



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

**DEVELOPMENT OF AUTOMATED RIVER TRASH
MANAGEMENT SYSTEM**

This report submitted in accordance with requirement of the Universiti Teknikal
Malaysia Melaka (UTeM) for the Bachelor Degree In Electrical Engineering
Technology (Industrial Automation And Robotics) (Hons.)

اونيورسيتي تېكنيكل مليسيا ملاك

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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DECLARATION

I hereby, declared this report entitled “Development Of Automated River Trash Management System” is the results of my own research except as cited in references.

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Electrical Engineering Technology (Industrial Automation And Robotics) with Honours. The member of the supervisory is as follow:



ABSTRAK

Berdasarkan pemantauan yang dijalankan oleh Jabatan Alam Sekitar Malaysia (JAS) pada tahun 2013, 341 daripada 473 sungai di Malaysia didapati telah tercemar. Ia menyumbang kepada pelbagai jenis penyakit yang boleh menjejaskan kesihatan manusia serta semua organisma yang hidup. Tambahan pula, ia akan memberi kesan kepada industri pelancongan di negara ini. Untuk menjadikan Malaysia sebuah negara berpendapatan tinggi menjelang tahun 2020, sektor pelancongan merupakan sebahagian daripada Bidang Ekonomi Utama Negara (NKEA) dalam Rancangan Malaysia Ke-10 (2011-2015). Sistem Pengurusan Sisa Sungai Automatik digunakan untuk membersihkan sungai daripada sampah sarap. Sistem ini menggunakan tenaga solar sebagai sumber tenaga. Dengan menggunakan penderia jarak sebagai input dan Arduino Uno R3 sebagai pengawal mikro, sebuah sistem pengumpulan sisa sungai automatik telah dapat dibina. Data yang diperolehi adalah hasil daripada beberapa ujian yang dilakukan di bawah sinaran matahari. Prototaip ini dapat menyumbang idea tentang bagaimana untuk membina suatu sistem yang boleh mengurangkan pencemaran sungai. Secara realitinya, projek ini dapat membersihkan sungai dengan lebih berkesan.

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ABSTRACT

Based on monitoring conducted by Department of Environment Malaysia (DOE) in 2013, 341 out of 473 rivers in Malaysia were found polluted. It contributes many type of disease which affects human being and living organism on Earth. Furthermore, it will affects tourism industry in this country. To transforms Malaysia into a high income nation by 2020, tourism sector is a portion of National Key Economic Areas (NKEA) in 10th Malaysia Plan (2011-2015). The Automated River Trash Management System is used to remove trash and debris floats on the river. This system used solar energy as its power source. By using distance sensor as an input and Arduino Uno R3 as microcontroller, an automated river trash collecting system was developed. The result of data is obtained from real test condition under the sun. This prototype may contributes some idea on how to build a system that will reduces river pollution. In real situation, this project will be able to clean our river more effectively.

DEDICATION

First of all, I would like to express my gratitude to Allah S.W.T for His blessing and guidance. He's the One who fulfill my invocation. Alhamdulillah. And then, I would like to dedicate my thesis to family. Their endless love, encouragement and supplication is the most important things happened in my life. In addition, I would like to dedicate this work to my beloved project supervisor, Ms. Intan Mastura binti Saadon. She had given a lot of guidance, encouragement, assistance and support to me in completing this project. Finally, I would like to dedicate my thesis to all lecturers and friends who gives me support and guidance in any situation.



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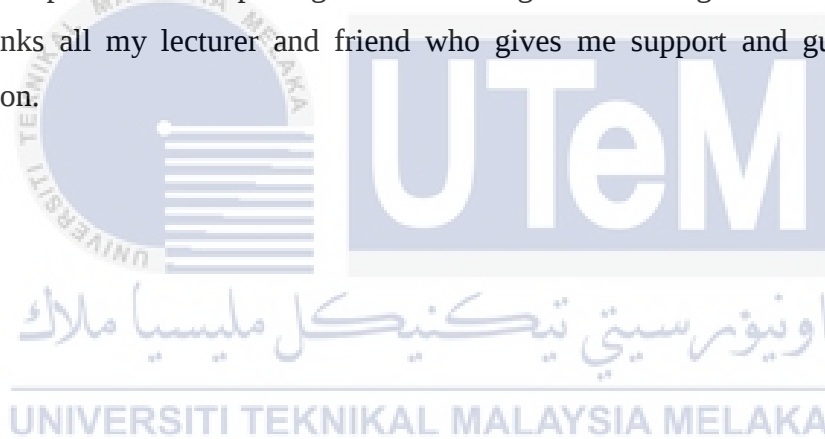


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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

DC	-	Direct Current
AC	-	Alternate Current
PWM	-	Pulse Width Modulation
MPPT	-	Maximum Power Point Tracking
PV	-	Photovoltaic
VMP	-	Maximum Power Voltage
IMP	-	Maximum Power Current
NKEA	-	National Key Economic Areas



CHAPTER 1

INTRODUCTION

1.0 Background Of The Study

Nowadays, most of the river is heavily polluted by trash and non-disposable waste. It contributes many type of disease which affects human being and living organism on Earth. Furthermore, it will affects tourism industry in this country. To transforms Malaysia into a high income nation by 2020, tourism sector is a portion of National Key Economic Areas (NKEA) in 10th Malaysia Plan (2011-2015). Therefore, an Automated River Trash Management System is used to reduce river pollution. In Europe, they have developed this system since a long time ago. However, in Malaysia, it is a new system. Moreover, this prototype may contributes some idea on how to build a system that will reduces river pollution.

Basically, this system is solar powered. Solar energy produced by the sun will be absorbed by module and change into DC output. When the system is ON, the water pump will pumps out water from the river itself with high velocity to rotate the water mill. After that, the water mill will moves the conveyor to pick up trash and rubbish floated on river surface. And then, all trash and rubbish will be stored inside an automated dumpster barge. If distance sensor detects dumpster barge is full, the system will automatically shuts the water pump and stops the conveyor from operate. In real situation, this project will be able to clean the river more effectively.

1.1 Problem Statement

In recent times, there are many people who tends to litter into the river. Based on monitoring conducted by Department of Environment Malaysia (DOE) in 2013, 341 out of 473 rivers were found polluted, although there is a law which protects cleanliness of the river. Furthermore, the trash that floats on a river is difficult to clean by human. Some of them spreads throughout the river. It may affects the ecosystem of nature and living organism in the river. This waste contains various of disease-causing organisms including E-coli which can leads to many health issue ie. diarrhea and abdominal pain. Moreover, it may indicates bad image to tourist from oversea that came to Malaysia.

To prevent this problem, a prototype of Automated River Trash Management System is build. In Europe, this project have been developed. However, the water pump is controlled manually by human. Therefore, a new system which control the water pump automatically is designed. The water pump will stop automatically when the dumpster barge is full. Arduino Uno R3 is used as microcontroller for the system.

1.2 Objective Of The Study

The objective of this project are:

- 1) To design and develop a solar powered water pump system.
- 2) To develop a prototype of river trash collecting system.
- 3) To develop an automated trash collecting system.

1.3 Work Scope Of The Study

This project will be focused on the way to sets maximum height of trash inside the dumpster barge and how the system stops water pump automatically when the dumpster barge is full. Moreover, programming codes for Arduino Uno R3 microcontroller and distance sensor should be considered. However, the cost, mass production and marketing of this project will be not covered in this task.

To design and develop a solar powered water pump system, determine the capacity of battery and module sizing of solar system components. And then, design a prototype of river trash collecting system using SketchUp and development of prototype using water wheel, conveyor belt and dumpster barge. By using distance sensor as an input and Arduino Uno R3 as microcontroller, the automated river trash collecting system can be developed.

1.4 Process Flow of Automated River Trash Management System

Figure 1.1 depicts the process flow of Automated River Trash Management System. At first, battery is fully charged by PWM charger controller, provided by PV array. And then, water pump is activated when ON button is pushed. The water jet produced by water pump will flow through the water wheel, causes it to rotate and runs the conveyor belt. The water current produced by the water wheel rotation attracts the trash to conveyor belt. After that, the conveyor belt will carries the trash and collects it into dumpster barge. When the dumpster barge is fully-loaded, the water will be deactivated automatically. At this condition, the water wheel and conveyor belt will stop from operates.

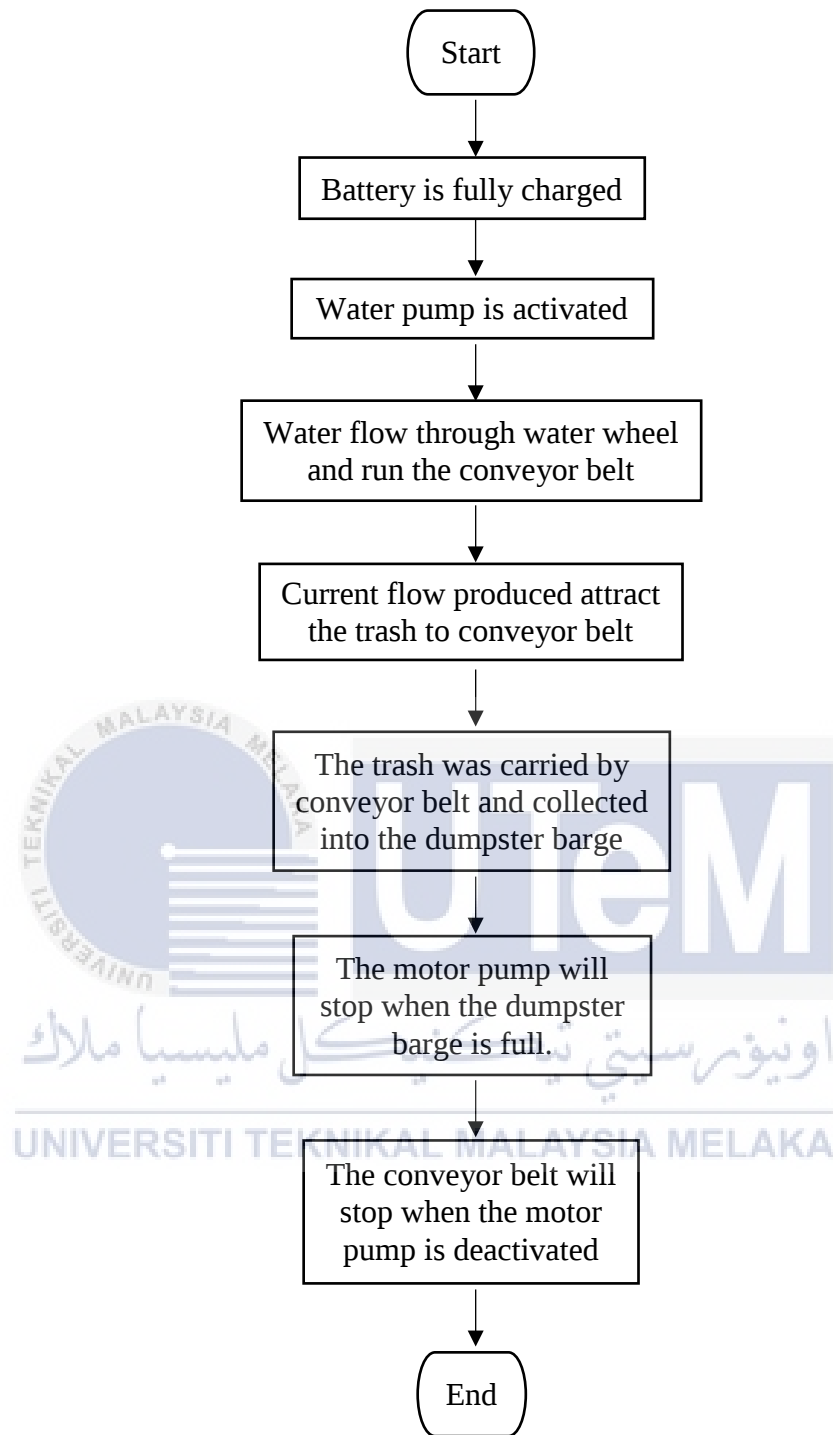
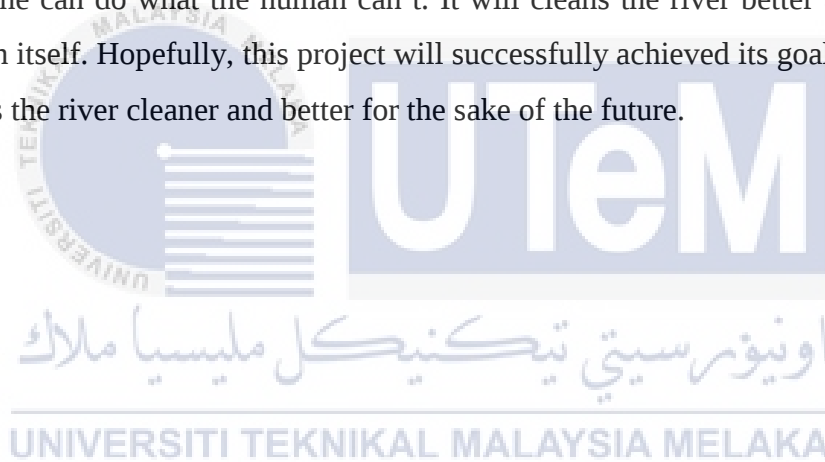


Figure 1.1: Process Flow of Automated River Trash Management System

1.5 Contribution

As a result, a solar-powered water pump was designed and developed. Therefore, human don't have to relies heavily on non- renewable source such as diesel and petrol. The system usage may conserves this energy source for future generation. Moreover, a prototype of river trash collecting system was developed.

This prototype will contributes idea to others in developing green technology product and awareness about the importance of river conservation for our nature. Furthermore, a fully-automated trash collecting system will be created. The prototype applicate modern and advanced technology in its system. In this project, most of theorytical knowledge and engineering technology will be applied. Furthermore, this machine can do what the human can't. It will cleans the river better and faster than human itself. Hopefully, this project will successfully achieved its goals and vision to makes the river cleaner and better for the sake of the future.



1.6 Thesis Organisation

The thesis of this project consist of five chapter,

Chapter 1: Introduction includes background, problem statement, objective, work scope, process flow, contribution and thesis organization of the study.

Chapter 2: Literature review includes water pollution, photovoltaic system (PV) and its operation, type of solar cell, stand-alone photovoltaic system, wiring connection of PV module, principle of battery, charger controller, DC to AC inverter, AC water pump, relay, Arduino Uno R3 microcontroller and distance sensor used in this project.

Chapter 3: Methodology includes flow chart, concept design, photovoltaic solar system flow, block diagram, formula to determination of load, PV module sizing, battery sizing, equipment and material, specification of solar module, solar charger controller, rechargeable sealed lead acid battery, water pump, Arduino Uno, relay and distance sensor, measuring equipment, work implementation and step in making a prototype model.

Chapter 4: Discussion and result of the project.

Chapter 5: Conclusion and recommendation of the project.

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CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

This project is to construct a prototype model of the Automated River Trash Management System which is a floating mobile plant specializing in the clearing and disposal of trash and debris on the surface of inland waterways such as canals and rivers and water catchment areas such as lakes and reservoirs.

This literature review is a combination of information gathered from various sources to form the basis for the development of Automated River Trash Management System. The information is collected from journal, website, book and research article to discuss the theory, basic principle and general character in the development of this project which uses the Photovoltaic system, Arduino Uno R3 Microcontroller, battery, distance sensor, DC relay and DC to AC inverter and AC water pump.

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2.1 Water Pollution

Water is a vital element for the survival of all living organism on Earth. If water cleanliness is not sustained, all living things on Earth particularly human being would be facing a major consumption and health crisis. Today, water pollution is a major issue on all parts of the world particularly the industrialized nation. Water pollution is chiefly cause by waste from agriculture, domestic and industrial activities (Ramandeep Singh Gambhin, *et al*, 2012).

The increase in the manufacturing sector result in the increase of air, land and water pollution which is seriously causing health problem to all living things throughout the world. The increase cases of water pollution chiefly contributed by industrial waste in our water catchment areas which if not removed, would contribute substantially to human sickness and death. This industrial waste include packaging plastic bags and paper material. Wastes polluting our inland waterways include offcut and rotten timber material which if not removed would obstruct the movement of boats and rivercrafts (Alexandra E. V. Evans, *et al*, 2012).

2.1.1 Malacca River Trash Size

A research have been conducted at Malacca River to tabulate the average size of trash that floating on the river as depicted in Figure 2.1. This research was conducted for five days. Table 2.1 depicts the average and biggest size of trash according to their width, in centimeter (cm). Based on this research, the highest average size of trash that floating on the river is 140 cm. Furthermore, the largest trash have been recorded is 145 cm. Meanwhile, the width of conveyor belt for real Automated River Trash Management System is 165 cm, which is larger than any trash that have been found. This research proved that the conveyor belt has sufficient space to pick up and carry the trash from the river.

Table 2.1: The Average And Biggest Size Of Trash Floating On Malacca River

Day	Average Width Of Trash (in cm)	Biggest Trash Width (in cm)
1	100	120
2	60	80
3	120	140
4	80	100
5	140	145



Figure 2.1: Trash Floating On Malacca River

2.2 Photovoltaic System

The Photovoltaic system (PV) converts solar power into electrical energy. Photovoltaic energy is a renewable energy source produced by radiation from the sun and do not involve movable parts to generate this type of power. PV system can be designed to produce from mill watt range to megawatt range. Unlike the use of petrol and gas, the use of the solar energy do not produce pollution. The solar energy is a clean and endless source of power for the PV system to generate current. (Fatimah Zohra Zerhouni, *et al*, 2010).

2.2.1 Operation

To convert light energy into electrical energy, solar cell is used in the Photovoltaic process. Photovoltaic effect will be produced when sunlight falls on a two-layer semiconductor resulting in some amount of voltage being generated between the two layers. The output current produced can be used through external electrical circuit.

[<http://micro.magnet.fsu.edu/primer/java/solarcell/>](http://micro.magnet.fsu.edu/primer/java/solarcell/)

Figure 2.2 denotes the electron, current flow and operation of solar cell. A simple three layer solar cell is assembled to comprise of a top junction layer made of N-type semiconductor, an absorber layer P-N junction and a back junction layer made of P-type semiconductor.

The P-N junction cell has its own built-in electric field to provide voltage to force electrons through a hole freed by light absorption allowing it to flow in their own directions. The electron will flow to the N-type side, and through the hole to the P-type side. The electron flow produces current whilst the cell's electric field produces voltage. Electric power is produced through the combination of the current and voltage.

http://www.solarbotics.net/starting/200202_solar_cells/200202_solar_cell_physics.html

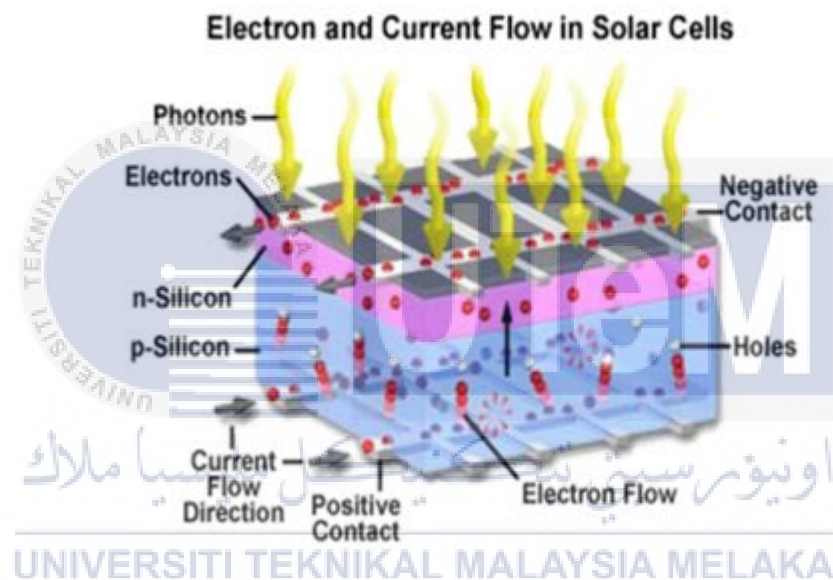


Figure 2.2: Electron And Current Flow In Solar Cell

Solar energy is converted into direct current (DC) by the solar cell semiconductor in the solar module by absorbing sunlight through the photovoltaic process. As shown in Figure 2.3, the solar cells are combined and sealed to increase its efficiency. The combined and sealed cell are known as module. Several module are assembled in series or parallel arrangements to achieve the desire output. The assembled module are known as array.

<http://www.samlexsolar.com/learning-center/solar-cell-module-array.aspx>

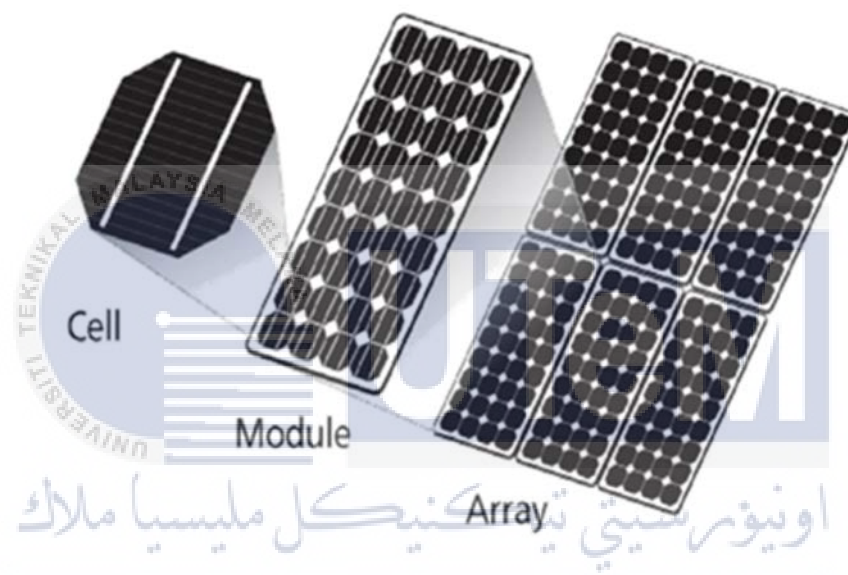


Figure 2.3: Cell, Module And Array

To obtain maximum efficiency output, the PV module surface is installed at a suitable angle perpendicular facing the sun path as depicted in Figure 2.4. To capture maximum sunlight, the PV module should be tilted 34 degree from the ground to face the sun. The green area in Figure 2.3 shows the path of sun. The tilted angle also allow water to be drain off. Accumulation of water can cause damage to the module.

<http://www.greenergystar.com/shop/content/14-optimizing-pv-array>

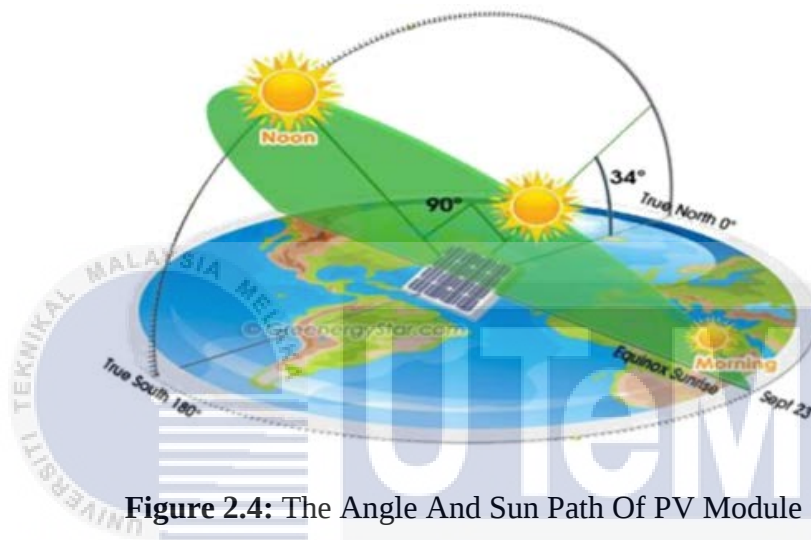


Figure 2.4: The Angle And Sun Path Of PV Module

The sun radiation in Malaysia from January to December is denoted in the graph of Figure 2.5. The average radiation per day is 4kWh and this information is used to calculate the required quantity of the solar module.

<http://www.pveducation.org/pvcdrom/properties-of-sunlight/average-solar-radiation#>



Figure 2.5: The Graph of Average Radiation In Malaysia

2.2.2 Type of Solar Cell

Solar cell made from silicon comprised of three main types ie. mono-crystalline silicon, thin-film silicon and polycrystalline silicon. The three types differ by their atomic structure and performance (John Balfour, *et al*, 2013). Mono-crystalline and polycrystalline play important role in photovoltaic system. Other cells such as amorphous which are cheaper are less efficient. (L.A. Dobrzanski, *et al*, 2012). As seen in the Table 2.1, the mono-crystalline silicon have the highest efficiency compare to others (L.A. Dobrzanski, *et al*, 2012).

Table 2.2 shows the efficiency and types of module that absorbs sun ray. Mono-crystalline efficiency is 25%, polycrystalline is 20.4%, nano-crystalline is 10.1% and amorphous is 10.1%. By this the mono-crystalline has the highest efficiency and it will be used in the project (L.A. Dobrzanski, *et al*, 2012).

NO	Classification	Efficiency
1	Mono-crystalline	25.0±0.5
2	Polycrystalline	20.4±0.5
3	Nano-crystalline	10.1±0.2
4	Amorphous	10.1±0.3

Table 2.2: The Efficiency Of The Module

2.2.3 Stand-Alone Photovoltaic System

There are two types of Photovoltaic system ie. on-grid PV system and off-grid PV system. On-grid system is connected to a grid where the solar power can be sold to a utility company. Off-grid system is connected to a grid allowing the power to be used for own system only which is known as stand-alone system (John Balfour, *et al*, 2013).

This project is using the stand-alone PV system. There is two types of stand-alone PV system ie. direct coupled system and small stand-alone system. Direct coupled system PV module is directly connected to the load whereas small stand-alone system module output will store power in the battery first before usage as depicted in Figure 2.6.

http://www.eai.in/ref/ae/sol/cs/tech/saps/stand_alone_solar_pv_systems.html

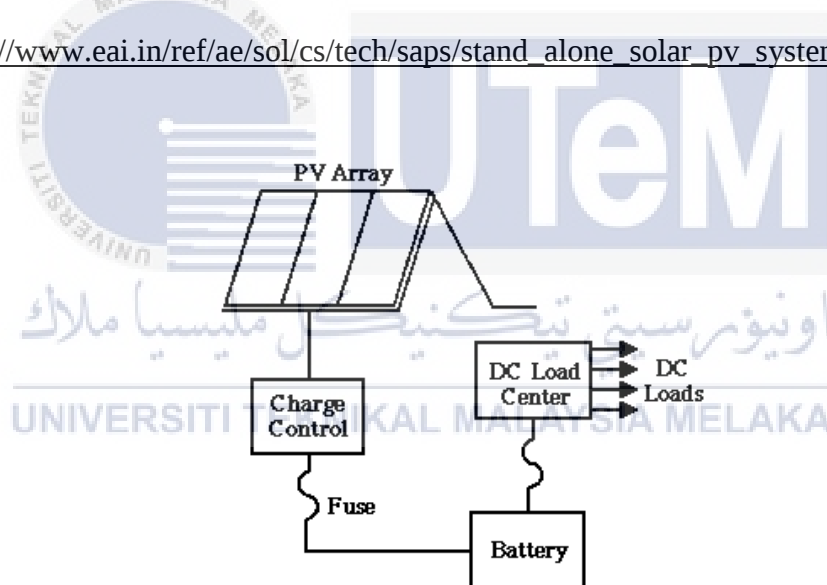


Figure 2.6: Stand-Alone Photovoltaic System

2.2.4 Wiring Connection Of PV Module

There are 2 types of wiring connection for PV module, ie. parallel connection and series connection. This project uses the parallel connection.

In series connection, wiring from battery is not connected via one common life wiring. Instead, wiring from battery is directly link to the first module, followed by a second wiring from the first module to the second module and a third wiring from the second module to the third module. Disadvantages of series connection is the current is low, voltage of module varies ie. not stable and should the first module be damaged all three module cannot function.

[<http://solarpanelsvenue.com/mixing-solar-panels/>](http://solarpanelsvenue.com/mixing-solar-panels/)

In parallel connection, wiring from battery is connected to all three PV module via one common life wiring as depicted in Figure 2.7. The advantage is, this connection can obtain a higher output current, a more stable voltage and if one module is damaged, the other two modules can still produce the output current.

[<http://solarpanelsvenue.com/mixing-solar-panels/>](http://solarpanelsvenue.com/mixing-solar-panels/)

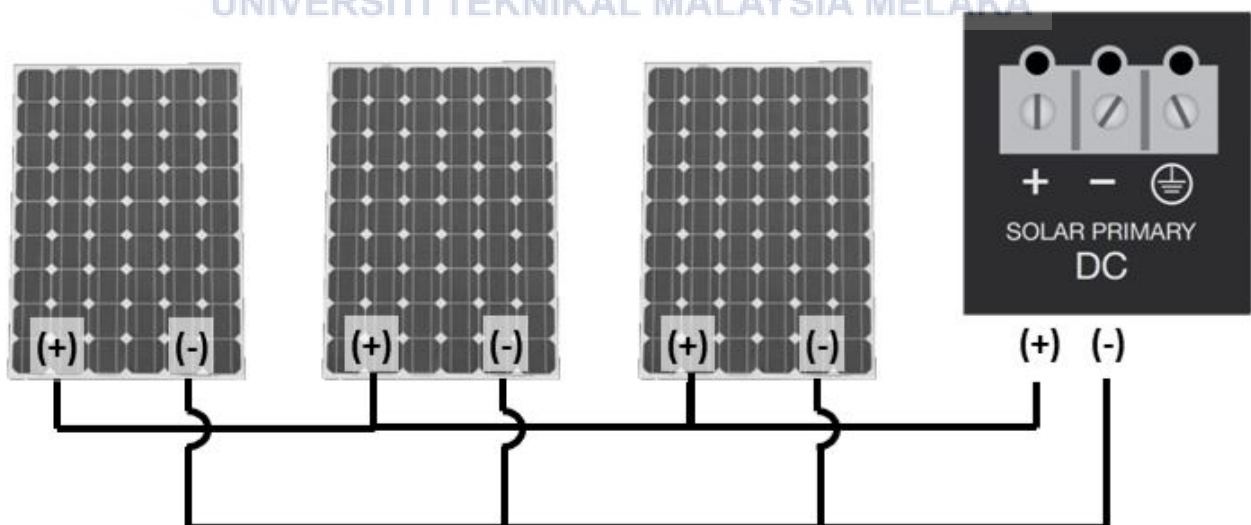


Figure 2.7: Parallel Connection Of Solar Module

2.3 Battery

Storage of power in battery banks is vital in the stand alone system as it supplies higher current when starting the motor if compared to the PV direct coupled system. The voltage can also be controlled to avoid damage to the load. To achieve maximum efficiency, the battery bank should be of high quality (Arjyadhara Pradhan, *et al*, 2012).

A rechargeable sealed lead acid battery depicted in Figure 2.8 is most suitable for the PV system. It is designed to produce lower current to prevent it from damage. This battery can store and charge according to its capacity known as amp hour (Ah). The rechargeable sealed lead acid battery is cheap, maintenance free, and have longer life span (Arjyadhara Pradhan, *et al*, 2012).



Figure 2.8: Rechargeable Sealed Lead Acid Battery

2.4 Charger Controller

A charger controller is a device that controls the amount of incoming and outgoing of current to and from the battery. The charger controller is connected between the battery and the PV array. It regulates the voltage between the battery and the PV array and control the battery from over-discharging that could reduce the battery life span (Shrish Sinha, *et al*, 2013).

Over-discharging would cause a chemical reaction in the battery which would not allow the battery to be recharged. Charger controller also prevent the battery from over charging and weakening the bond of electrolyte. Two main types of charger controller used in solar system is the pulse width modulation (PWM) controller and the Maximum Power Point Tracking (MPPT) controller (John Balfour, *et al*, 2013). PWM charger controller is used in this project. Figure 2.9 depicts the sample of PWM charger controller used in PV system.

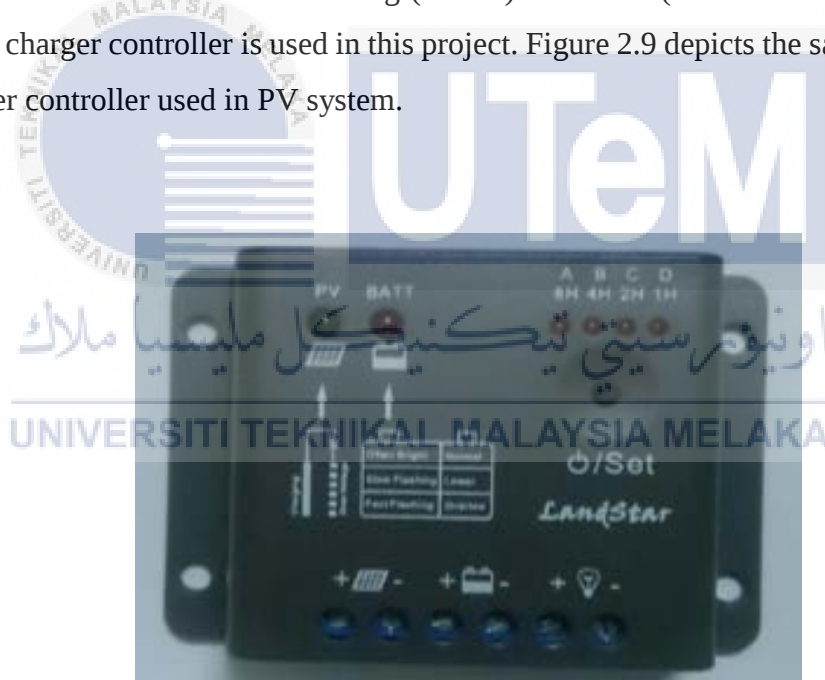


Figure 2.9: Solar Charger Controller

The charging efficiency of the pulse-width modulation (PWM) is at the range of 60% to 70% and 75% to 85%. The charging efficiency of the maximum power point tracking (MPPT) is from 90% to 93% (Geeta Laxmanrao Kale, *et al*, 2011).

Although the maximum power point tracking (MPPT) have higher efficiency in charging, it is expensive and is not cost effective (Geeta Laxmanrao Kale, *et al*, 2011). Other comparison between PWM and MPPT is denoted in Table 2.3.

	PWM Charge Controller	MPPT Charge Controller
Module voltage	PV module voltage is equal to battery voltage.	PV module voltage is higher than battery voltage.
Battery voltage	Perform well in warm temperature when battery is almost full because it operates at battery voltage.	Provide “boost” in cold temperature and when battery is low because it operates above the battery voltage.

Table 2.3: Comparison Between PWM And MPPT

<http://solarcraft.net/articles/comparing-pwm-and-mppt-charge-controllers/>

2.5 Water Pump

A water pump is an appliance for moving fluid through mechanical pressure. It varies in size and purpose and is used widely in building, aquarium, pond and industrial application. Pump can be immerse in or above water level. Types of pump also varies from electrical pump, diesel pump, steam pump, valve less pump, impulse pump and flexible pump. An efficient pump should have a high flow rate and selection should be based on its purpose (Ahmed Mohamedi, *et al*, 2013).

Figure 2.10 depicts an electrical multifunctional AC water pump that will be used in this project. The rated voltage is 12V. The input power is 100 Watt with frequency of 50Hz. The flow rate is 277.78 ml/sec. The pump incorporate an internal blower and piping covered by an outer plastic casing. The function of the water pump is to suck in and eject water at the water wheel to allow it to rotate.



Figure 2.10: 12V Multifunctional AC Water Pump

2.6 Inverter

Inverters are electronic devices which convert solar array generated direct current (DC) power to alternative current (AC) power. Direct current flows from one direction only but alternative current can flow from different directions. Photovoltaic system inverter is installed between batteries and load (Shrish Sinha, *et al*, 2013) and converts DC power from batteries or solar array into 50Hz AC power.

Inverter can be a stand-alone unit or be connected to a utility such as socket outlet or it can also be a combination of both. The inverter output from DC is a pure AC sine wave. Inverters can also be tied to electric grids (Shrish Sinha, *et al*, 2013). Figure 2.11 shows the conversion of DC input to AC output.

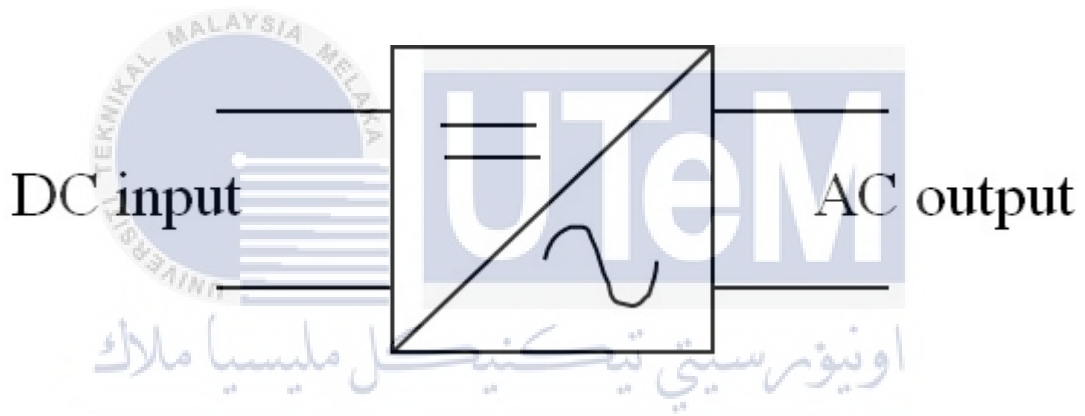


Figure 2.11: DC Input to AC Output Conversion

2.7 DC Relay

Relay is used to switch ON and switch OFF the water pump. If the water pump is connected directly to the battery, it may damage the water pump. In choosing suitable relay for the project, the operating voltage must be same with the voltage of battery. If not, the relay may be damaged internally or failed to function.

Figure 2.12 depicts the type of relay used in this project. DC relay is used in this project because it generates current by DC supply from the battery. The relay also incorporate two gates, one is opened and another one is closed. The opened gate will not supply current until the coil is energized. The closed gate will not supply current when the coil is energized.

<http://www.circuitstoday.com/working-of-relays>



Figure 2.12: 12V DC Relay

2.8 Distance Sensor

Distance sensor is used in this project to detect height of collected trash inside dumpster barge. The Sharp distance sensors is a good choice for this project because it gives accurate height measurement. The detection range of this version is approximately 10 cm to 80 cm (4" to 32"). The range of the distance sensor installed in the dumpster barge is approximately 8 cm from the maximum height of the accumulated waste.

Figure 2.13 show the sensor used for this project. The GP2Y0A21 uses a 3-pin JST PH connector that works with a 3-pin JST PH cables for Sharp distance sensors. These cables have 3-pin JST connectors on one end and are available with pre-crimped male pins, pre-crimped female pins, and with unterminated wires on the other end. It is also possible to solder three wires to the sensor where the connector pins are mounted. When looking at the front, the three connections from left to right are output, ground, and the power signal as depicted in Figure 2.14.

www.sharp-world.com/products/.../datasheet/gp2y0a41sk_e.pdf



Figure 2.13: Infrared Distance Sensor

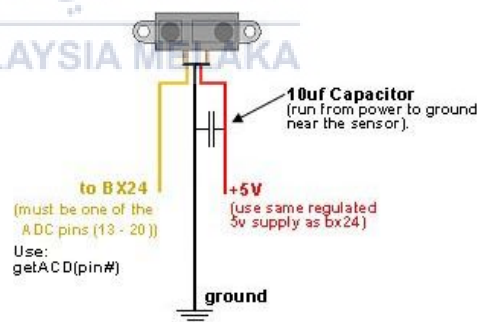


Figure 2.14: Three Connection Pin

2.8.1 Trash Detection Using Distance Sensor

This project uses Infrared (IR) distance sensor for trash detection. IR sensor radiates invisible light, but it can be detected by electronic devices. IR sensor section consists of the IR transmitter and IR receiver. IR transmitter consists of LED which transmit the IR beam (Vikrant Bhor, *et al*, 2015).

IR (infrared) object detection is to transmit the IR signal (radiation) in the direction of the object. The signal is received by the IR receiver when the IR radiation bounces back from a surface of the object. In Figure 2.15, the IR LED transmits the IR signal on to the object and the signal is reflected back from the surface of the object. The reflected signals is received by an IR receiver. The IR receiver can be a photodiode phototransistor or a ready-made module which decodes the signal.

http://www.coregravity.com/html/detecting_obstacle_with_ir_in.html

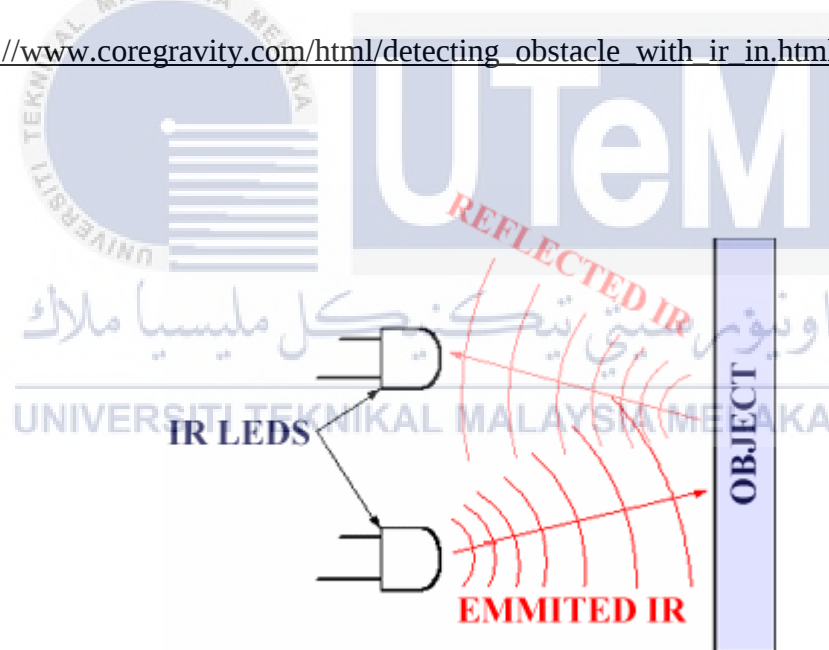


Figure 2.15: Emmited And Reflected Signal

2.9 Arduino Microcontroller

Arduino is a software company, project, and user community that designs and manufactures computer open-source hardware, open-source software, and microcontroller-based kits for building digital devices and interactive objects that can sense and control physical devices. . These systems provide sets of digital and analog I/O pins that can interface to various expansion boards and other circuits. The boards feature serial communication interfaces, including Universal Serial Bus (USB) on some models, for loading programs from personal computers.

Figure 2.16 depicts the microcontroller used for this project. Arduino Uno R3 is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins, 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller by simply connect it to a computer with a USB cable or power it with the AC-to-DC adapter or battery to get started.

<https://www.arduino.cc/en/main/arduinoBoardUno>



Figure 2.16: Arduino Uno R3 Microcontroller

2.10 Conclusion

This literature review contains article, figure and tables related to the project which is useful in choosing of the right material. Data and information gathered from the research is used to identify the method in completing the project and to proceed with the methodology. The decision to choose the appropriate materials ie. mono-crystalline solar module, sealed lead acid battery, (PWM) charger controller, AC multifunctional water pump, DC-AC inverter, Arduino Uno R3 microcontroller, distance sensor and the stand alone photovoltaic system would contribute to the excellent development and performance of the project's Automated River Trash Management System prototype model.



CHAPTER 3

METHODOLOGY

3.0 Introduction

The method used in conducting research and assembling process for this project is described in this chapter. The project is designed from data, formula and information collected from journals, website, books and research article. All data collected is utilized to choose the appropriate material used for the assembling process. Dimension and function of each material is fully understood so as to achieve the objective of this project. This include data for designing and using the appropriate material to develop a pollution free and renewable source of electrical energy for the project's Automated River Trash Management System prototype model. This efficient system is known as Photovoltaic solar system and involve used of solar module and sealed lead acid battery to power the plant.

3.1 Flow Chart

Figure 3.1 denotes the flow chart of methodology for this project. At first, the literature review need to be prepared in advance. And then, the suitable material used for the project should be searched. After that, compute the sizing for solar module and battery by using related formula. Furthermore, some simulations will be made by using PVGIS application. If the simulation failed, the recalculation of sizing should be made. However, if the simulation is successful, the system of the project can be designed by using SketchUp software and then the hardware assemble in line with the sketch. When the hardware is assembled, testing of the hardware is conducted to ensure that the hardware operates at its optimum level. If there is any fault, identify the area of weakness and rectify the same. Finally, when the hardware is operating satisfactorily, the project is considered complete.

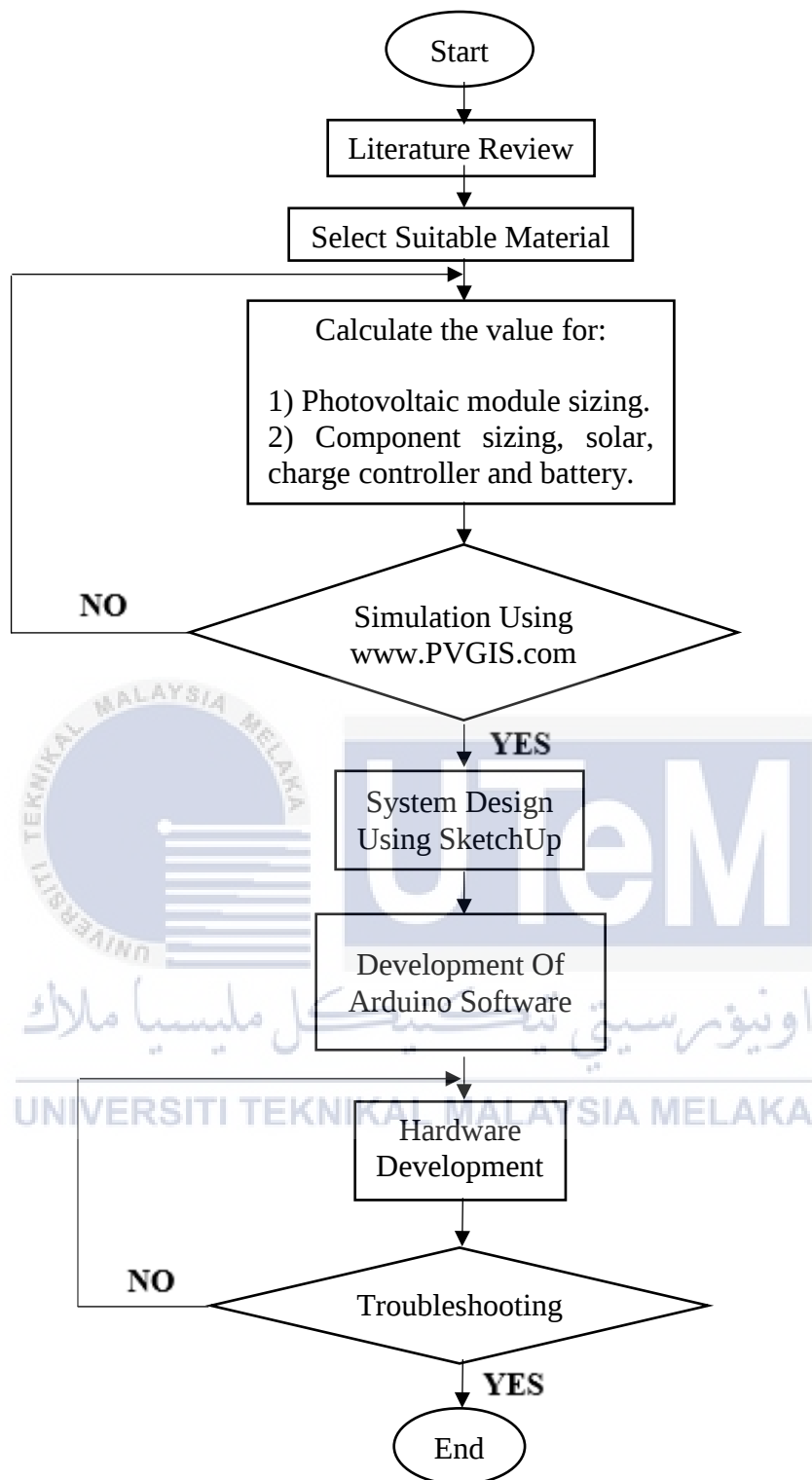


Figure 3.1: Flow Chart

3.2 Concept Design of The Project

Figure 3.2 denote the concept design of an automated river trash management system. Number 1 denotes the solar module area which is installed on the roof top. Number 2 denotes the roof. Number 3 denotes the debris racking which retain the trash. Number 4 denotes the hull of the management system which allows the plant to float. Number 5 denotes the water wheel which moves the conveyor belt. Number 6 denotes the conveyor belt which collects the trash. Number 7 denotes the dumpster barge which hold the trash. Number 8 denotes the water pump which ejects water jet to run the water wheel.

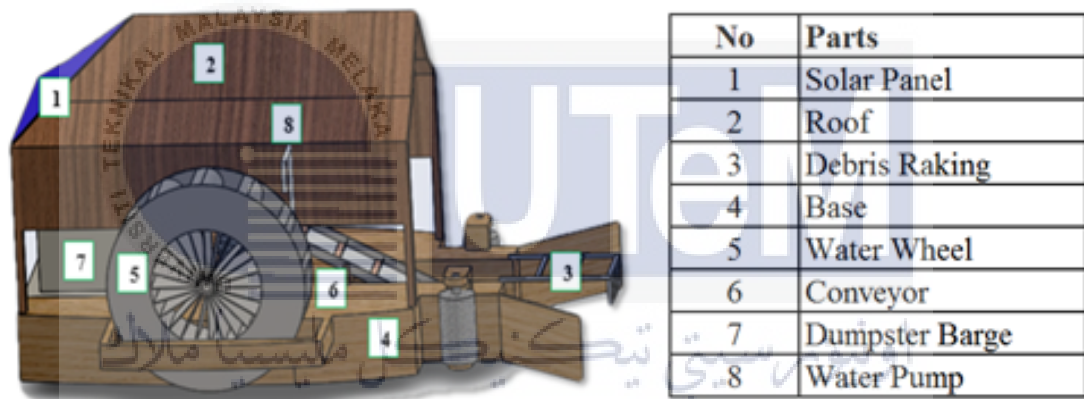


Figure 3.2: Side View Of The Concept Design

3.2.1 Dimension of Automated River Trash Management System In Real Model

Figure 3.3 depicts the dimension of Automated River Trash Management System in real model. Based on this figure, the total area of the base is (600 x 450) cm². The area of conveyor belt at front part is (150 x 165) cm². And then, the area of water wheel on left hand side is (340 x 130) cm². Furthermore, the area of dumpster barge is (150 x 200) cm².

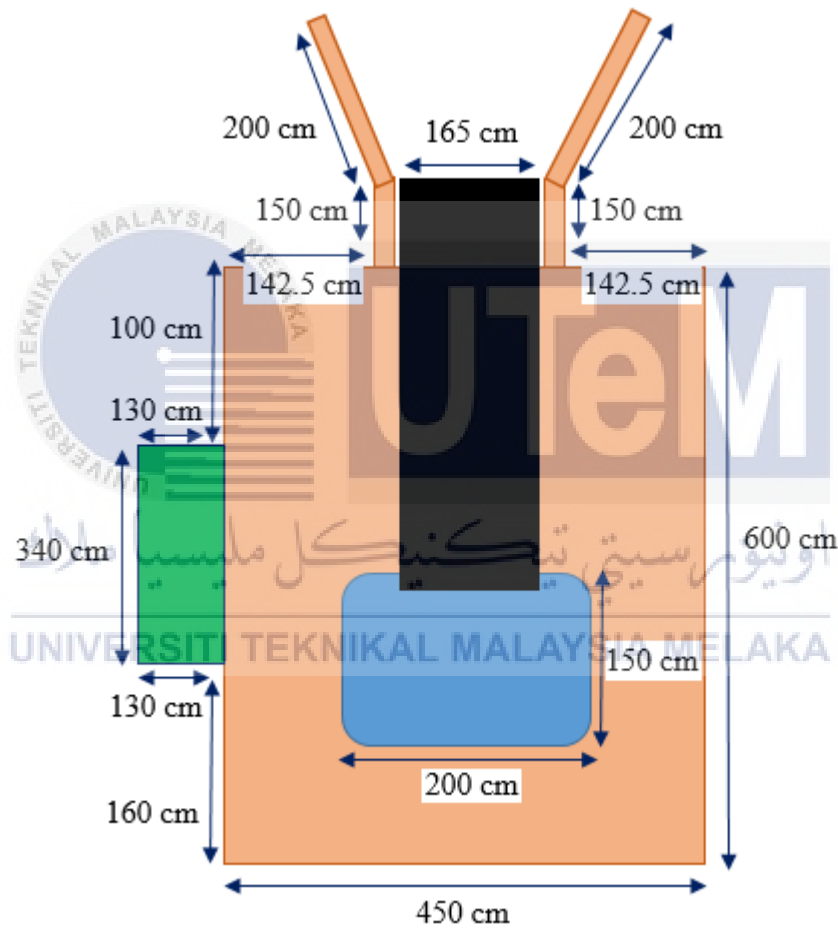


Figure 3.3: The Dimension of Automated River Trash Management System From Top View.

3.2.2 Dimension Of Prototype

Figure 3.4 depicts the dimension of Automated River Trash Management System prototype model. The size ratio of real model and model prototype for this project is 10:1. Based on this figure, the total area of the base is $(60 \times 45) \text{ cm}^2$. The area of conveyor belt at front part is $(15 \times 16.5) \text{ cm}^2$. Furthermore, the area of dumpster barge is $(15 \times 20) \text{ cm}^2$ as depicted in Figure 3.5. And then, the area of water wheel at the left hand side is $(34 \times 13) \text{ cm}^2$ as depicted in Figure 3.6.

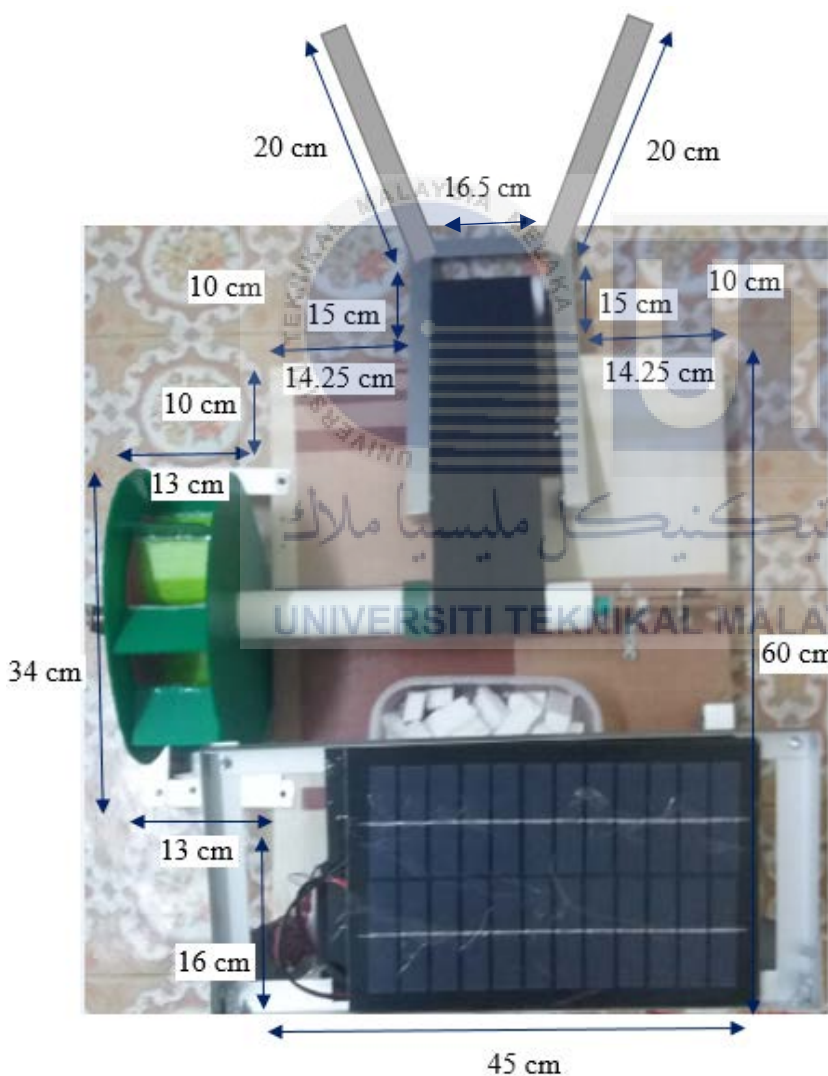


Figure 3.4: Dimension of Prototype

From Top View

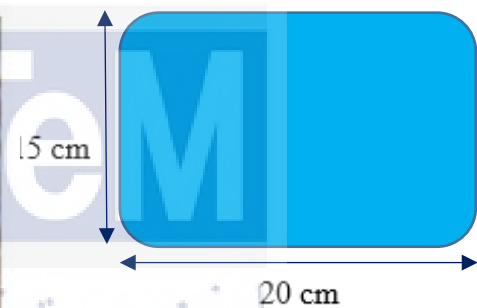


Figure 3.5: Area of Dumpster

Barge from Top View

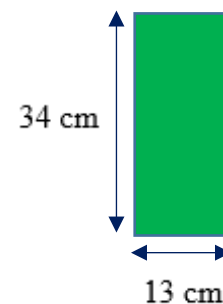


Figure 3.6: Area of Water Wheel

From Top View

3.3 Photovoltaic Solar System

Figure 3.7 denotes the operation of the photovoltaic solar system. Mono-crystalline solar array is tilted 34 degree to face the sun in order to absorb maximum solar energy so as to produce direct current (DC) from the array to the solar charger controller unit. The tilted position also prevent accumulation of rain water on the solar module surface. Stagnant water accumulated water on the solar module surface may block the sun ray or damage the module. DC power supply is produced by the battery which is charged by the solar charger controller unit. Battery overcharging or discharging is also prevented by the charger controller unit. The DC supply is converted into AC by using DC-AC inverter. The AC water pump is powered by alternate current (AC) produced by inverter to eject water to the water wheel allowing it to rotate. Meanwhile, DC current supplies Arduino Uno R3 microcontroller that control the water pump. Arduino Uno R3 microcontroller provides 5V DC supply to the infrared distance sensor input.

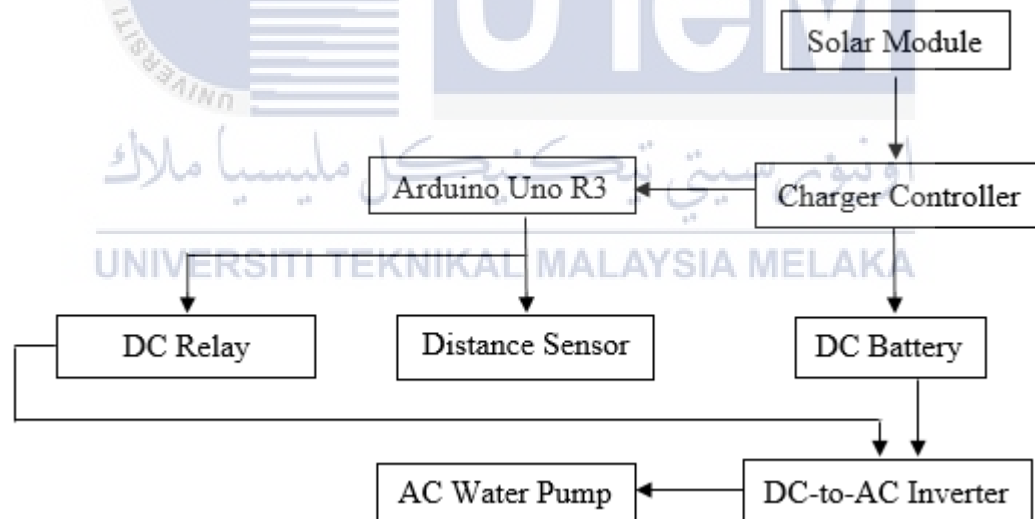


Figure 3.7: Flow Of The System

3.4 Block Diagram Of The System

Figure 3.8 denotes the electrical circuit in this project for the development of a prototype automated river trash management system. The solar module used in this project is mono-crystalline solar module which is installed on the rooftop to absorb solar energy produced by the sun. This energy will be converted to direct current (DC) as output current to be sent to PWM solar charger controller. The solar charger controller charges the battery and store the energy for backup application during cloudy days and raining days. PWM charger controller supply energy from the battery to the Arduino Uno R3 microcontroller and DC-AC inverter. The DC-AC inverter will injects AC supply to the water pump. The Arduino Uno R3 microcontroller supply energy to infrared distance sensor and DC relay.

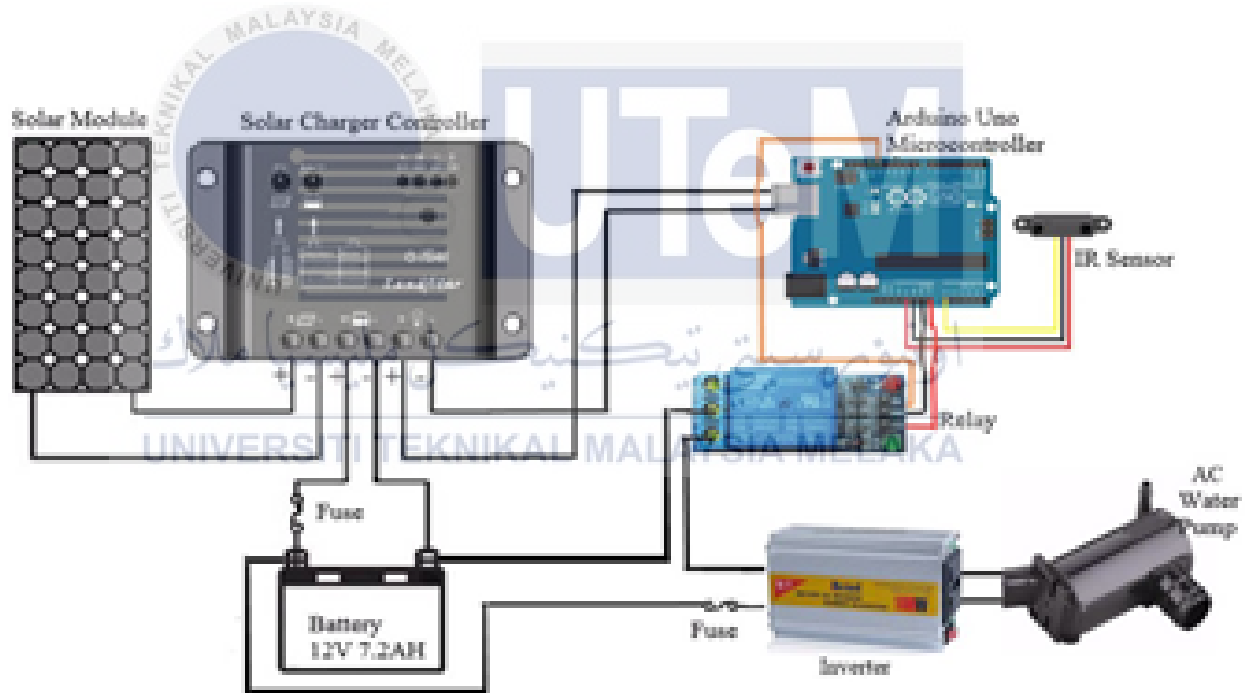


Figure 3.8: Block Diagram Of The System

3.5 Formula to Determination of Load

At first, the total load used in this project have to be tabulated as depicted in Table 3.1. The total load used is denoted as watt hour per day (Wh/day).

Table 3.1: Total Load in WH/day.

LOAD	QUANTITY	WATT	HOURS/DAY	(WATT.HOURS) / DAY
Water Pump	1	12	4	48
System	1	3	4	12
TOTAL LOAD				60

3.5.1 The Formula

At first, Formula (2) is derived from Formula (1). In Formula (2), the value of peak power (W_p) was determined. And then, the value of W_p will be used in Formula (3) to find number of module unit used in this project. Finally, the capacity of battery used (I) is determined by dividing Wh with the rated voltage of battery (V), as denoted in Formula (4). It is defined as Amp.Hours (AH).

$$(Wh = W_p \times PSH \times Pr) \quad (1)$$

$$(W_p = Wh / (PSH \times Pr) \quad (2)$$

$$(Unit\ of\ module = W_p / Module\ Power) \quad (3)$$

$$(I = Wh / V) \quad (4)$$

3.5.2 Module Sizing Calculation

$$60 \text{ Wh/day} = W_p \times 4 \times 0.70 \quad \text{substitute into (1)}$$

$$W_p = 60 \text{ Wh/day} / (4 \times 0.70)$$

$$W_p = 21.43 \text{ Wp}$$

$$\text{Unit of Module} = 21.43 \text{ Wp} / 10 \text{ W} \quad \text{substitute into (3)}$$

- Unit of module used = 2.14 (Minimum = 3 units)

3.5.3 Battery Sizing Calculation

$$I = 60 \text{ Wh} / 12 \text{ V} \quad \text{substitute into (4)}$$

$$I = 5 \text{ AH}$$

- In this project, we used 7.2 AH sealed lead acid battery because it is the nearest to 5 AH.

3.6 Equipment and Material

The equipment and material used to develop the prototype of this project comprised of three solar module, PWM solar charger controller, battery, AC multifunctional water pump, DC-AC inverter, DC relay, Arduino Uno R3 microcontroller, infrared distance sensor and related testing equipment.

3.6.1 Mono-Crystalline Solar Module

Figure 3.9 denotes the mono-crystalline solar module used in the development of the prototype automated river trash management system. The solar module power is 10 Watt. Maximum power point VMP is 12V and IMP is 0.833A. Open circuit voltage VOC is 14.55V and short circuit current ISC is 0.90A. The solar module will be tested under a 25° Celcius and 1000W/m² irradiance.



Figure 3.9: Solar Module

3.6.2 PWM Solar Charger Controller

Figure 3.10 denotes pulse width modulation (PWM) solar charger controller used to energize the battery and activate the pump. MOSFET electronic switch is used to automatically recognized the day and night. This solar charger controller nominal system voltage 12VDC, maximum PV input voltage 35V and nominal charge or discharge current is 5A. This controller can be worked in -35° Celcius to +55° Celcius temperature.



Figure 3.10: Solar Charger Controller

3.6.3 12V Sealed Lead Acid Battery

Figure 3.11 denotes a maintenance-free rechargeable sealed lead acid battery. The battery is charged by solar charger controller using solar energy. The battery voltage and current supply is 12V and 7.2 AH respectively used in the prototype to energize the battery and activate the pump. The calculation of battery sizing should be done to select the most suitable battery to be used in this project.



Figure 3.11: Rechargeable Sealed Lead Acid Battery

3.6.4 AC Multifunctional Water Pump

Figure 3.12 denotes AC multifunctional water pump used in aquarium and pond to spray water to the certain area. The pump, connected to the water tank, is powered by 12V DC supplied from the battery which is converts into 240V AC by inverter. When the water pump is activated, water is suck up by the motor through an entry point and pump out through a nozzle at an exit point.



Figure 3.12: 12V Multifunctional Water Pump

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3.6.5 AC to DC Inverter

Figure 3.13 depicts the DC-AC inverter used in this project. It is used to convert DC supply to AC. It can change the DC 12V into AC 220V. It can be widely used in all kind of electrical apparatus whose voltage rating are AC 220V and frequency are equal to 50 Hz. The USB output voltage is DC 5V. The continuous output power is 100W. The over voltage shutdown range is from DC 14V to DC 16V. The low voltage shutdown range is from DC 9V to DC 11V.



Figure 3.13: 100W DC to AC inverter

3.6.6 12V DC Relay

The type of relay used in this project is 12V DC relay as depicted in Figure 3.13. This relay is used to switch ON and switch OFF the water pump. The voltage rating is 12VDC. The maximum current rating is 10A. The power consumption is about 0.45W. The pull-in voltage rating is 75% from maximum voltage. The drop-out voltage rating is 10% from minimum voltage. The maximum allowable voltage is around 110% from voltage rating.



Figure 3.14: 12V DC Relay

3.6.7 IR Distance Sensor

The type of sensor used in this project is GP2Y0A21YK IR distance sensor as depicted in Figure 3.14. It is used to detect trash inside the dumpster barge at certain height. The detecting distance is about 10 cm to 80 cm. The judgement distance is 24 cm. The supply voltage is 5V. The output terminal voltage is 0.3V. The operating temperature range is from -10°C to $+60^{\circ}\text{C}$. The storage temperature range is from -40°C to $+70^{\circ}\text{C}$.



Figure 3.15: GP2Y0A21YK IR Distance Sensor

3.6.8 Arduino Uno R3 microcontroller

The type of microcontroller used in this project is Arduino Uno R3 microcontroller as depicted in Figure 3.15. It is used to control the operation of water pump. The board used is ATmega328P. The operating voltage is 5V. The input voltage range is from 7V to 12V. It have 14 digital I/O pins. The DC current per I/O pin is 20mA. The flash memory is 32 kilobyte of which 0.5 kilobyte used by bootloader. The clock speed is 16 MHz.

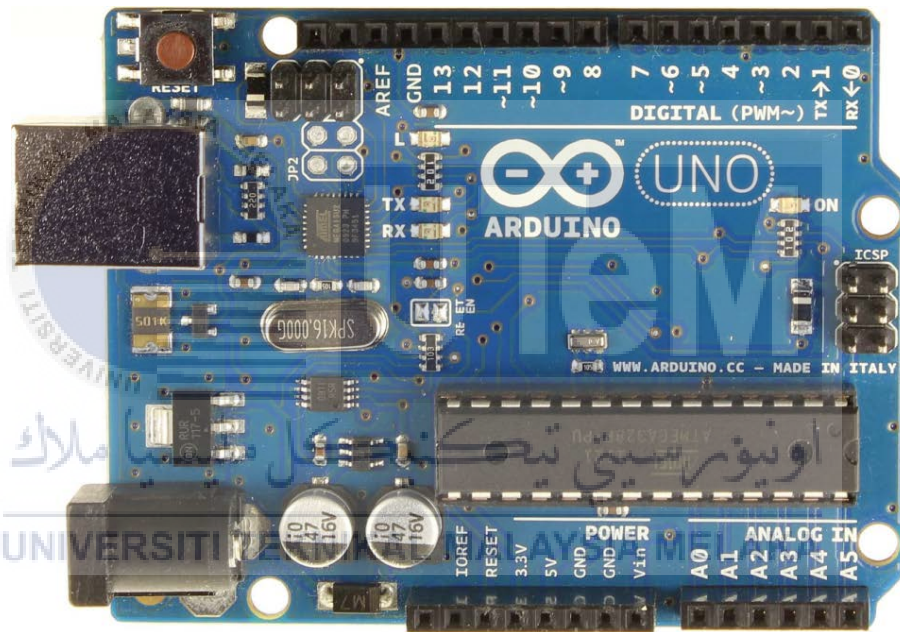


Figure 3.16: Arduino Uno R3 microcontroller

3.6.9 Irradiance Meter

Figure 3.16 denotes a multifunction irradiance meter. The meter displays the solar module tilt angle, orientation, temperature and irradiance. The irradiance meter is used to measure the sun radiation absorbed by the solar module at tilt angle. The meter will be installed on top of the module to get the irradiance value and the tilt angle of the module. The irradiance meter will indicate the tilted angle and irradiance value which is recorded as (W/m^2).



Figure 3.17: Seaward Solar 200R Irradiance Meter

3.6.10 Thermometer

Figure 3.17 denotes Fluke 568 IR Thermometer used to record the module temperature. The thermometer uses infrared laser beams to measure and indicate accurate temperature reading. To get the temperature reading, the fluke meter shoots behind the module. Shooting in front of the module may block sun ray and may affects the output reading.



Figure 3.18: Fluke 568 IR Thermometer

3.6.11 Clamp Meter

Figure 3.18 denotes the clamp meter which is used to measure electric current flowing in the conductor without open connection. It is also used to measure voltage in the solar module output that will show the amount of current flow in Ampere. Shorting the module wiring will obtain the current range.



Figure 3.19: Clamp Meter

3.7 Work Implementation

The main parts of the prototype automated river trash management system comprise of off-grid stand-alone solar system consisting of solar module, charger controller, battery, DC-AC inverter, AC water pump, DC relay, Arduino Uno R3 microcontroller and distance sensor. The structure of automated river trash management system also show the full operation of its system.

3.7.1 Step of Making A Prototype

1) The plastic sheet is marked in round shape by using the marker pen as depicted in Figure 3.19. And then, the marked surface is cropped by using steel cutter. The round shaped plastic sheet is used to construct a water wheel.



Figure 3.20: Marking and Cutting The Plastic Sheet

2) The aluminium bar is measured and marked by using mechanical pencil as depicted in Figure 3.20. After that, cut the aluminium bar by using steel cutter. The aluminium bar is used for several mechanical parts and as the stand of PV module.



Figure 3.21: Marking and Cutting Aluminium Bar

3) The round shaped plastic sheet is attached together with the corrugated plastic by using glue gun as depicted in Figure 3.21. The function of corrugated plastic is to allow water jet to rotate the water wheel.

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Figure 3.22: Attach the Plastic Sheet With Corrugated Plastic

4) The banana cable is fixed with the cable conductor as depicted in Figure 3.22. By using hot glue, the banana cable is attached to the PV module. The cable conductor is soldered with banana cable by using solder iron to strengthen the bonding.

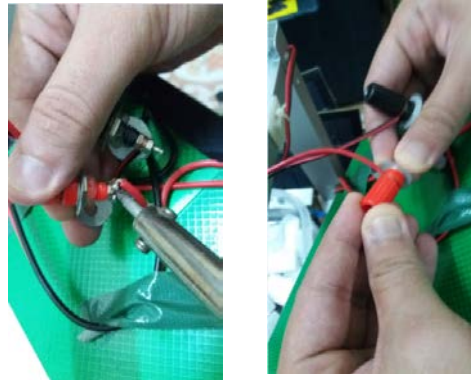


Figure 3.23: Soldering And Fixing The Banana Cable

5) The sensor holder is installed to the dumpster barge by using bolt and nut as depicted in Figure 3.23. The sensor is attached to sensor holder by using cable tie.



Figure 3.24: Fixing Sensor And Sensor Holder

6) The plywood is measured by using measuring tape. And then, the plywood is marked and cropped by using steel saw as depicted in Figure 3.24. The plywood surface is covered by plastic cover.



Figure 3.25: Cutting And Covering The Plywood

7) Figure 3.25 depicts the complete prototype model of Automated River Trash Management System and its electronic box. The Photovoltaic system is tested under the sun to collect data and result.

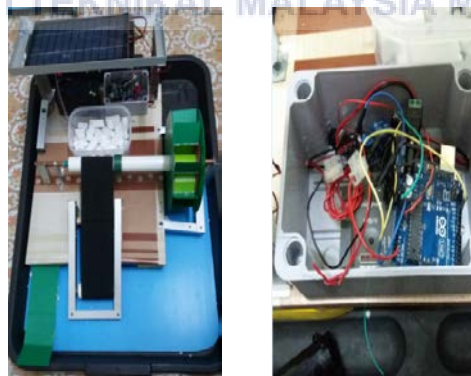


Figure 3.26: The Prototype Model And Electronic Box

8) The photovoltaic system is tested in real condition as depicted in Figure 3.26. By implementing this experiment, the data and result such as open circuit voltage, short circuit voltage, temperature and irradiance can be obtained.



Figure 3.27: Testing Photovoltaic system

9) Reading of irradiation and temperature displayed on testing equipment as depicted in Figure 3.27 is taken to tabulate data and result.



Figure 3.28 Measurement Reading

3.8 Conclusion

This report have shown the design and materials used in the development of a prototype automated river trash management system. The assembling flow chart also simplifies the development of this project. The completed prototype is energy efficient and environment friendly. Test equipment used such as irradiance meter can provide accurate data to be recorded in tables and graphs for future research and development purposes.



CHAPTER 4

RESULT AND DISCUSSION

4.0 Introduction

This chapter depicts the result and analysis of data collected from the solar system prototype which is designed to be off-grid and stand-alone. The solar module will produce and supply electricity to run the water pump to rotate the wheel. The result of the experiment to produce power by the solar system is listed in the following table and figures.

4.1 Load Calculation for Prototype

Table 4.1: Load Sizing For a Prototype

Load	Quantity	Wattage (W)	Hours/day	Load (WH/day)
Water Pump	1	12	4	48
System	1	3	4	12
Total Load				60

Calculation for quantity of solar module sizing from Formula (3.5.1) :

$$(W_h = W_p \times PSH \times Pr) \quad (1)$$

$$(W_p = W_h / (PSH \times Pr) \quad (2)$$

$$(\text{Unit of module} = W_p / \text{Module Power}) \quad (3)$$

$$60 \text{ Wh/day} = W_p \times 4 \times 0.70 \quad \text{substitutes into (1)}$$

$$W_p = 60 \text{ Wh/day} / (4 \times 0.70) \quad \text{substitutes into (2)}$$

$$W_p = 21.43 \text{ Wp}$$

$$\text{Unit Of Module} = 21.43 \text{ Wp} / 10 \text{ W} \quad \text{substitutes into (3)}$$

$$\text{- Unit Of Module} = 2.14 \text{ (Minimum} = 3 \text{ units)}$$

Calculation for battery sizing from Formula (3.5.1) :

$$I = Wh / V \quad (4)$$

$$I = 60 \text{ Wh} / 12 \text{ V} \quad \text{substitutes into (4)}$$

$$I = 5 \text{ AH}$$

- In this project, we used 7.2 AH sealed lead acid battery because it is the nearest to 5 AH.

Load sizing for prototype calculated using power (W) of water pump which its voltage is 12 VDC and current is 1.0 A. Therefore, the power is 12W and estimated to run for 2 hours.

4.2 Measurement Result And Discussion

The result of prototype off-grid stand-alone solar system is obtained from the measurements of the automated river trash management system. The result is obtained from real test condition under the sun. The data collected comprise of temperature, irradiance, short circuit current, open circuit voltage, voltage at maximum power point, current at maximum power point, and battery charging voltage. Another data from the Faculty of Electrical Engineering (FKE) Solar Lab is used as comparison to analyze the off-grid stand-alone measurement data. The measurement were taken on 10th September 2016 from 9.00 am to 5.00 pm using devices shown in methodology.

4.2.1 Measurement Result of Prototype

Table 4.2 shows the result obtained from the off-grid stand-alone photovoltaic solar system. The solar module is tilted at 15° degree and result is recorded every 30 minutes.

Table 4.2: Data Collection for Solar Module

Time (am-pm)	Tilt Angle (n°)	Irradiance (W/m ²)	Temperature (°C)	Power Voltage, V _{mp} (V)	Power Current, I _{mp} (A)	Power Point (W)	Battery Voltage (V)
9.00am	15	808	39.3	12.05	0.08	0.85	11.43
9.30am	15	860	45.4	12.24	0.09	0.98	11.47
10.00am	15	868	48.7	12.33	0.12	1.36	11.49
10.30am	15	905	52.5	12.29	0.16	1.85	11.52
11.00am	15	897	55.0	12.33	0.17	1.98	11.57
11.30am	15	944	53.9	12.41	0.13	1.37	11.60
12.00pm	15	913	61.5	12.35	0.14	1.63	11.65
12.30pm	15	1023	62.6	12.39	0.20	2.36	11.70
1.00pm	15	1031	63.9	12.34	0.21	2.47	11.77
1.30pm	15	980	60.7	12.35	0.14	1.62	11.83
2.00pm	15	966	62.2	12.34	0.16	1.85	11.89
2.30pm	15	948	64.7	12.40	0.19	2.25	11.95
3.00pm	15	973	62.7	12.38	0.20	2.00	12.10
3.30pm	15	996	63.9	12.22	0.17	1.47	12.19
4.00pm	15	926	63.9	12.24	0.13	1.46	12.23
4.30pm	15	941	63.9	12.26	0.16	1.85	12.26
5.00pm	15	939	63.9	12.25	0.12	1.35	12.29

4.2.2 The Relationship Of Voltage With Irradiance And Temperature

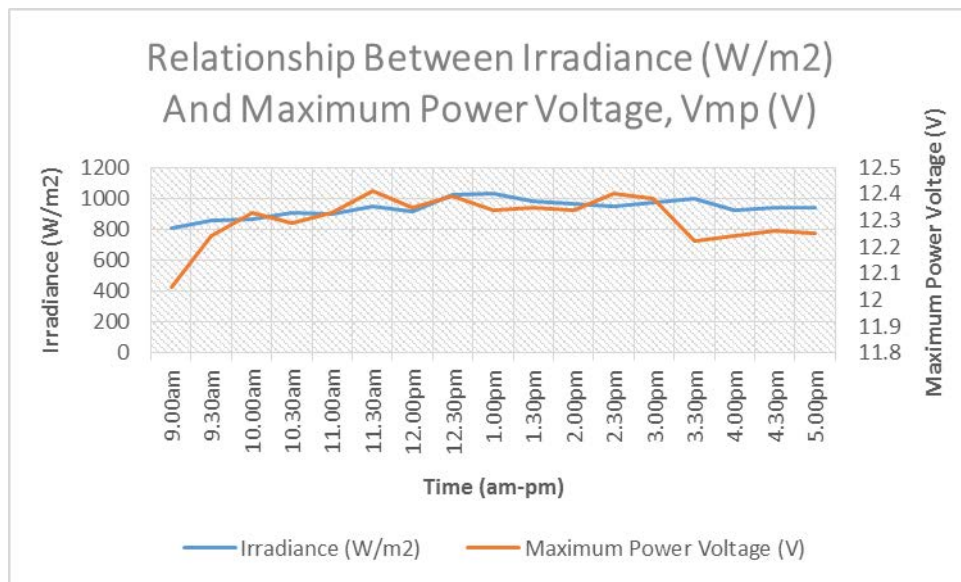


Figure 4.1: Irradiance Effect On Voltage

Figure 4.1 depicts the irradiance effect on voltage. Irradiance is low in the early morning and increases as the sun rises. The voltage also increases when the radiation from the sun increased. At 9.00 am, the irradiance was 808 W/m² and the voltage was 12.05 V. The irradiance value and voltage value recorded is at its lowest at 9.00 am. The highest recorded irradiance is 1031 W/m² at 1.00 pm, which is the peak time to obtain high irradiance especially when the sky is cloudless. The voltage is maintained until evening. The solar energy from the sun is absorbed by the solar module to produce energy. As the sun sets from 3.00 pm to 5.00 pm, the voltage starts to drop. Irradiance may also be blocked by cloud and shadow factors. The volt produced by solar module decreases when the irradiance is blocked. Based on the experiment, the voltage produced by solar module which is 12V and above, is sufficient to run the system.

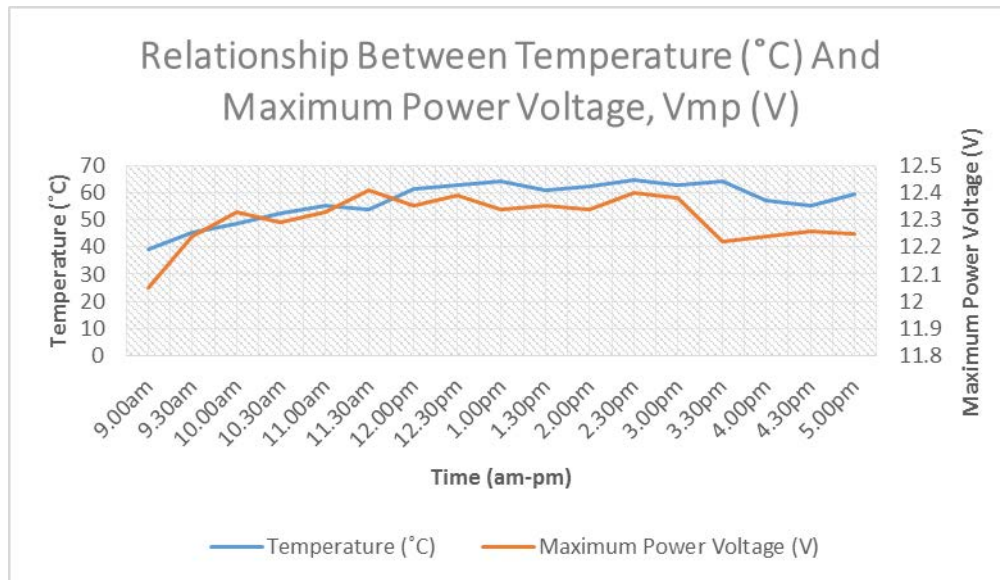


Figure 4.2: Temperature Effect on Voltage

Temperature plays an important role in producing energy from irradiance. Figure 4.2 depicts the temperature effect on voltage level. In the morning at 9.00 am, the temperature is 39.3 °C and the voltage is 12.05 V. At 11.30 am, the voltage is at its peak at 12.41 V at 53.9 °C in temperature. After 11.30 am, the voltage starts to drop due to drop in temperature. At 12.00 pm, the temperature is 61.5 °C and the voltage is 12.35 V. At 5.00 pm the temperature is 63.9 °C and voltage is 12.25 V. By this time the temperature is also increased. The solar cell and panel materials absorb the solar irradiance and also absorb the heat to maintain a high value of temperature and voltage. Based on the experiment, the voltage produced by solar module which is 12V and above, is sufficient to run the system.

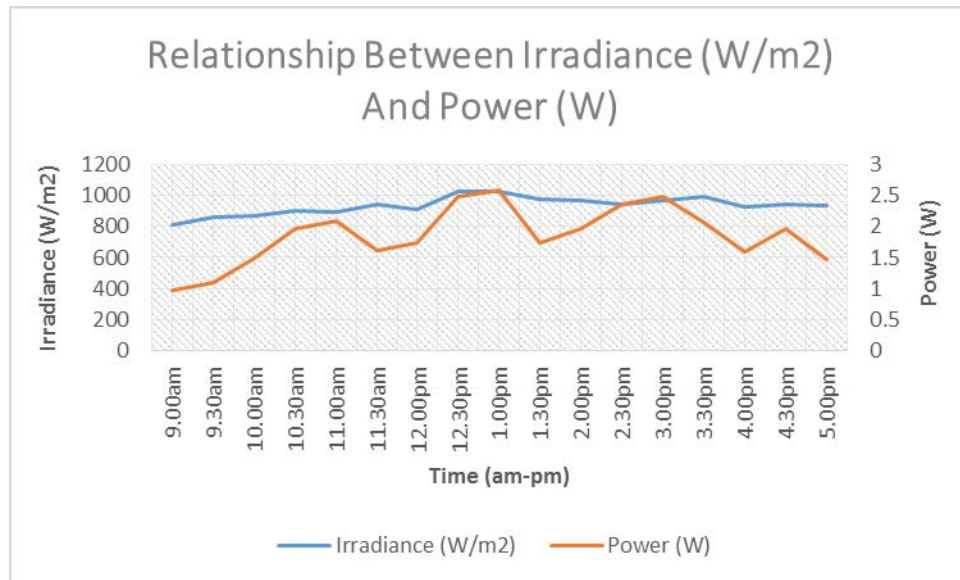


Figure 4.3: Relationship Between Irradiance And Power

Figure 4.3 depicts the relationship between irradiance (W/m²) and power point (W). The increment and decrement of solar module output power point (W) due to the temperature and irradiance effects. The power point value was calculated by multiplying the data of maximum power voltage, V_{mp} with the maximum power current, I_{mp} from Table 4.2. The power point (W) produced is sufficient to charge the battery to run the system. The battery was charged from morning until evening. The power is low in the morning at 0.85W because of low irradiance. At 1.00 pm, the power increases to 2.47W because of high level of irradiance of 1031 W/m². Therefore, the best time to charge the battery is from 11.00 am to 3.00 pm.

4.2.3 Analysis of Solar Irradiance and Temperature

Table 4.3 depicts the comparison between the irradiance (W/m^2) value and temperature ($^{\circ}\text{C}$) value of the prototype data and the data obtained from Faculty of Electrical Engineering Solar Lab.

Table 4.3: Comparison of Solar Irradiance and Temperature

Time (am-pm)	Faculty of Electrical Engineering (FKE) Solar Lab		Automated River Trash Management System Prototype	
	Irradiance (W/m^2)	Temperature ($^{\circ}\text{C}$)	Irradiance (W/m^2)	Temperature ($^{\circ}\text{C}$)
9.00am	683	35.3	808	39.3
9.30am	945	37.0	860	45.4
10.00am	637	37.3	868	48.7
10.30am	947	50.7	905	52.5
11.00am	961	54.0	897	55.0
11.30am	972	57.5	944	53.9
12.00am	1002	54.4	913	61.5
12.30am	1005	58.1	1023	62.6
1.00pm	1038	58.3	1031	63.9
1.30pm	1065	62.5	980	60.7
2.00pm	986	46.1	966	62.2
2.30pm	899	59.9	948	64.7
3.00pm	808	56.0	973	62.7
3.30pm	940	59.4	996	63.9
4.00pm	781	51.2	926	56.9
4.30pm	879	51.9	941	55.4
5.00pm	767	49.4	939	59.6

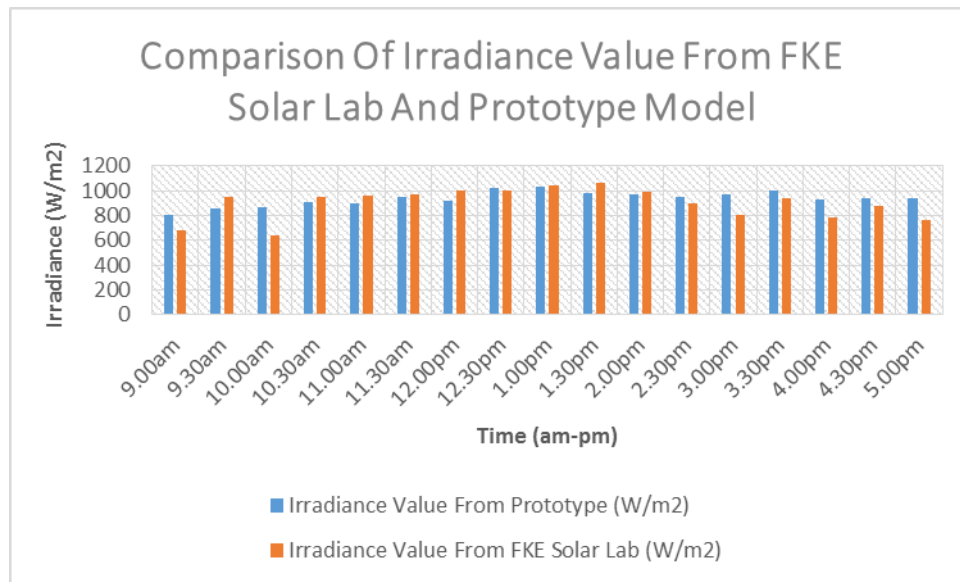


Figure 4.4: Measured Irradiance and FKE Solar Lab Irradiance

The bar graph were derived from Table 4.3, which shows the comparison between two readings. Figure 4.4 which is derived from Table 4.3 shows the comparison of irradiance between prototype value and FKE solar lab value. In the morning, the irradiance value is 808 W/m² higher than the solar lab value of 683 W/m². At 1.00 pm the solar lab value is 1038 W/m² higher than the prototype value of 1031 W/m². The bar graph shows that there is not much difference between the prototype irradiance value and the data obtained from FKE solar lab. The difference is due to the shadowing factors of clouds.

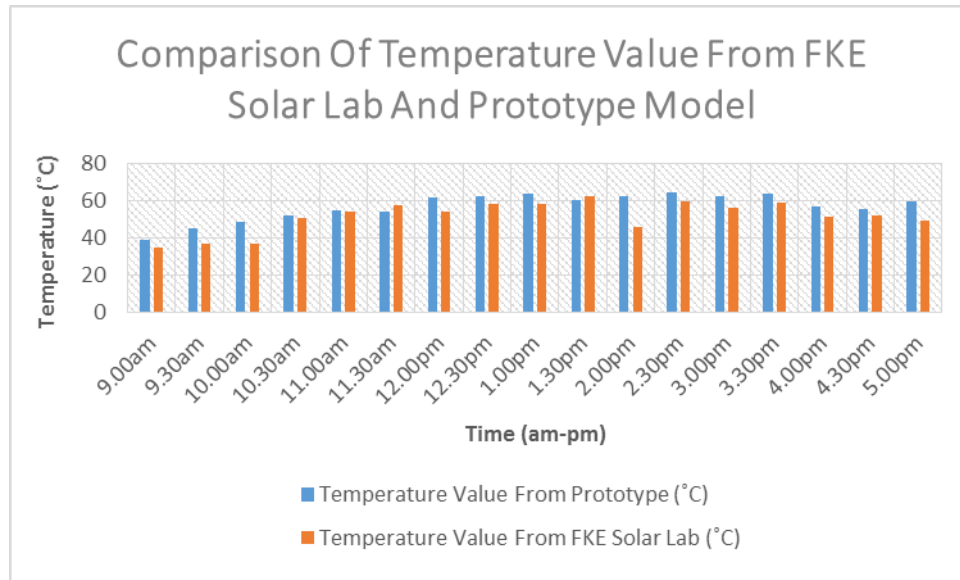


Figure 4.5: Measured Temperature and FKE Solar Lab Temperature

Temperature and irradiance play an important role to obtain voltage and current from the solar module. Figure 4.5 also derived from Table 4.3 compares the temperature value between the prototype value and the value from the FKE solar lab data. The prototype temperature reading is taken from the rear of the module. In the morning the prototype temperature is at 39.3 °C higher than the solar lab temperature reading of 35.3 °C. At 5.00 pm in the evening the prototype temperature is 59.6 °C and solar lab temperature is 49.4 °C. This slight difference in value reading may be due to two different equipment used.

4.2.4 Battery Charging Time

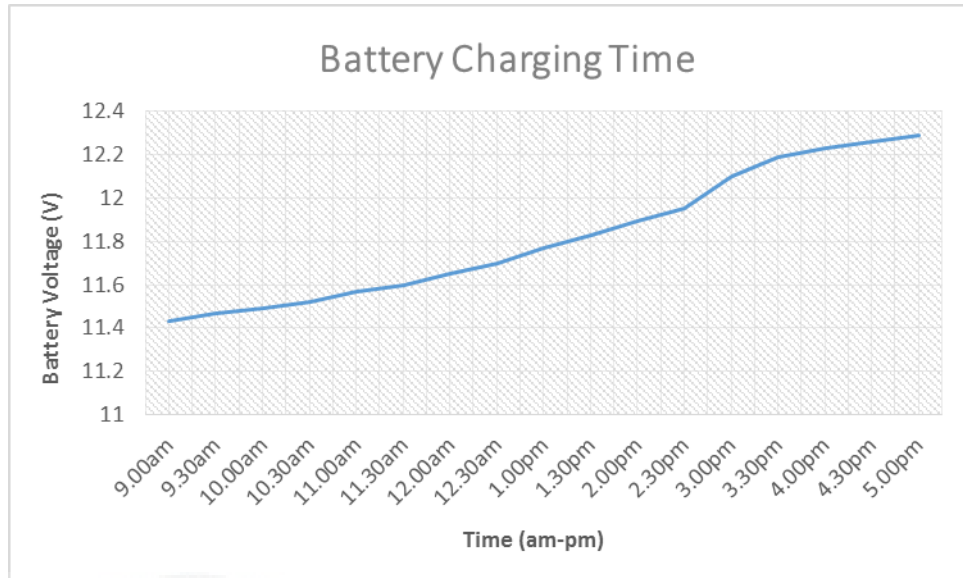


Figure 4.6: Battery Charging Time

Figure 4.6 depicts the battery charging time. The battery is slowly charged from morning till evening allowing the voltage to increase steadily until the battery is fully charged. Based on the experiment, 6 hours is required to achieve battery rated voltage which is 12V. The battery used in the prototype is a sealed lead acid battery 12 V and 7.2 Amp Hour, which releases 7.2 Ampere for 1 hour.

The following calculation can determine how long the battery will last to run the prototype automated river trash management system.

$$\text{Charge/discharge time (in hour)} = \frac{\text{Ampere – hour rating}}{\text{Continuous current / load (in ampere)}} \quad (1)$$

Calculation of Battery Charge / Discharge Time

$$\begin{aligned} \text{Charge / Discharge time (hour)} &= 7.2 \text{ Ah (battery)} / 1.0 \text{ Ampere} \quad \text{subs into (1)} \\ &= 7.2 \text{ hours} \end{aligned}$$

- From Equation (1), it is shown that the battery can be charged or discharged for 7.2 hours or 432 minutes.

Calculation of Battery Current

$$\text{Continuous current / load (in Ampere)} = \frac{\text{Ampere – Hour rating}}{\text{Charge/discharge time (in Hour)}} \quad (2)$$

$$\begin{aligned} \text{Continuous current / load (in Ampere)} &= 7.2 \text{ Ah (battery)} / 8 \text{ Hour} \quad \text{subs into (2)} \\ &= 0.9 \text{ Ampere} \end{aligned}$$

- From Equation (2), it is shown that the required amount of current to charge the battery is 0.9 Ampere. The current produce by the solar module can slowly charge the battery.

4.3 Water Pump



Figure 4.7: Water Pump Flow Rate Test Setup

Figure 4.7 depicts the test of the water pump used in this prototype for automated river trash management system to rotate the water wheel. Table 4.4 shows the flow rate reading of water pump used in this prototype model.

Table 4.4: Flow Rate Reading

Water Level	Reading 1	Reading 2	Reading 3	Total Time
1000 ml	3.70 sec	3.60 sec	3.50 sec	10.80 sec

The flow rate is calculated as follows ;

$$\text{Average Time} = \text{Total Time} / \text{Total Reading} \quad (1)$$

$$10.80 \text{ seconds} / 3 = 3.60 \text{ second} \quad \text{subs into (1)}$$

$$\text{Volume per second} = \frac{\text{Water Level (in milliliter)}}{\text{Average Time (in second)}} \quad (2)$$

$$1000 \text{ ml} / 3.60 \text{ second} = 277.78 \text{ ml/sec} \quad \text{subs into (2)}$$

$$\text{Volume per minute} = \text{Volume per second} \times \frac{1 \text{ Liter}}{1000 \text{ milliliter}} \times \frac{60 \text{ second}}{1 \text{ minute}} \quad (3)$$

$$277.78 \text{ ml/sec} \times \frac{1 \text{ Liter}}{1000 \text{ milliliter}} \times \frac{60 \text{ second}}{1 \text{ minute}} = 16.67 \text{ Liter/min} \quad \text{subs into (3)}$$

From the calculation, the water flow rate of water pump is 277.78 ml/s or 16.67 Liter/min. This flow rate allows the water jet to rotate the water wheel.

4.4 Conclusion

This chapter shows the measured results of prototype automated river trash management system using an off-grid stand-alone photovoltaic solar system with the solar module tilted at 15° angle. The temperature and irradiance play an important role on the output of the solar module. The lowest irradiance is 860 W/m² at 9.30 am and the highest irradiance is 1031 W/m² at 1.00 pm. The lowest temperature is 39.3 °C at 9.00 am and the highest temperature is 64.7 °C at 2.30 pm. The highest power voltage, V_{mp} value is 12.41V at 11.30 am and the highest power current, I_{mp} value is 0.21 A at 1.00 pm. The voltage produced by solar module which is 12V and above, is sufficient to run the system. The battery was charge slowly and steadily from morning till evening. Based the experiment, 6 hours is required to fully-charged the battery.

CHAPTER 5

CONCLUSION

5.0 Introduction

This chapter discuss the development and the process of automated river trash management system and summarize the objective, methodology and result obtained from data. This would assist in future projects to further improve and develop the system to be more efficient and productive.

5.1 Summary of Project

The automated river trash management system is develop to collect and dispose waste floating on surfaces of river, reservoir, lakes or other water sources. This will significantly reduce water pollution and promote healthier environment for both human and marine animal which would also enhance tourism. The off-grid stand-alone photovoltaic system used as power source to run the automated river trash management unit is pollution-free and in-line with the green project concept.

5.2 Summary of Research Objective

The objective of this project is to design an off-grid stand-alone photovoltaic solar system to power the automated river trash unit and allow us to measure the quantity of energy produced by photovoltaic system and select a suitable water pump and conveyor to rotate the water wheel and collect the floating water waste.

5.3 Summary of Methodology

The project is built to reduce water pollution and improve the health of both human and marine animal at the same time to promote tourism result in the development of automated river trash management system. From the selection of material equipment, it was decided that the off-grid stand-alone photovoltaic system is developed to power the system. It incorporates a prototype solar system using 10W power mono-crystalline solar module which have 12 V DC of voltage and 0.833 A of current, solar charger controller with high efficient pulse width modulation (PWM) charger with 12 V DC system voltage and 5A rated current, and rechargeable sealed lead acid battery 12VDC and 7.2 Ah. (Alternatively, the prototype model can also be powered by direct current). The unit was assemble and tested under real condition to produce data for graph and table. The type of microcontroller used in this project is Arduino Uno R3 microcontroller. It is able to control the operation of water pump. The microcontroller process the input from distance sensor to produce output through the water pump. The suitable coding for microcontroller is compulsory to run the system correctly.

5.4 Summary of Result

Measured results were presented in chapter 4 with table and graph. The result were taken on 10th September 2016 from 9.00 am to 5.00 pm using multimeter, irradiance meter and IR thermometer. The mono-crystalline solar module were set at 15° to get more sunlight. The prototype produced recommended voltage due to sunny day and high irradiance value. The highest irradiance value were at 1.00 pm which irradiance is 1031 W/m². The voltage and current produced were used to charge the battery fully. Although the voltage and current produced is sufficient the voltage starts to drop when the temperature starts to increase at 11.30 am.

An increase in temperature slightly affects the output value. Irradiance and temperature play important roles in producing solar power. The high irradiance value is produced from the high power solar source. If the temperature increases the performance of solar module will decrease. Solar charger controller with pulse width modulation charges the battery slowly to maintain the life of battery. The battery voltage which increases from 11.43 V to 12.23 V provides sufficient voltage to power up the water pump. The selected 12 V AC water pump propels water at 4287 ml/min or 4.3 litre per minute and is sufficient to rotates the water wheel waste collection conveyor system.

5.5 Recommendation

The weakness found in the off-grid stand-alone photovoltaic system using the solar module is the reduction of power during rainy and cloudy days. The sun light is blocked by rainfall and clouds from reaching the solar module thus reducing power generation.

To overcome this weakness, in future development, the use of river underwater current turbine or the use of wind turbine mounted on the river trash unit may be considered as an alternative power source to the solar module.

REFERENCES

- (Mustapha, Zayegh, & Begg, 2014)Indoware. (2013). Ultrasonic Ranging Module HC - SR04. Datasheet, 1–4. Retrieved from <http://www.micropik.com/PDF/HCSR04.pdf>
- Mustapha, B., Zayegh, A., & Begg, R. K. (2014). Ultrasonic and infrared sensors performance in a wireless obstacle detection system. Proceedings - 1st International Conference on Artificial Intelligence, Modelling and Simulation, AIMS 2013, 487–492. <http://doi.org/10.1109/AIMS.2013.89>
- M. Benghanem, K.O. Daffalah, A.A. Joraid, S.N. Alamri, A. Jaber, “Performance of solar water pumping system using helical pump for a deep well”, Elsevier, vol. 65, pp 50-56, Jan 2013.
- G. L. Kale and N.N. Shinde, “Implementation of Prototype Device – Off Grid – Charge Controller – Suitable for Wind Solar Hybrid, “Int J. Res. Mech. Eng. Technol., vol. 5762, no. 1, pp 89-92, 2011.
- F. Z. Zerhouni, M. H. Zerhouni, M. Zegrar, M. T. Benmessaoud, A. B. Stambouli, and A. Midoun, “Proposed methods to increase the output efficiency of a photovoltaic (PV) system,” Acta Polytech. Hungarica, vol. 7, no. 2 pp. 55-70, 2010.
- Y. Zeng, J. Liu, Q. Xie, Q. Chen, D. Liu, F. Li, “Research and Design of a Kind of Water Surface Floating Garbage Cleaning Machine”, Journal of Xuzhou Institute of Technology (Natural Sciences Edition), Jan 2013.
- Pradhan, S. M. Ali, and P. Behera, “Utilization of Battery Bank in case Solar PV System and Classification of Various Storage Batteries,” vol. 2, no. 12, pp. 1-5, 2012.
- B. Chowdhury, “ An approach for monitoring and smart planning of urban solid waste management using smart-M3 platform”, IEEE Proceedings of 15th Conference of Open Innovations Association FRUCT, St. Petersburg, pp. 55-70, 2010.

V. Kumar Chinnaiyan, J. Jerome and J. Karpagam, "An experimental investigation on a multilevel inverter for solar energy applications," Int. J. Electr. Power Energy Syst., vol. 47, pp. 157-167, 2013.

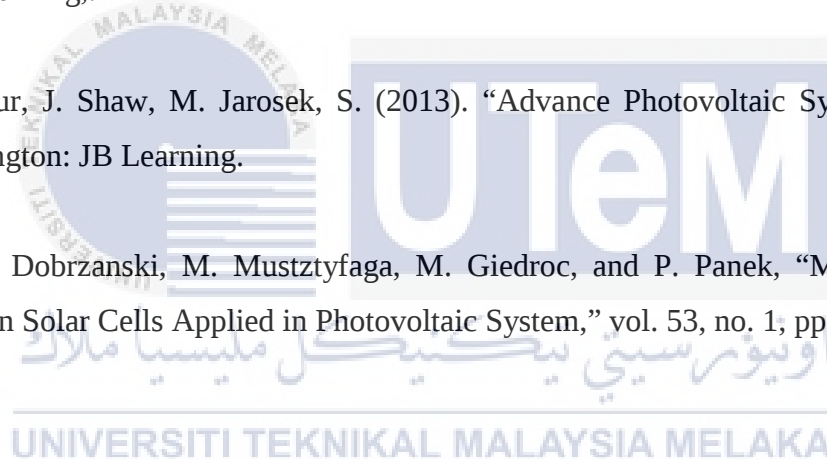
Ahmed Mohammedi, Djamila Rekioua, "Experimental Study of a PV Water Pumping System" Nabil Mezzai 1," vol. 2, pp. 212-222, 2013.

Sinha S. Shukla, A. et al, (2013). "From Sunlight To Electricity." New Delhi: The Energy and Resources Institute, pp. 8-21.

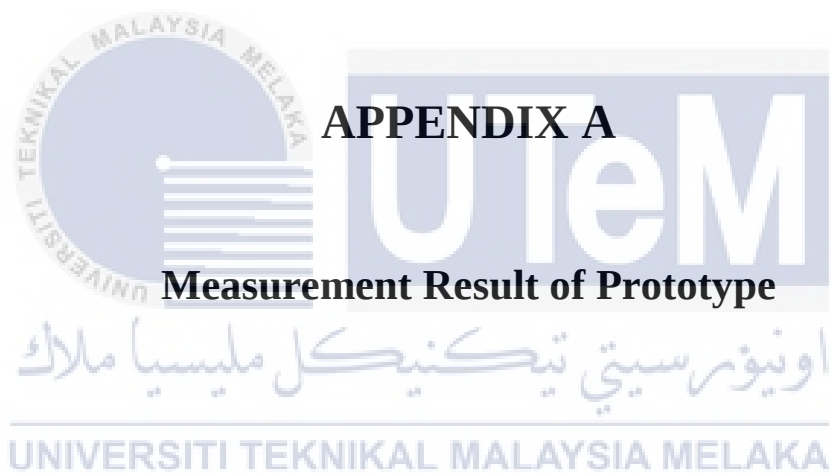
Balfour, J. Shaw, M. Jarosek, S. (2013). "Introduction to Photovoltaics." Burlington: JB Learning.

Balfour, J. Shaw, M. Jarosek, S. (2013). "Advance Photovoltaic System Design," Burlington: JB Learning.

L. A. Dobrzanski, M. Mustztyfaga, M. Giedroc, and P. Panek, "Monocrystalline Silicon Solar Cells Applied in Photovoltaic System," vol. 53, no. 1, pp. 7 – 13, 2012.



APPENDICES



**Measurement Result for Automated River Trash Management System
Prototype**

Time (am-pm)	Tilt Angle (n°)	Irradiance (W/m ²)	Temperature (°C)	Power Voltage, V _{mp} (V)	Power Current, I _{mp} (A)	Power Point (W)	Battery Voltage (V)
9.00am	15	808	39.3	12.05	0.08	0.85	11.43
9.30am	15	860	45.4	12.24	0.09	0.98	11.47
10.00am	15	868	48.7	12.33	0.12	1.36	11.49
10.30am	15	905	52.5	12.29	0.16	1.85	11.52
11.00am	15	897	55.0	12.33	0.17	1.98	11.57
11.30am	15	944	53.9	12.41	0.13	1.37	11.60
12.00pm	15	913	61.5	12.35	0.14	1.63	11.65
12.30pm	15	1023	62.6	12.39	0.20	2.36	11.70
1.00pm	15	1031	63.9	12.34	0.21	2.47	11.77
1.30pm	15	980	60.7	12.35	0.14	1.62	11.83
2.00pm	15	966	62.2	12.34	0.16	1.85	11.89
2.30pm	15	948	64.7	12.40	0.19	2.25	11.95
3.00pm	15	973	62.7	12.38	0.20	2.00	12.10
3.30pm	15	996	63.9	12.22	0.17	1.47	12.19
4.00pm	15	926	63.9	12.24	0.13	1.46	12.23
4.30pm	15	941	63.9	12.26	0.16	1.85	12.26
5.00pm	15	939	63.9	12.25	0.12	1.35	12.29

APPENDIX B

Faculty of Electrical Engineering (FKE) Solar Lab Data

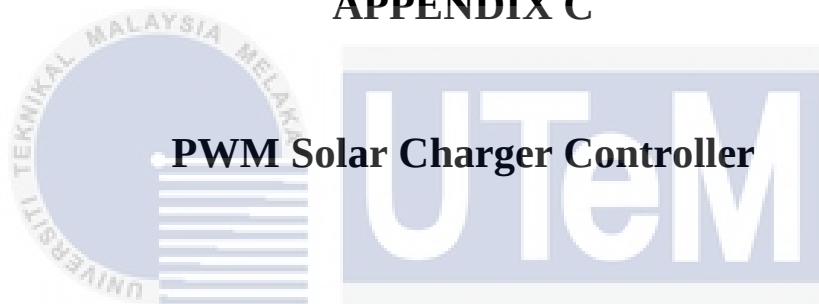
اونيورسيتي تيكنيكل مليسيا ملاك

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Faculty of Electrical Engineering (FKE) Solar Lab Data

	Faculty of Electrical Engineering (FKE) Solar Lab		Automated River Trash Management System Prototype	
Time (am-pm)	Irradiance (W/m ²)	Temperature (°C)	Irradiance (W/m ²)	Temperature (°C)
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11.00am	961	54.0	897	55.0
11.30am	972	57.5	944	53.9
12.00am	1002	54.4	913	61.5
12.30am	1005	58.1	1023	62.6
1.00pm	1038	58.3	1031	63.9
1.30pm	1065	62.5	980	60.7
2.00pm	986	46.1	966	62.2
2.30pm	899	59.9	948	64.7
3.00pm	808	56.0	973	62.7
3.30pm	940	59.4	996	63.9
4.00pm	781	51.2	926	56.9
4.30pm	879	51.9	941	55.4
5.00pm	767	49.4	939	59.6

APPENDIX C



اونيورسيتي تيكنيكل مليسيا ملاك

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

PWM Solar charge controller

LandStar series (LS0512R)



LandStar series solar light controller that adopts the most advanced digital technique and operates fully automatically. The Pulse Width Modulation (PWM) battery charging can greatly increase the lifetime of battery.

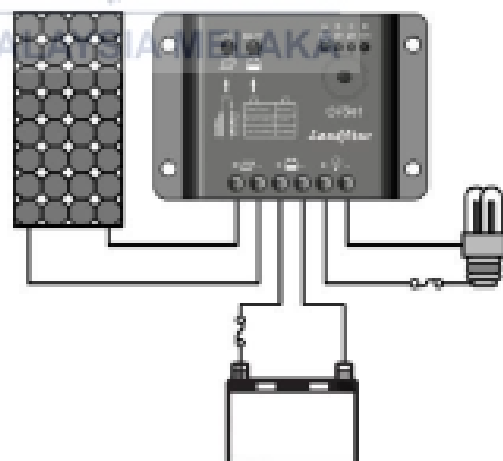
Features:

- + High efficient Series PWM charging
- + LED Indicators Indicate battery status
- + Widely used, automatically recognize day/night
- + Intelligent timer function with 1-12 hours option
- + Use MOSFET as electronic switch
- + Temperature compensation
- + Electronic protection: over charging, over discharging, overload, and short circuit
- + Battery reverse polarity protection

Application:

Ideal for small off-grid solar lighting system that needs light and timer control.

- + Solar street lights
- + Solar garden lights
- + Solar detection equipment at night



Technical specifications

Electrical parameters	LS0512R
Nominal system voltage	12 VDC
Max. battery voltage	16V
Rated battery current	5A
Charge circuit voltage drop	≤0.26V
Discharge circuit voltage drop	≤0.15V
Self-consumption	≤6mA

Battery voltage parameters (temperature at 25℃)	
Battery type	Sealed
Equalize charging voltage	14.6V
Boost charging voltage	14.4V
Float charging voltage	13.8V
Low voltage reconnect voltage	12.6V
Low voltage disconnect voltage	11.1V
Equalize duration	2 hours
Boost duration	2 hours

Environmental parameters		Mechanical parameters	
Working temperature	-35℃ to +55℃	Overall dimension	97x66x25mm
Storage temperature	-35℃ to +80℃	Mounting dimension	86x44mm
Humidity	10%-90% NC	Terminal	2.5mm ²
Enclosure	IP30	Net weight	0.05kg



BEIJING EPSOLAR TECHNOLOGY CO.,LTD.
 Add: BLDG #18, CO.PARK ,NO.8 HEYING
 ROAD,CHANGPING DISTRICT, BEIJING, CHINA
 Tel: 010-82894962 / 82894112
 Fax: 010-82894882
 E-mail: info@epsolarpv.com

APPENDIX D



Powered by



GP 1272 ▶ 12V 7.2Ah

GP 1272 is a general purpose battery up to 5 years in standby service or more than 250 cycles at 100% discharge in cycle service. As with all CSB batteries, all are rechargeable, highly efficient, leak proof and maintenance free.



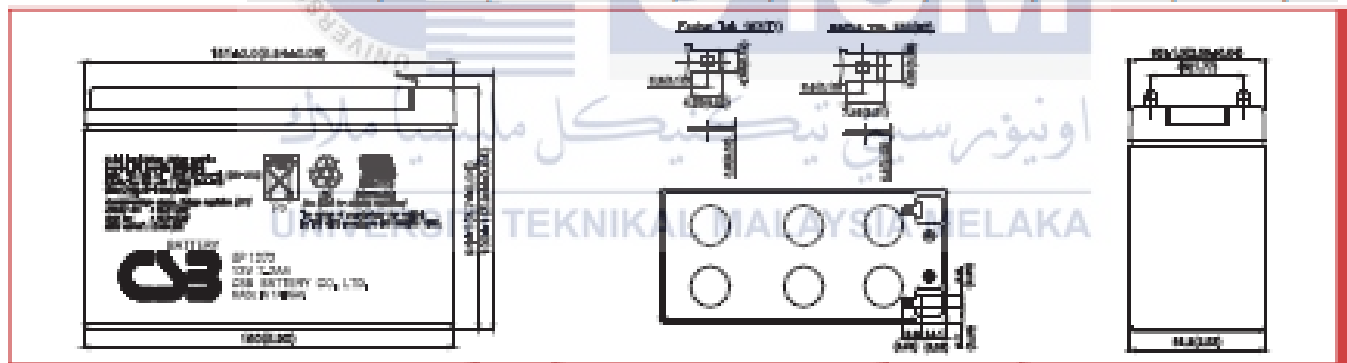
► Specification

Cells Per Unit	6
Voltage Per Unit	12
Capacity	7.2Ah @ 20hr-rate to 1.75V per cell @ 25 °C (77°F)
Weight	Approx. 2.4 kg (5.29 lbs)
Maximum Discharge Current	100A/130A (5sec)
Internal Resistance	Approx. 23 mΩ
Operating Temperature Range	Discharge: -15°C~50°C (5°F~122°F) Charge: -15 °C~40°C (5°F~104°F) Storage: -15°C~40°C (5°F~104°F)
Nominal Operating Temperature Range	25°C±3°C (77°F±5°F)
Float Charging Voltage	13.5 to 13.8 VDC/unit Average at 25°C (77°F)
Recommended Maximum Charging Current Limit	2.16A
Equalization and Cycle Service	14.4 to 15.0 VDC/unit Average at 25°C (77°F)
Self Discharge	CSB Batteries can be stored for more than 6 months at 25°C (77°F). Please charge batteries before using. For higher temperatures the time interval will be shorter.
Terminal	F1/F3-Flat Tab 187/250
Container Material	ABS (UL 94 HB/Fire E50263)*Flammability resistance of (UL 94-V0/Fire E88637) can be available upon request.

► Dimensions :

Unit: mm (inch)

Overall Height (H)	Container height (h)	Length (L)	Width (W)
100±1 (3.94±0.04)	94±1 (3.7±0.04)	151±2 (5.94±0.08)	65±1 (2.56±0.04)



MH14533(N)



CSB-manufactured VRLA batteries are UL-recognized components under UL924 and UL1989.

CSB is also certified by ISO 9001 and ISO 14001.

Constant Current Discharge Characteristics Unit:A (25°C,77°F)

F.V/Time	5MIN	10MIN	15MIN	30MIN	1HR	2HR	3HR	4HR	5HR	8HR	10HR	20HR
1.60V	35.6	22.0	16.5	9.61	5.51	3.08	2.14	1.65	1.35	0.925	0.778	0.466
1.67V	33.1	21.0	15.9	9.36	5.42	3.03	2.09	1.60	1.32	0.906	0.762	0.447
1.70V	31.9	20.5	15.6	9.24	5.37	3.00	2.06	1.58	1.30	0.897	0.756	0.438
1.75V	29.6	19.6	15.1	9.03	5.30	2.96	2.02	1.54	1.28	0.883	0.742	0.428
1.80V	27.2	18.6	14.4	8.77	5.23	2.92	1.99	1.50	1.25	0.871	0.732	0.421
1.85V	24.5	17.4	13.7	8.45	5.14	2.87	1.96	1.48	1.23	0.861	0.720	0.409

Constant Power Discharge Characteristics Unit:W (25°C,77°F)

F.V/Time	5MIN	10MIN	15MIN	30MIN	1HR	2HR	3HR	4HR	5HR	8HR	10HR	20HR
1.60V	360	245	183	108	64.4	37.7	26.6	20.8	17.3	11.8	9.80	5.37
1.67V	340	235	177	106	63.6	37.1	26.3	20.5	17.0	11.6	9.69	5.27
1.70V	331	231	174	105	63.1	36.9	26.2	20.4	16.9	11.5	9.54	5.23
1.75V	313	222	170	103	62.4	36.4	25.9	20.2	16.7	11.4	9.48	5.15
1.80V	295	213	165	101	61.7	35.9	25.6	19.9	16.5	11.3	9.40	5.07
1.85V	276	202	158	99.0	60.8	35.4	25.2	19.6	16.3	11.2	9.29	4.99

APPENDIX E

Mono-Crystalline Solar Module



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SANYO



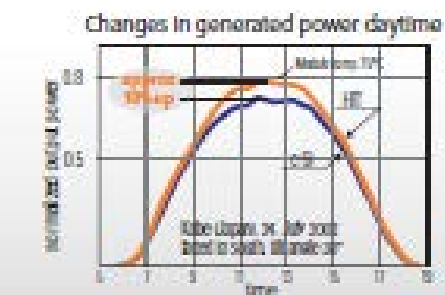
اؤنفر سیتی ٹیکنیکل ملیسیا ملائ
HIT HD Solar

Downloaded from <http://ajphaphysocpharm.sagepub.com/> at 10:06 11 September 2014

Changes in generated power daytime

	2007	2008	9	8

Robert Chapman, 24, July 2000
Bored to death, all night long



The HIT cell and module have very high conversion efficiency in mass production.

Model	Cell Efficiency	Module Efficiency	Output / m ²
HIT-H250E01	20.8%	18.0%	180W/m ²
HIT-H245E01	20.4%	17.7%	177W/m ²

HIT[®] HD
Photovoltaic Module

HT is a registered trademark of SAMCO Electric Co., Ltd. The name "HT" comes from "Heteromutation with Intrauterine Trans-ester" which is an original technology of SAMCO Electric Co., Ltd.

Electrical data (at STC)

Models HIT-H250E01

	250	245
Maximum power (P _{max}) [W]	250	245
Max. power voltage (V _{mp}) [V]	34.3	34.4
Max. power current (I _{mp}) [A]	7.35	7.14
Open circuit voltage (V _{oc}) [V]	43.1	42.7
Short circuit current (I _{sc}) [A]	7.74	7.73
Maximum over current rating [A]	15	
Output power tolerance [%]	+10/-5*	
Maximum system voltage [V]	1000	

Note: Standard Test Conditions: Air mass 1.5, Irradiance = 1000W/m², cell temperature = 25°C
* All modules measured by SANYO factory have output with positive tolerance

Temperature characteristics

	250	245
Temperature (NOCT) (°C)	46.0	46.0
Temperature coefficient of P _{max} (%/°C)	-0.30	-0.30
Temperature coefficient of V _{oc} (%/°C)	-0.108	-0.107
Temperature coefficient of I _{sc} (mA/°C)	2.32	2.32

At NOCT

	250	245
Maximum power (P _{max}) [W]	188.5	185.4
Max. power voltage (V _{mp}) [V]	32.8	32.4
Max. power current (I _{mp}) [A]	5.76	5.73
Open circuit voltage (V _{oc}) [V]	40.5	40.1
Short circuit current (I _{sc}) [A]	6.23	6.23

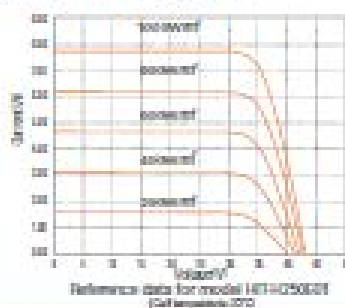
Note: Nominal Operating Cell Temperature: Air mass 1.5 spectrum, irradiance = 800W/m², Air temperature = 25°C, wind speed 1 m/s

At low irradiance

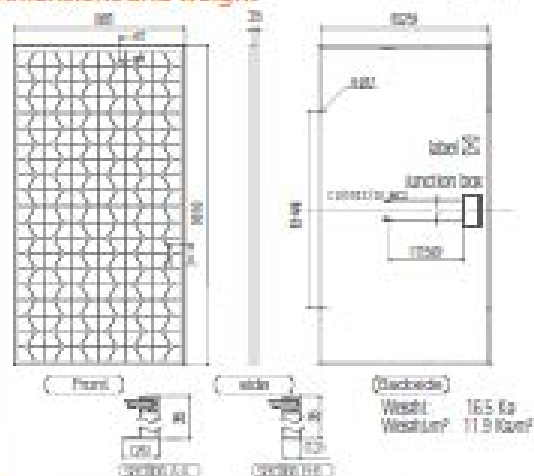
	250	245
Maximum power (P _{max}) [W]	46.8	42.7
Max. power voltage (V _{mp}) [V]	34.1	33.6
Max. power current (I _{mp}) [A]	1.40	1.40
Open circuit voltage (V _{oc}) [V]	40.1	39.7
Short circuit current (I _{sc}) [A]	1.55	1.55

Note: Low irradiance: Air mass 1.5 spectrum, irradiance = 200W/m², cell temperature = 25°C

Dependence on irradiance



Dimensions and weight



Guarantee

Power output: 10 years (80% of P_{min}) 25 years (80% of P_{min})
Product workmanship: 10 years
(Based on guarantee documents)

Materials

Cell material: Honeycomb Design HIT cells
Glass material: AR coated tempered glass
Frame materials: Black anodized aluminium
Connector type: MC3

Certificates



Member of



Please consult your local dealer for more information.

⚠ CAUTION! Please read the installation manual carefully before using the products.

Due to our policy of continual improvement the products covered by this brochure may be changed without notice.

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SANYO

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APPENDIX F

16W AC Multifunctional Water Pump

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LifePower® LP-7800

MODEL	VOLTAGE	POWER	Q. MAX/HR	H. MAX
LP-6800	220-240V / 50Hz	12W	800L/h	1.2m
LP-7800	220-240V / 50Hz	16W	1000L/h	1.3m
LP-8800	220-240V / 50Hz	30W	1200L/h	1.5m
LP-9800	220-240V / 50Hz	45W	1400L/h	2.0m

Dibungkus / Disediakan oleh:
 DAYA AQUATICS SON, BHD / 40274-R
 No.122, Jalan Pahlawan 2, Taman Ungu Tur Amanah, 81560 Skudai, Johor.
 Email: dayaaquatics@gmail.com Website: www.dayaquatics.com

LifePower®

LP-7800

**4 IN 1 MULTIFUNCTIONAL
AQUARIUM WATER PUMP**

16w
watts

- Silent operation
- Powerhead lifts and moves water
- Strong currents and consistent output

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Technical Specification

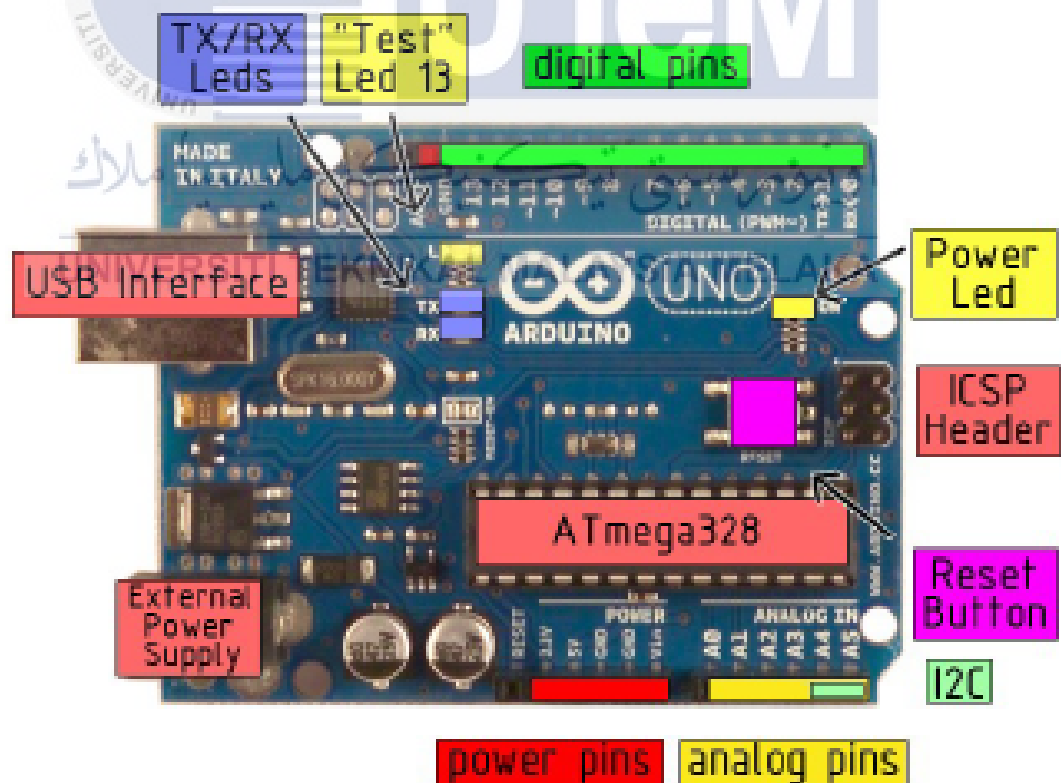


EAGLE files: [arduino-dreamilabv2-uno-design.zip](#) Schematic: [arduino-uno-schematic.pdf](#)

Summary

Microcontroller	ATmega328
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
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 of which 0.5 KB used by bootloader
SRAM	2 KB
EEPROM	1 KB
Clock Speed	16 MHz

the board



APPENDIX H



FEATURES

- Digital Output
- LED Pulse Cycle Duration: 32 ms
- Range: 10 to 80 cm
- Typical response time: 39 ms
- Typical start up delay: 44 ms
- Average Current Consumption: 30 mA
- Detection Area Diameter @ 80 cm: 12 cm

DESCRIPTION

The GP2Y0A21YK is a wide-angle distance measuring sensor.

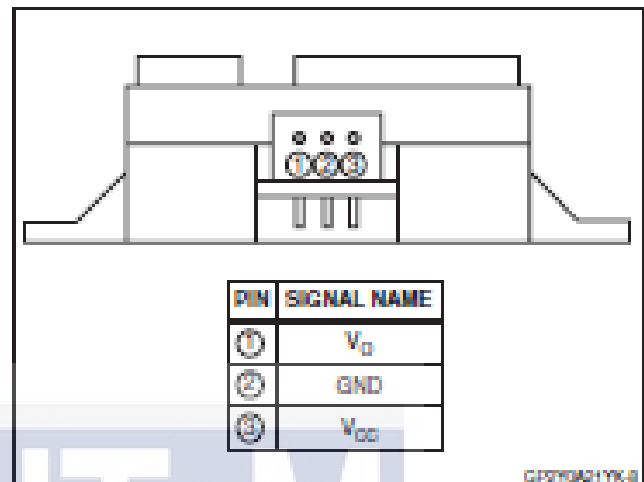


Figure 1. Pinout

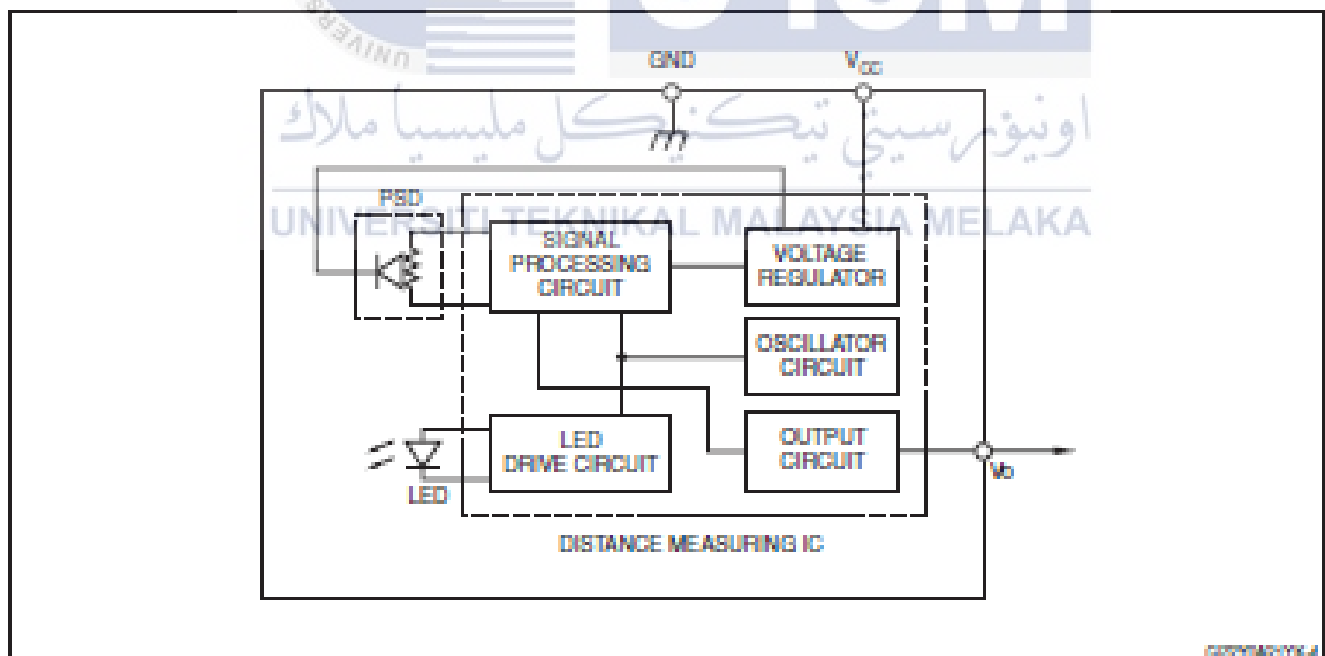


Figure 2. Block Diagram

ELECTRICAL SPECIFICATIONS

Absolute Maximum Ratings

 $T_a = 25^{\circ}\text{C}$, $V_{CC} = 5\text{ VDC}$

PARAMETER	SYMBOL	RATING	UNIT
Supply Voltage	V_{CC}	-0.3 to +7	V
Output Terminal Voltage	V_O	-0.3 to ($V_{CC} + 0.3$)	V
Operating Temperature	T_{opr}	-10 to +60	$^{\circ}\text{C}$
Storage Temperature	T_{stg}	-40 to +70	$^{\circ}\text{C}$

Operating Supply Voltage

PARAMETER	SYMBOL	RATING	UNIT
Operating Supply Voltage	V_{CC}	4.5 to 5.5	V

Electro-optical Characteristics

 $T_a = 25^{\circ}\text{C}$, $V_{CC} = 5\text{ VDC}$

PARAMETER	SYMBOL	CONDITIONS	MIN.	TYP.	MAX.	UNIT	NOTES
Measuring Distance Range	ΔL		10	-	80	cm	1, 2
Output Terminal Voltage	V_O	$L = 80\text{ cm}$	0.25	0.4	0.55	V	1, 2
Output Voltage Difference	ΔV_O	Output change at ΔL (80 cm - 10 cm)	1.65	1.9	2.15	V	1, 2
Average Supply Current	I_{CC}	$L = 80\text{ cm}$	-	30	40	mA	1, 2

NOTES:

- Using reflective object: white paper (made by Kodak Co. Ltd.) gray cards R-27, white face, reflective ratio: 90%.
- L = Distance to reflective object.

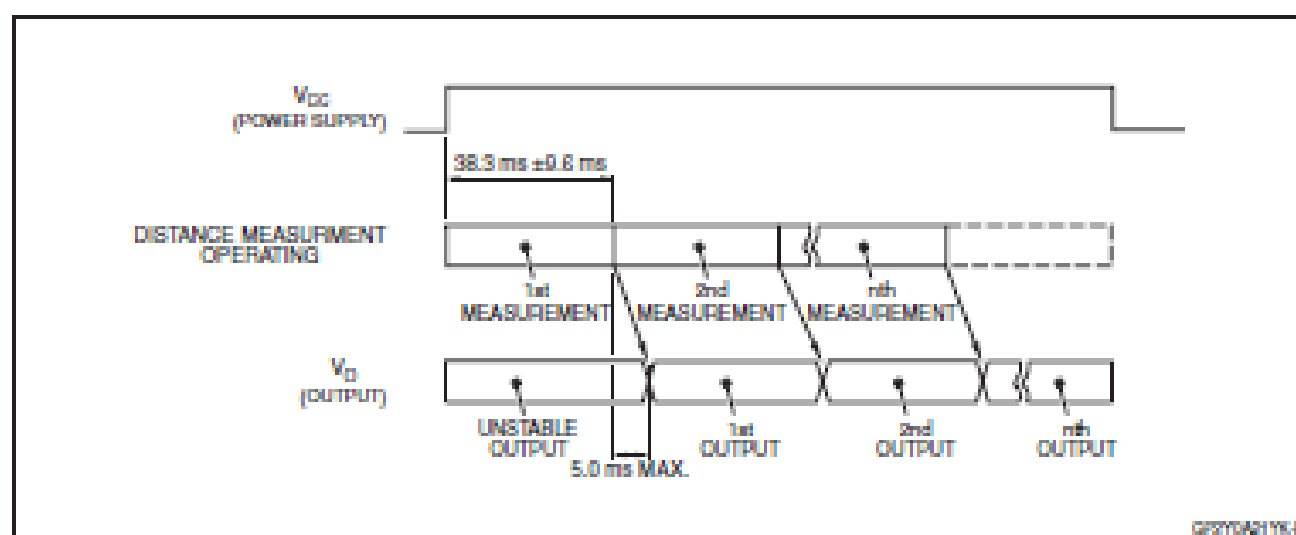


Figure 3. Timing Diagram



APPENDIX I

100W DC TO AC INVERTER



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Specifications

Input Voltage Range: DC 10-15V

Output Voltage Range: AC 220V 100V

USB Output: DC 5V

Continuous Output Power: 100W

Over Voltage Shutdown: DC 14-16V

Low Voltage Shutdown: DC 9-11V

Short Circuit protection: Yes

Dimension: 3.0" x 2.5" x 1.6" (L x W x H)

Weight: 10.30oz / 292g

Color: Black



APPENDIX J

12V DC Relay



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SONGLE RELAY

	RELAY ISO9002	SRD
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1. MAIN FEATURES

- ☐ Switching capacity available by 10A in spite of small size design for high density P.C. board mounting technique.
- ☐ UL, CUL, TUV recognized.
- ☐ Selection of plastic material for high temperature and better chemical solution performance.
 - ☐ Sealed types available.
- ☐ Simple relay magnetic circuit to meet low cost of mass production.

2. APPLICATIONS

- ☐ Domestic appliance, office machine, audio, equipment, automobile, etc.
(Remote control TV receiver, monitor display, audio equipment high rushing current use application.)

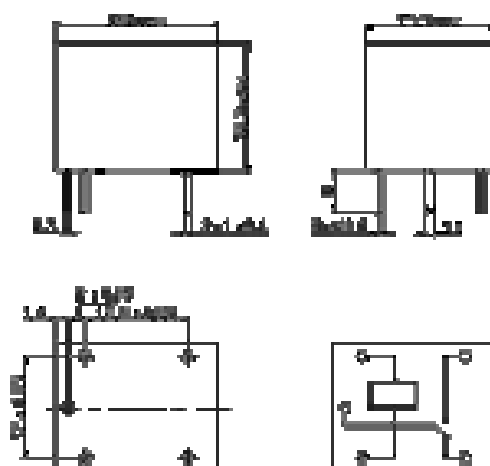
3. ORDERING INFORMATION

SRD	XX VDC	S	L	C
Model of Relay	Rated Load voltage	Structure	Coil	Contact form
SRD	03 05 06 09 12 24 48 VDC	S: Sealed type F: Flux free type	L: 0.36W D: 0.45W	A: 1 form A B: 1 form B C: 1 form C

4. RATING

CCC	FILE NUMBER: CQC03001003729	7A/240VDC
CCC	FILE NUMBER: CQC03001003731	10A/250VDC
UL/CUL	FILE NUMBER: E167986	10A/125VAC 28VDC
TUV	FILE NUMBER: R50056114	10A/250VAC 30VDC

5. DIMENSION (unit:mm) DRILLING (unit:mm) WIRING DIAGRAM



6. COIL DATA CHART (AT20 ° C)

Coil Sensitivity	Coil Voltage Code	Nominal Voltage (VDC)	Nominal Current (mA)	Coil Resistance (Ω) □ 10%	Power Consumption (W)	Pull-In Voltage (VDC)	Drop-Out Voltage (VDC)	Max-Allowable Voltage (VDC)
SRD (High Sensitivity)	03	03	120	25	abt. 0.36W	75%Max.	10% Min.	120%
	05	05	71.4	70				
	06	06	60	100				
	09	09	40	225				
	12	12	30	400				
	24	24	15	1600				
	48	48	7.5	6400				
SRD (Standard)	03	03	150	30	abt. 0.45W	75% MAX.	10% MIN.	110%
	05	05	89.3	55				
	06	06	75	80				
	09	09	50	180				
	12	12	37.5	320				
	24	24	18.7	1280				
	48	48	10	4500	abt. 0.51W			

7. CONTACT RATING

Item	Type	SRD FORM C	SRD FORM A
Contact Capacity		7A	10A 30VDC
Resistive Load (cosφ=1)		30VDC	10A 240VAC
Inductive Load (cosφ=0.4 L/R=7msec)		10A 125VAC 10A 250VAC	5A 120VAC 5A 28VDC
		3A 120VAC 3A 28VDC	
Max. Allowable voltage		250VAC/110VDC	250VAC/110VDC
Max. Allowable Power		800WAC/240W	1200WAC/300W
Contact Material		AgCdO	AgCdO

8. PERFORMANCE (at initial values)

Item	Type	SRD
Contact Resistance		100mΩ Max.
Operation Time		10msec Max.
Release Time		5msec Max.
Dielectric Strength		
Between coil & contact		1500VAC 50/60HZ (1 minute)
Between contacts		1000VAC 50/60HZ (1 minute)
Insulation Resistance		100 MΩ Min. (500VDC)
Max. ON/OFF Switching		
Mechanically		300 operation/min
Electrically		30 operation/min
Ambient Temperature		-25℃ to +70 °C
Operating Humidity		45 to 85% RH
Vibration		
Endurance		10 to 55Hz Double Amplitude 1.5mm
Error Operation		10 to 55Hz Double Amplitude 1.5mm
Shock		
Endurance		100G Min.
Error Operation		10G Min.
Life Expectancy		
Mechanically		10 ⁷ operations Min. (no load)
Electrically		10 ⁵ operations Min. (at rated coil voltage)
Weight		abt. 10grs.

9. REFERENCE DATA

