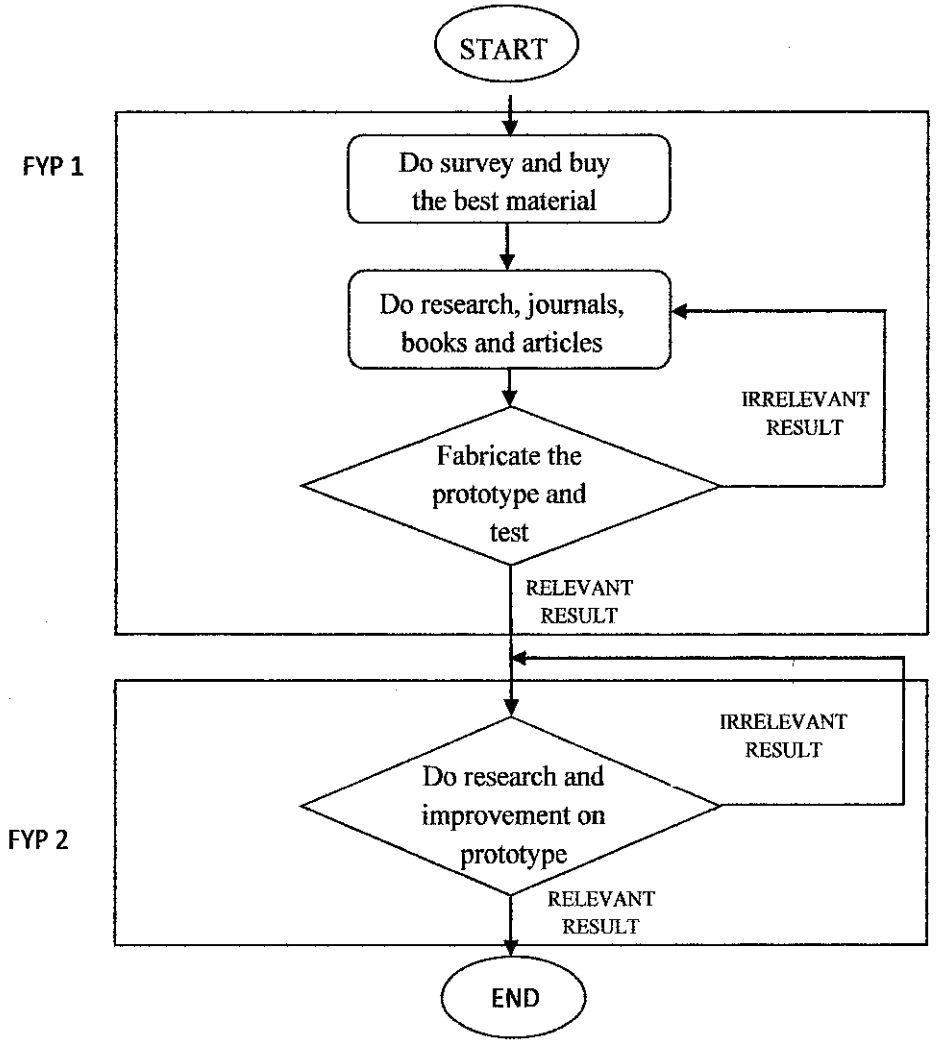


**Figure 8 : Procedure Identification**

It is important to have a several steps to strive the project to the successful level. Thus the steps taken for consideration in this project are discussed in the following. :

1. **Identify need**

   Construct a prototype of the Battery indication system for generator set application.

2. **Define problem**

   The current practice is the battery is only detected when it is in a weak condition. The situation will lead to failure to start generator set.

3. **Research**

   Conduct a research by surfing from internet, journals, conference papers and etc. Understand the principle working of the sensors, relay and the whole indication system.

4. **Set constraint**

   Target of this project is to complete fabricated and test the prototype of the innovation within the time given. Budget for this prototype is estimated to be less than RM 2000 which is covers all the material use for this project.

5. **Set criteria**

   The project must be cost effective, power efficient, reliable, practical, marketable and safe for usage.

6. **Analysis**

   All pros and cons of the proposed ideas are considered. The general idea must be clear understand and know how to construct the prototype. Alternative ideas are analyse as back-up plans if problems would arise unexpectedly in the future.

7. **Decision**

   A final decision made by choosing the most practical considering the objective and other constraint to make it achievable.

**8. Specification**

Specification of the prototype made for detailed project report once everything has finalized and confirmed. Points to consider for specification are as follows:

Quality → Lasting

Material → Affordable

Performance → Efficient

## 3.2 Tools and equipment required

### *3.2.1 Simulink Software*

Simulink® is an environment for multi domain simulation and Model-Based Design for dynamic and embedded systems. It provides an interactive graphical environment and a customizable set of block libraries that let user design, simulate, implement, and test a variety of time-varying systems, including communications, controls, signal processing, video and image processing

### *3.2.2 Breadboard*

Breadboard will be using as the medium to test the circuit before materials are connected on the prototype board.

### *3.2.3 DC Power Supply*

The DC power supply is needed to make testing to the system representing the input voltage from battery and battery charger.

### *3.2.4 DC Battery Charger*

DC battery charger is very important to charge the battery when the voltage level is low. During the experiment, we need to use the battery by connecting to high current rating load.

### *3.2.5 Mobile Phone*

Mobile phone will be used to receive the message from GSM system about the battery condition.

### *3.2.6 Terminal Block*

Terminal block become as a medium to connect wires to the devices.

### *3.2.7 Bell*

Bell will be as the indicator when the sensor triggers the overvoltage and under voltage.

### *3.2.8 Lamp*

The small size lamp will be used as another indicator.

### *3.2.9 Grinder Machine*

The machine is used to cut metal and plastic material.

### *3.2.10 Saw Machine*

The machine is used to cut the wood as the base of prototype.

### *3.2.11 Drill Machine*

The machine is used to drill holes to put screws and attach the materials and devices to the based board.

# CHAPTER 4

# RESULT & DISCUSSION

The project has been completed 100%. The prototype had been made to show how the system works before doing a test at industrial application.

## 4.1 Prototype

### *4.1.1 The Battery Indication System Prototype*

Figure 9 shows the prototype of battery indication system.

**Figure 9 : Set of Battery Indication System**

The prototype base is made of plywood. Most of the devices are mounted on the wood for easy mobilized. The devices that are mounted on the board are 2 set of 12 V dry-cell

sealed lead acid batteries, 24 V DC indicator bell, 1 set box of switches, 1 GSM module, and control panel consist of voltmeter, relay, 24 V voltage sensors and a circuit breaker.

### *4.1.2 Control Panel*

Figure 10 shows the control panel of battery indication system.

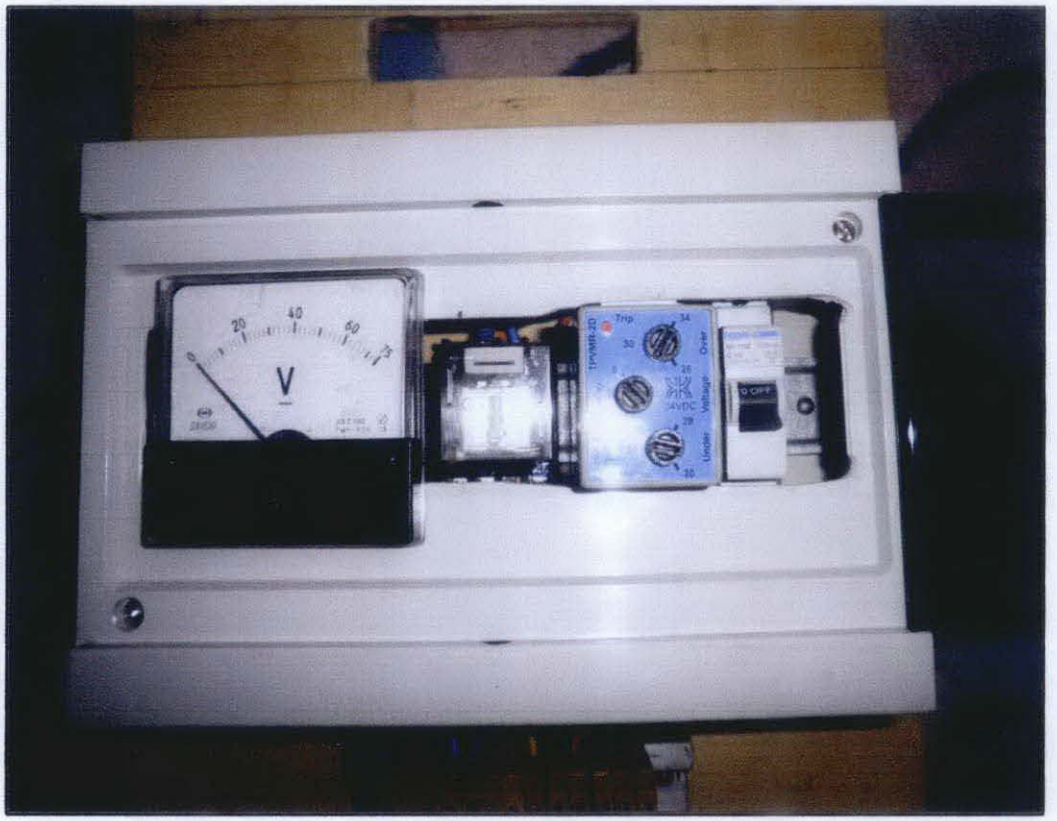


**Figure 10 : Control Panel**

The control panel is a box where voltage sensor, circuit breaker, relay and voltmeter are placed together. The voltage limit for over and under voltage can be set from this control panel at voltage sensor devices. Control panel can be considered as the centre of the system.

### *4.1.3 Terminal Block*

Figure 11 shows the terminal block of battery indication system.

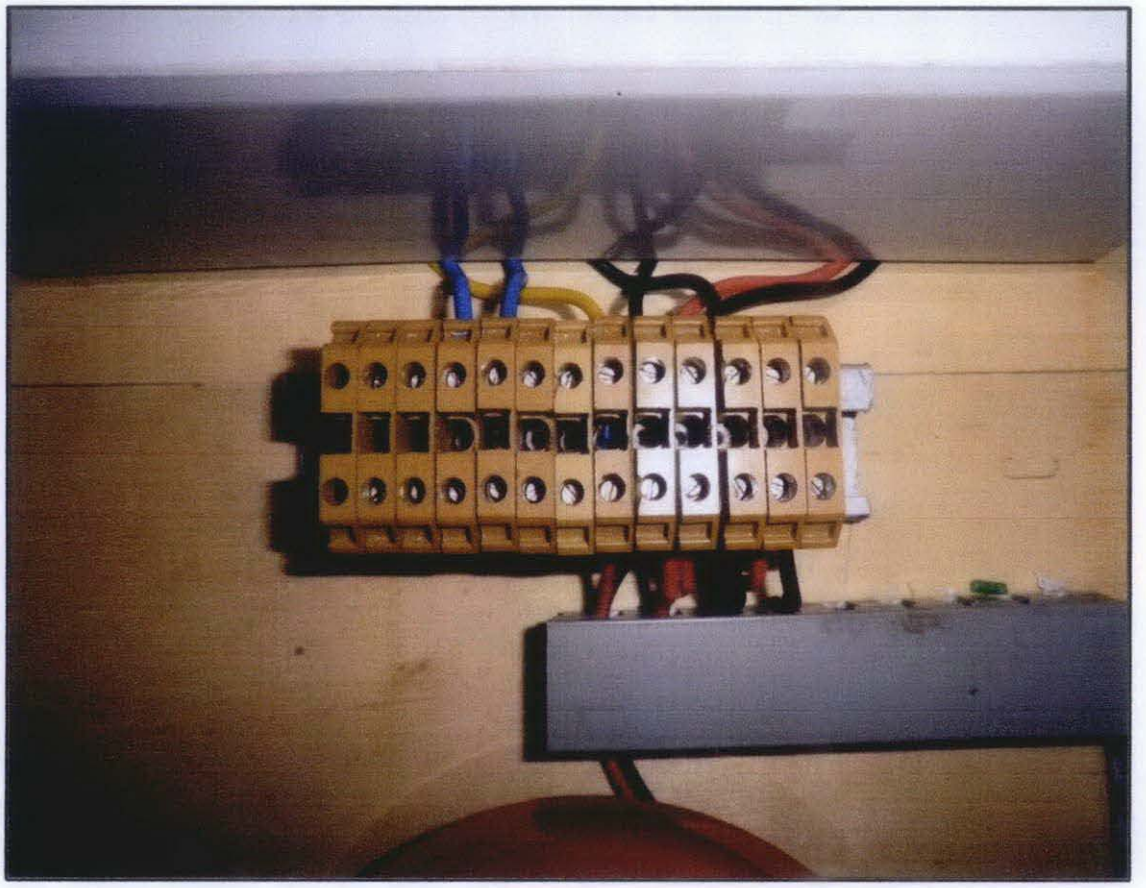

**Figure 11 : Terminal Block**

All wires are connected to terminal block before connect to the control panel. This is to ensure easy recognition of the connection between devices. Terminal block has the advantage where it is easy to connect or disconnecting between devices through the terminal block.

*4.1.4 Bell*

Figure 12 shows the alarm bell (indication device 1) of the system.

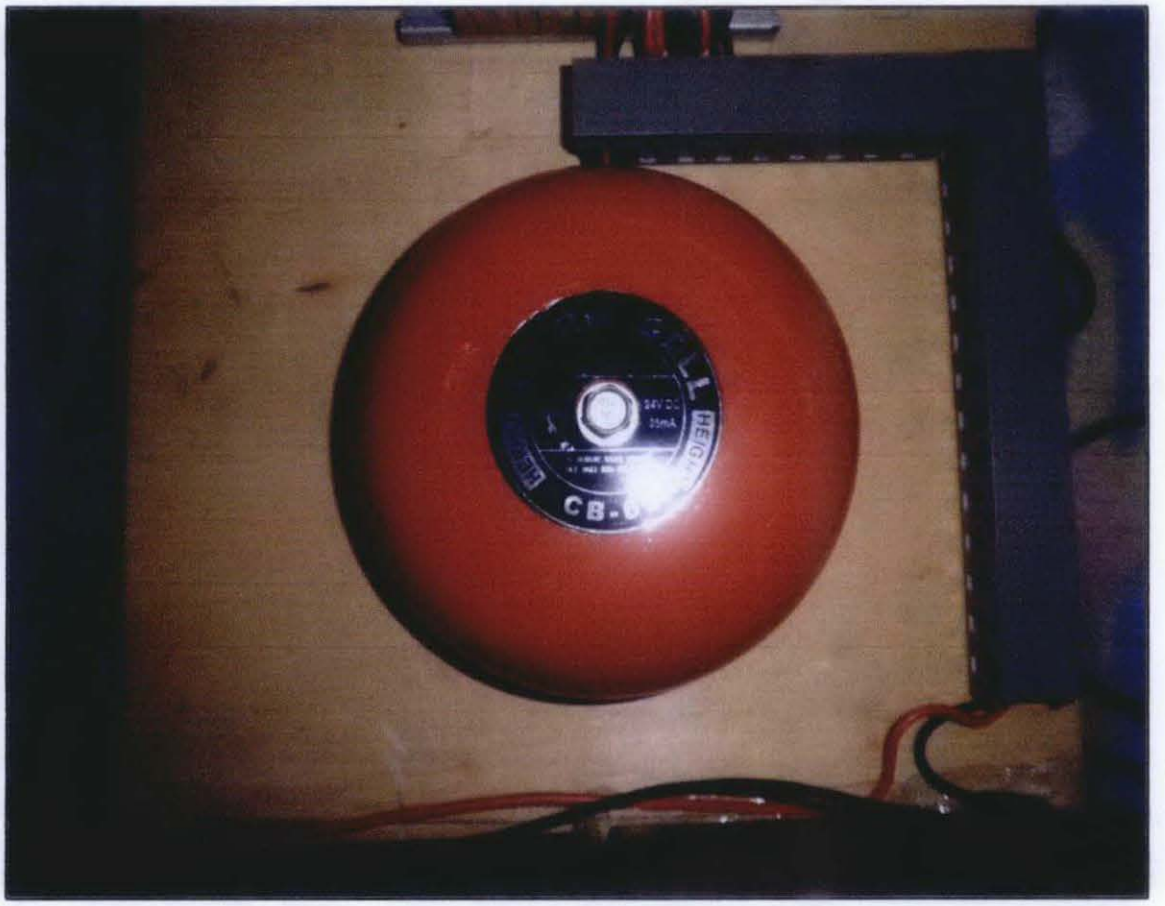

**Figure 12 : Indication Devices 1**

The indication device 1 (bell) is used to tell operator about the low voltage or high voltage battery within the set limit. The alarm bell has voltage rating of 24 V DC with current rating of 0.5m A. This alarm bell will be ringing when the voltage of battery reach 29 V for over voltage and 25 V for under voltage.

*4.1.5 Battery*

Figure 13 shows the batteries of the system.

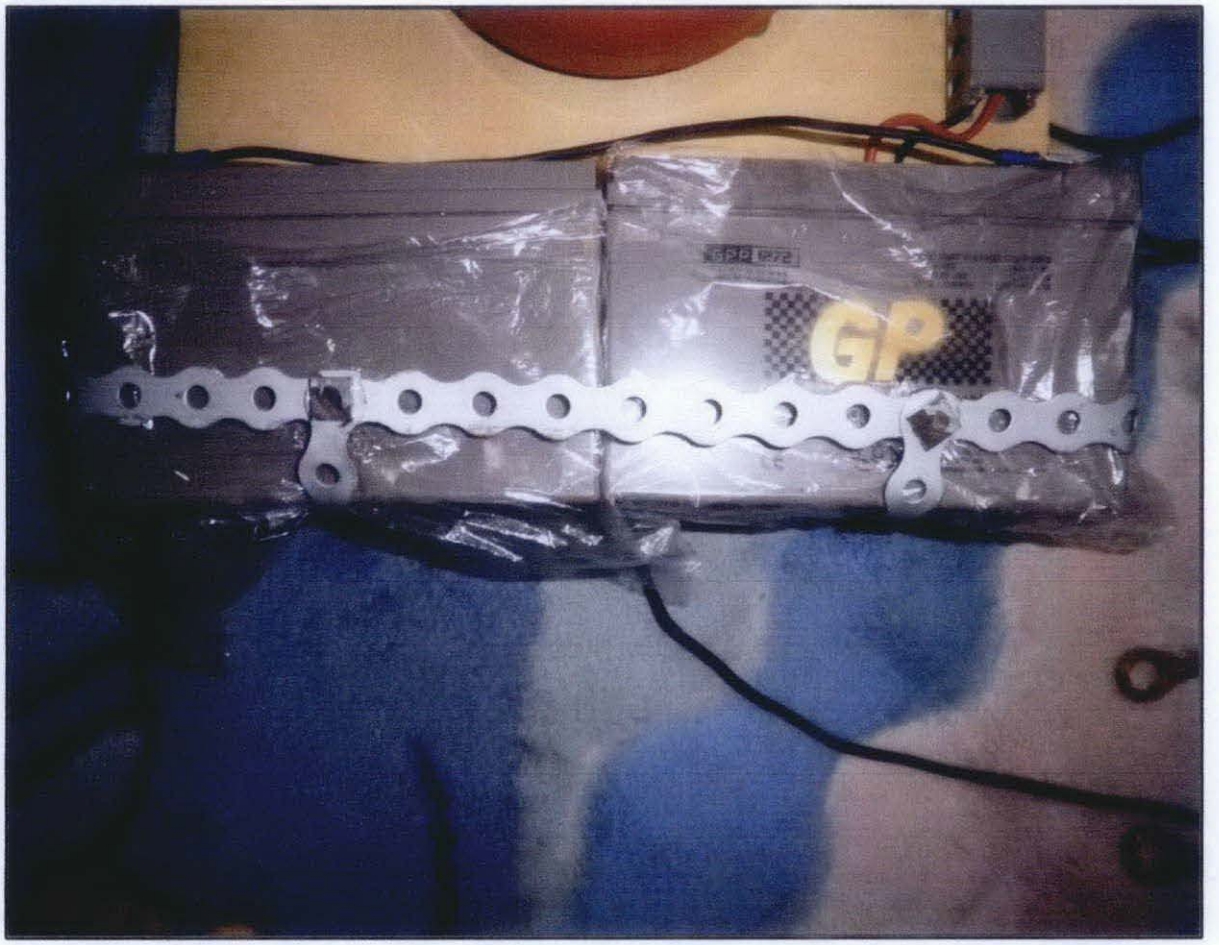


**Figure 13 : A Set of 2 x 12v Battery**

Two dry-cell sealed lead acid 12V batteries are connected in series resulting in 24 V. The batteries are providing power to the bell, lamps and energize the relay when it is triggered. In real life application, batteries will be using to supply voltage to starter motor and spark plugs of the engine. Without batteries, the engine cannot be started.

*4.1.6 Lamp(spotlight)*

Figure 14 shows the spotlight used in experiment.

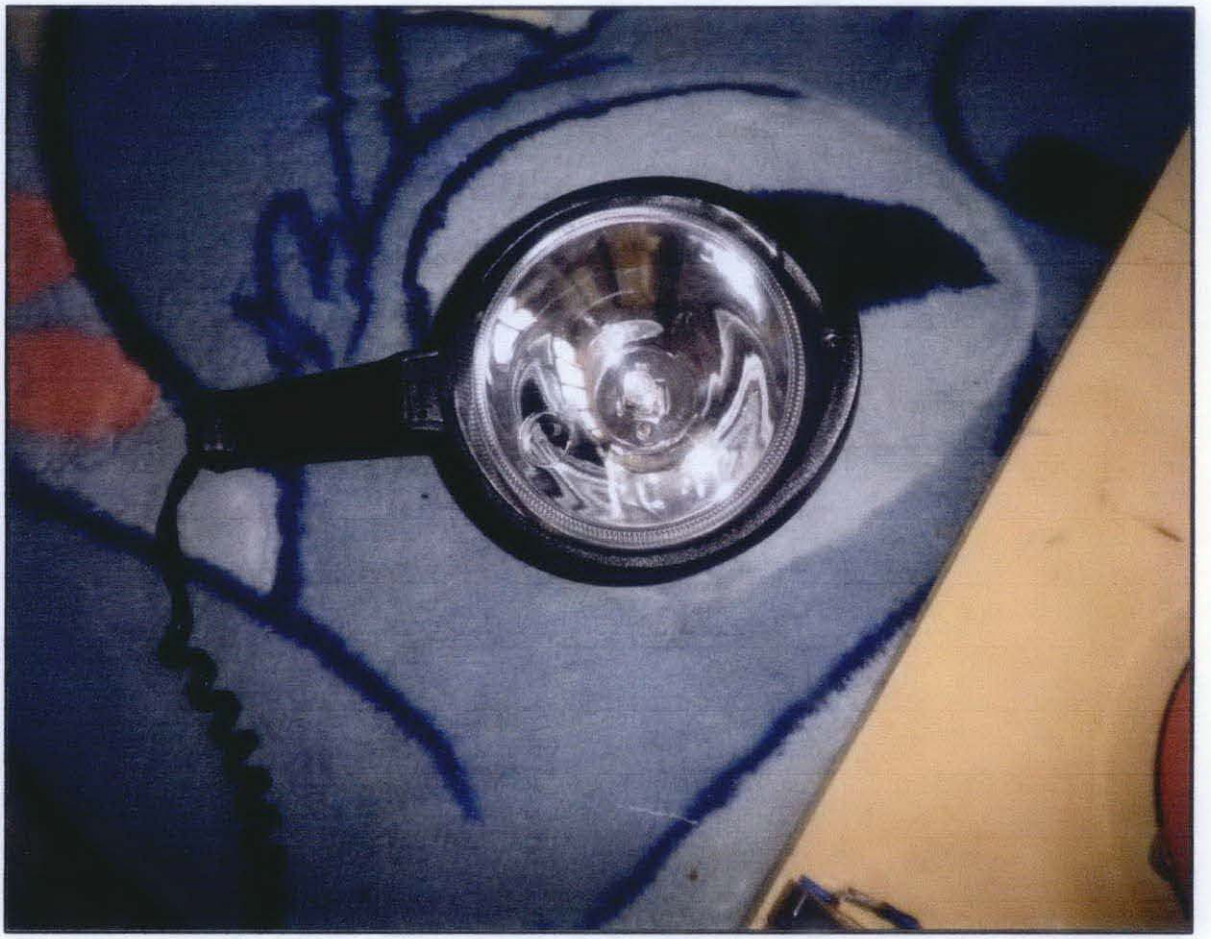

**Figure 14 : Load for the System (Lamp)**

A 12v spotlight is used as load to reduce the battery voltage during experiment. The spotlight is replacing the load from starter motor and plugs of the engine. During cranking, diesel engine will use batteries to power up the starter motor to give initial rotation to the flywheel of the engine, so that the engine can be started. Meanwhile the spark plugs are using the batteries voltage to create ignition in the combustion chamber engine to start up.

### *4.1.7 Battery Charger*

Figure 15 shows the battery charger used in experiment.

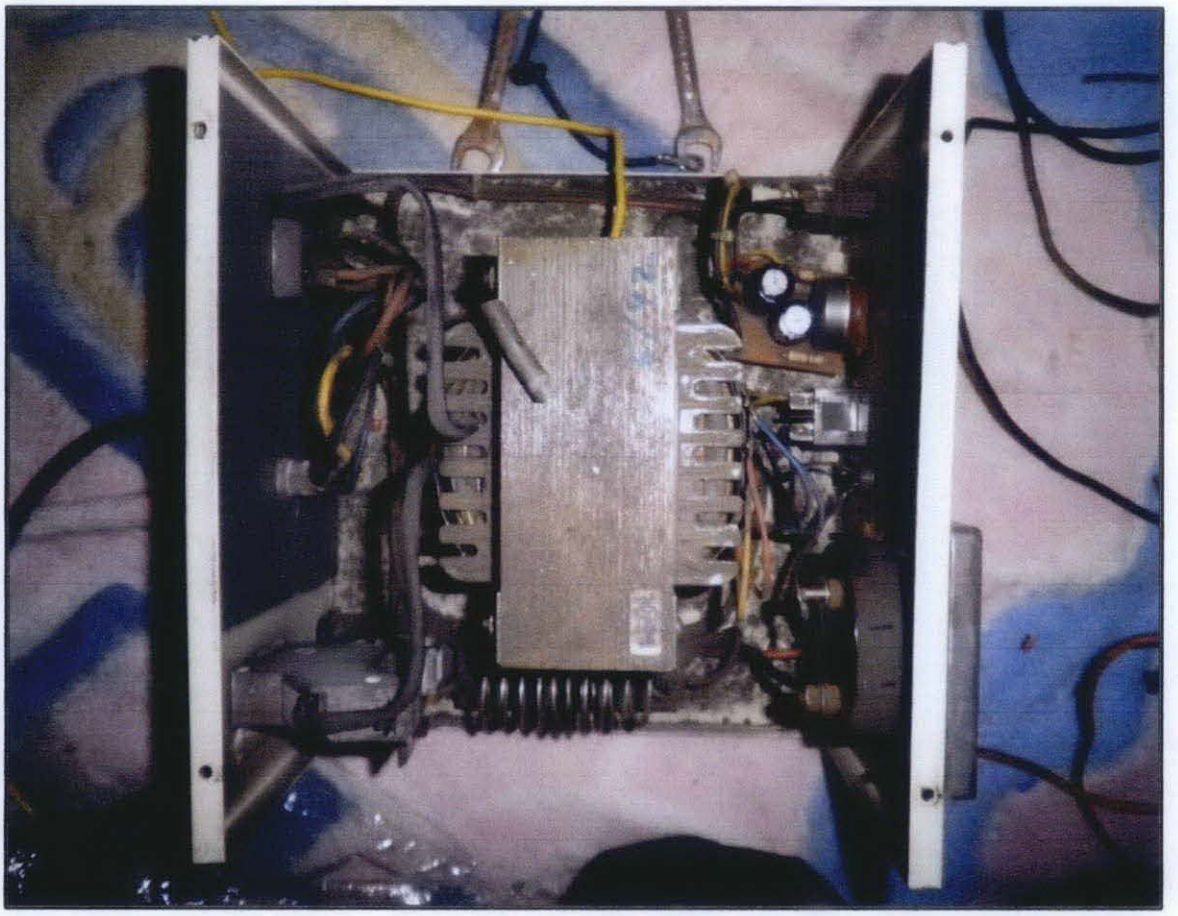

**Figure 15 : Battery Charger**

The 24V-DC battery charger is used to charge the battery to desired voltage. In real life application, battery charger is used during normal operation to charge batteries when generator is off. Battery charger will make overcharging to batteries or not charging the batteries if it is broken. Thus the battery indication system can detect the failure of battery charger to prevent batteries from overcharging which can cause damage to batteries and undervoltage which cause diesel engine fail to start. When generator is working, small alternator will provide voltage to charge batteries. The same concept is applied where we can detect the failure of alternator like the battery charger.

### *4.1.8 GSM Module*

Figure 16 shows the Global System for Mobile (GSM Module) of the system.

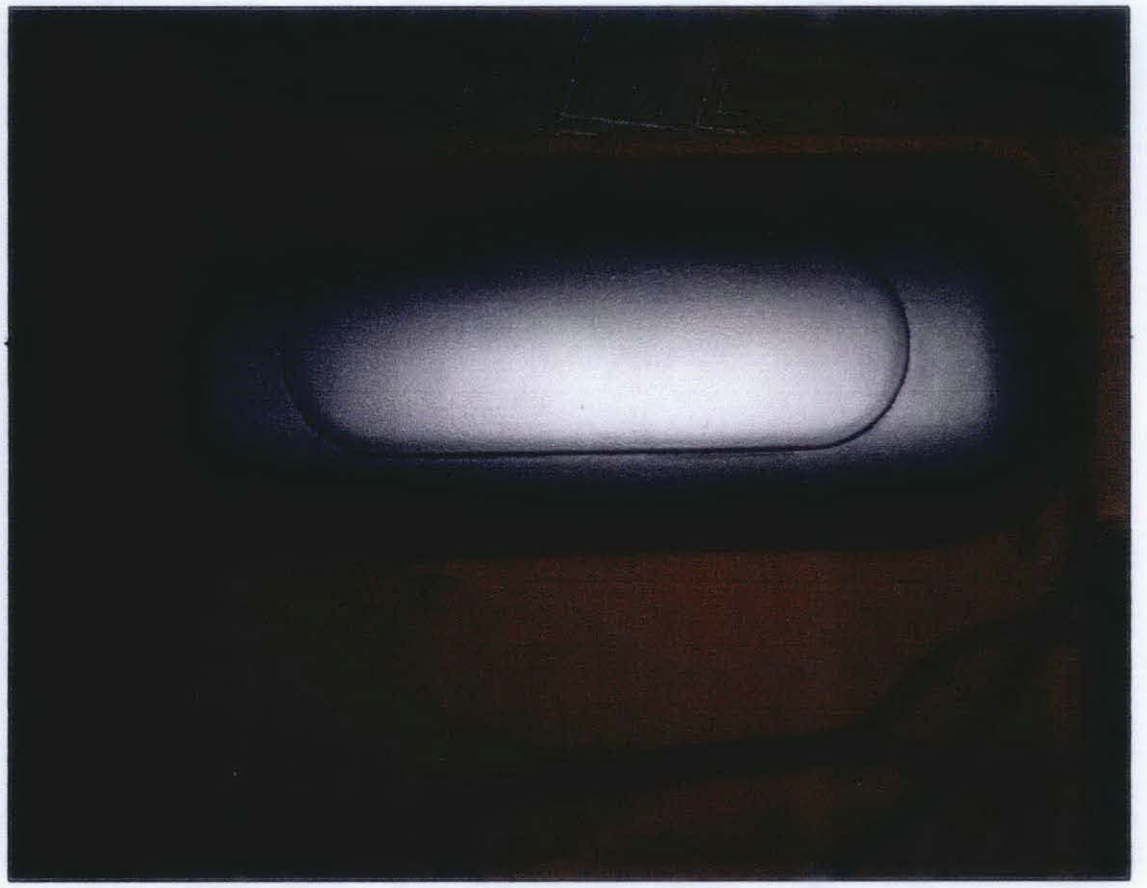

**Figure 16: The GSM Module**

GSM Module is a device used to connect battery indication system to wireless phone line. The GSM module works similar to mobile phone where it needs Subscriber Identity Module (known as SIM Card).When voltage sensor is triggered for overvoltage and undervoltage, GSM module will be triggered to send message / to make a phone call to operator's phone number.

*4.1.9 Switches*

Figure 17 shows the switches box for indication devices.


**Figure 17 : Switches**

Switches above referred to indicator devices where "B" for bell, "L" for lamp and "GSM" for GSM Module. All indicators can be TURN ON or TURN OFF at these switches box.

*4.1.10 Voltmeter*

Figure 18 shows the voltmeter of the system.

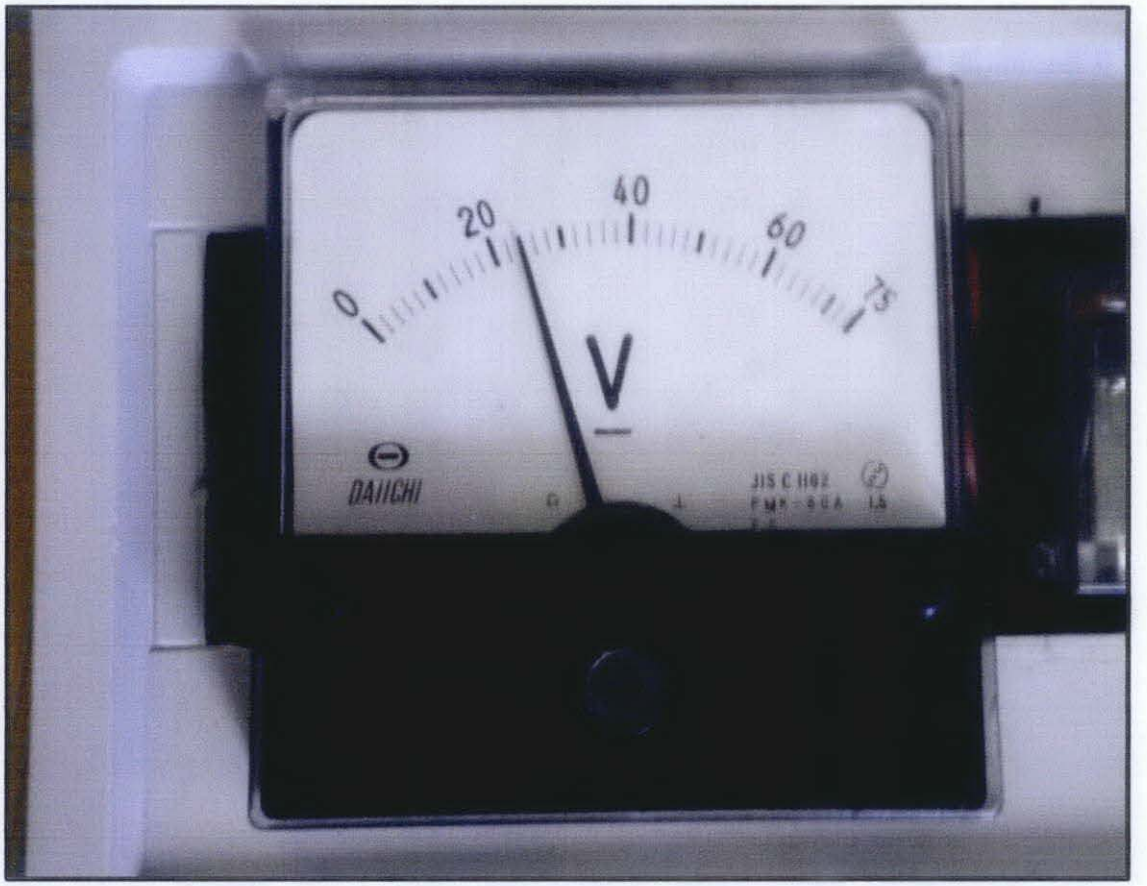


**Figure 18 : Voltmeter**

Voltmeter is a device used to detect the voltage level of batteries. Operator can check the battery voltage level via this voltmeter which located in the control panel box. AS shown in the picture above, the voltage is 24 V which is under the set limit of 25 V, thus the system will trip and all indication devices will TURN ON.

*4.1.11 Voltage Sensor*

Figure 19 shows the voltage sensor of the battery indication system.

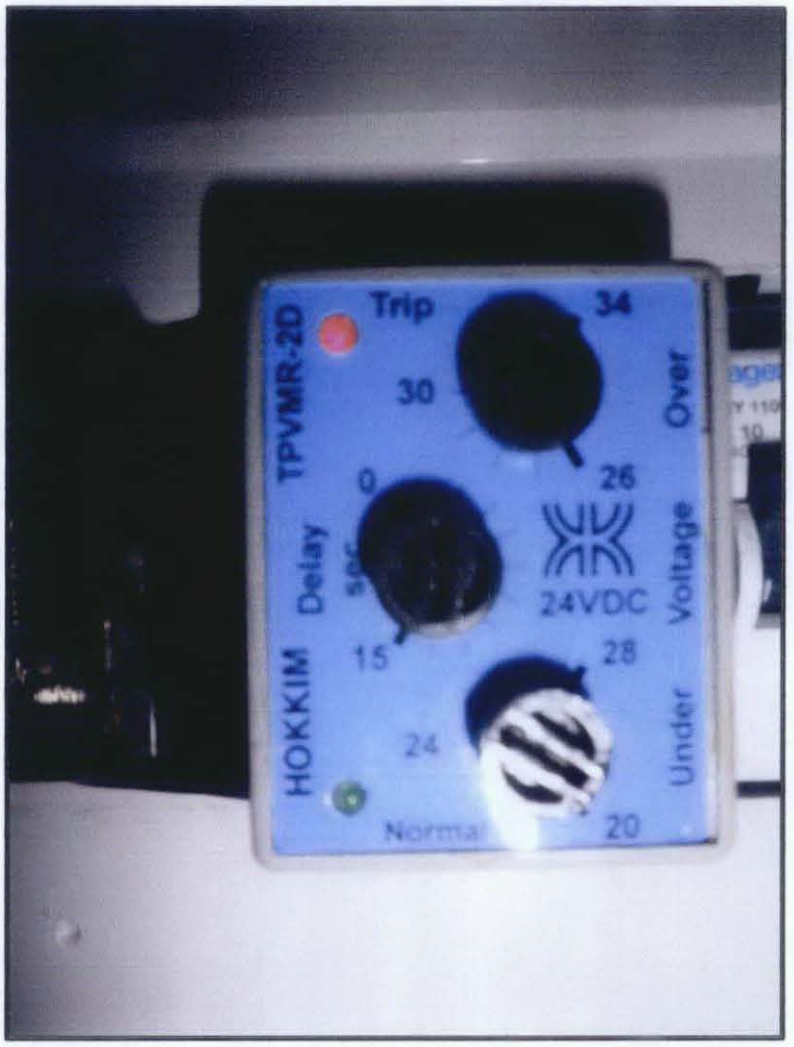


**Figure 19 : Voltage Sensor**

Voltage sensor is a device that can detect the voltage level of the batteries. The device can be set to trip the voltage at the given range. Over voltage range is from 26V – 34V while undervoltage range is from 20V – 28V. We are interested to set the limit for over voltage trip at 29 V while 25 V for under voltage limit.

*4.1.12 Relay*

Figure 20 shows the relay of the battery indication system.

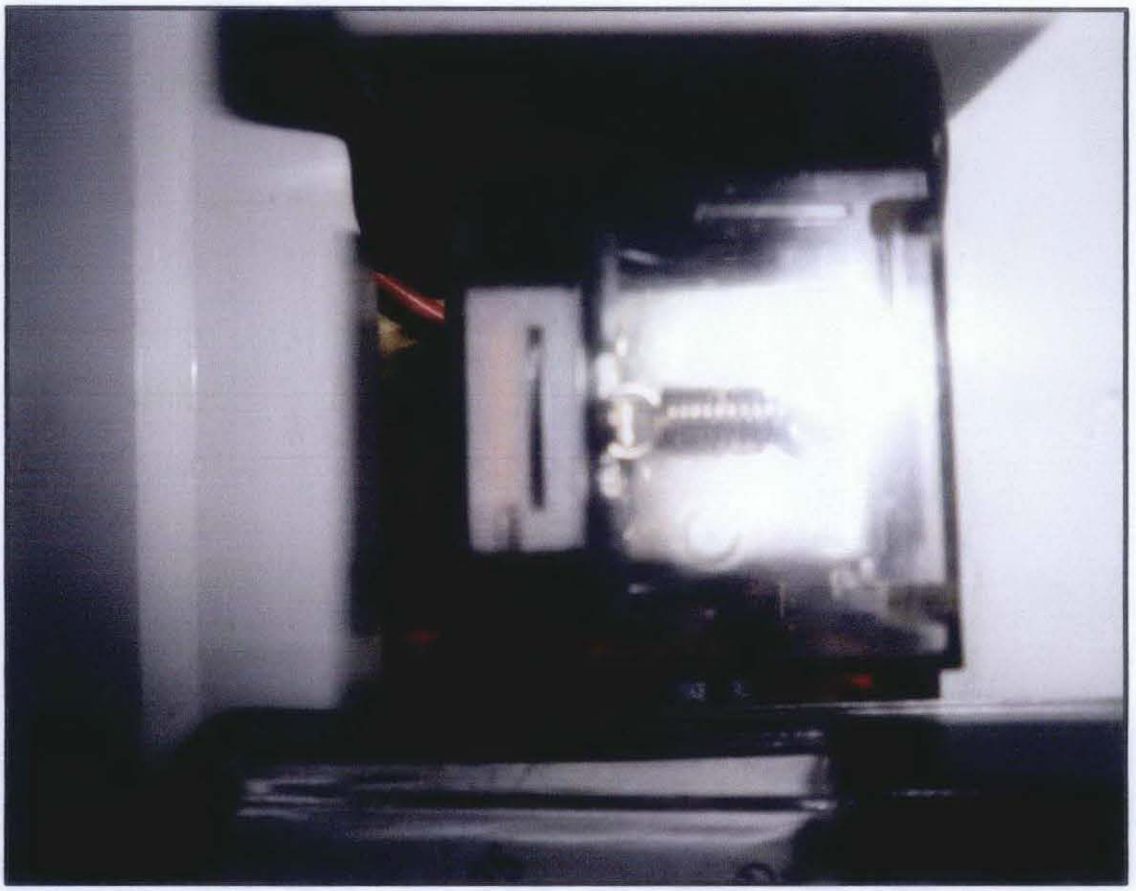

**Figure 20 : Relay**

Relay is a device which will close or open the contact when the coil is energize. Relay is used in this system to make a contact from batteries to the devices which are bell, lamp and GSM module. Coil in the relay will be energized when voltage of batteries reach the limit which are 29 V for over voltage and 25 V for under voltage.

## 4.2 Results of Experiment

**Table 1 : Result of experiment**

| Voltage Condition | Indication Device 1 ( Bell ) | Indication Device 2 ( GSM ) | Indication Device 3 ( Light ) |
|---|---|---|---|
| **Over 29 V** | ON | Dial | ON |
| **Under 25 V** | ON | Dial | ON |
| **26 V – 28 V** | OFF | OFF | OFF |

Based on the experiment, we can conclude that all indication devices will be ON when battery voltage is reaching 29 V and above for over voltage limit, meanwhile for under voltage limit is 25 V and below. The GSM module indicator will make a phone call to operator when voltage limit is triggered. All indication devices will turn off when battery voltage condition is normal between 26 V and 28 V.

# CHAPTER 5

# CONCLUSION & RECOMMENDATIONS

## 5.1 Conclusion

This project had been completed as the indication for generator set battery when the battery is weak or over voltage. The sensor will be set with desired high (28V) and low voltage (24). The alarm will trigger and the short message will be sent to mobile when the voltage of battery is over 28 V and below 24 V. The application of global system for mobile (GSM) will enable the sending of message about the battery condition to mobile phone. This will ensure people in charge can get instant message and information about the battery condition.

## 5.2 Recommendations

The project of battery indication system for generator set had been completed. The prototype is working properly but still has a room to improvise it. In order to improve the project, it is recommended in future that the system is made as water proof so that it will not be vulnerable to water. The advantage of water proof system is, it can be mounted anywhere including outdoor place.

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# APPENDICES

## APPENDIX A

## GANTT CHART FYP 1

| No. | Detail/ Week | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Select topic from list | | | | | | | | | | | | | | | |
| 2 | Confirmation of the topic | | | | | | | | | | | | | | | |
| 3 | Extended proposal preparation | | | | | | | | | | | | | | | |
| 4 | Extended proposal submission | | | | | | | | | | | | | | | |
| 5 | Extended proposal defence | | | | | | | | | | | | | | | |
| 6 | Justifying and purchasing material | | | | | | | | | | | | | | | |
| 7 | Analysis of circuit | | | | | | | | | | | | | | | |
| 8 | Interim report | | | | | | | | | | | | | | | |

# APPENDIX B

## GANTT CHART FYP 2

| No. | Detail/ Week | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Integrate Mobile Phone with GSM | | | | | | | | | | | | | | | |
| 2 | Fabricate the circuit | | | | | | | | | | | | | | | |
| 3 | Test the circuit | | | | | | | | | | | | | | | |
| 4 | Finishing the prototype of battery indication | | | | | | | | | | | | | | | |
| 5 | Test and analysis the final prototype product | | | | | | | | | | | | | | | |
| 6 | Submission progress report | | | | | | | | | | | | | | | |
| 7 | Submission draft report | | | | | | | | | | | | | | | |
| 8 | Submission of Final Report (soft copy) | | | | | | | | | | | | | | | |
| 9 | VIVA | | | | | | | | | | | | | | | |
| 10 | Submission of Final Report (hard copy) | | | | | | | | | | | | | | | |