# CHAPTER I INTRODUCTION

## 1.1 Background

The development of technology that is growing rapidly today has touched all aspects of people's lives, from urban to rural areas. The demands of technology lead people to think about creating something new. The Indonesian government has implemented various programs to bring people into this condition, one of which is encouraging the development of appropriate technology in various fields, such as the provision of facilities and infrastructure for the benefit of the community and for the creation of a clean environment. Garbage is a material that is discarded or disposed which originated from human activities and natural processes.

Garbage is a problem in all countries in the world. Some waste is easily decomposed and some is difficult to decompose so that it can cause soil and water pollution, which of course will have problems with the health of the surrounding environment. To answer this, what is most needed is creativity in order to create innovations related to technology. But the big problem today is the availability of electrical energy sources which are the main needs in society.

The limited source of fossil energy as a producer of electrical energy has encouraged research and development towards using alternative energy sources, one of which is solar energy sources. The use of solar energy in Indonesia has very good prospects, considering that geographically as a tropical country, it has good potential for solar energy across the equator. Utilization of solar energy

through photovoltaic conversion has been widely applied, including the application of individual systems and hybrid systems, namely a system of combining conventional energy sources with renewable energy sources.

This solar cell will produce direct electricity (DC) when its surface is exposed to sunlight with a certain intensity. The potential of solar energy sources can provide a large contribution if it can be utilized optimally by designing an energy converter system that can supply energy needs. The use of this solar energy source has several advantages, including the availability of free energy sources, environmentally friendly so that it is pollution-free and unlimited. Therefore, it is necessary to conduct a more detailed study to understand the electrical system derived from this solar energy source.

One problem that arises with the use of solar energy is that the energy produced varies depending on the season and the environment. This will be felt in areas where the intensity of the sun varies in powerful ways. Therefore, an energy storage system is needed, namely an accumulator or battery. Solar energy generated from the sun can be used to charge power to the accumulator for further use from the accumulator.

Based on the abovementioned matters, the researchers design an automatic garbage scraper using a solar panel equipped with an automatic charger to charge the battery as a store of electrical energy generated by solar panels. This system consists of a solar cell as a electrical energy generator, an ATMega8 microcontroller as a controller, a battery, and an inverter. Researcher is trying to create an independent electric power source as a power source to operate an

automatic garbage scraper. By designing a garbage collection machine that can be attached to the boat and is easy to operate. Because the research funds prepared in this research are very limited, the design of this garbage collection machine is designed in a small carrying capacity.

## 1.2 Problem Limitation

This research only focuses on utilizing solar energy using solar cells as a medium to convert solar energy into electrical energy as an alternative energy for machine operation.

This research relies on the weather which can determine how much its maximum performance.

## 1.3 Problem Formulation

Based on the above background, this research focuses on the discussion:

1. Utilization of solar energy to drive the automatic garbage scraper.
2. Researching the process of converting solar energy into electrical energy.
3. Researching the effect of changes in light intensity and temperature on the current and voltage of the Solar Cell.
4. Using polycrystalline Solar Cell panels with a capacity of 20 WP, a maximum current of 1 Ampere and a voltage of 8 - 20 Volts.
5. Using a 12-volt battery as a storage place for electric current when the Solar Cell gets energy from sunlight.

6. What are the advantages and disadvantages of using this type of this solar cell?

## 1.4 Research Objectives

This research aims to utilize solar energy through the energy conversion process that occurs in solar panels, namely the process of converting solar energy into electrical energy. Then produce a solar cell system using a battery as an effort to save the use of electrical energy, so that solar energy can be an independent source of electrical energy that can be used free of charge for the needs of operating an automatic garbage scraper, with the hope that this prototype can operate on its own without human assistance.

## 1.5 Research Benefits

For Students

As a means to apply knowledge on new and renewable energy and develop self-potential in developing the science of designing, analysing, and realizing in a model of a tool or prototype, as well as to explore and utilize knowledge about renewable energy.

For Society

As an alternative solution that can help people to recognize and start applying solar energy in their homes.

## 1.6 Systematics of Writing

As for the systematics of writing this thesis are as follows:

**CHAPTER 1 : INTRODUCTION**

The background, problem formulation, research objectives, research benefits, research schedule, and data analysis are described.

**CHAPTER 2: THEORY BASIC**

Contains the basic theory concerned about the title, which was made into a thesis.

**CHAPTER 3: RESEARCH METHODS**

Discusses the steps of research and also about system development and working principles.

**CHAPTER 4: RESULTS AND DISCUSSION**

Contains the results of testing and measurements from research.

**CHAPTER 5: CONCLUSIONS AND SUGGESTIONS**

Make conclusions and suggestions obtained in the discussion problem.

**REFERENCES**

# CHAPTER II

# THEORY BASIC

## 2.1 Solar Cell

The solar cell is basically a large photodiode and is designed with reference to the photovoltaic phenomenon so that it can produce as much power as possible. A solar cell is an active element that converts sunlight into electricity. This understanding is based on a solar cell slice consisting of positive and negative semiconductor materials with a minimum thickness of 0.3 mm, which when a light falls on it, a voltage difference arises at the two poles, causing a direct current. P-. type silicon is a surface layer that is made very thin so that sunlight can penetrate directly to reach the junction. The P section is given a ring-shaped nickel layer as the positive output terminal. Below the P section, an N-typed section is nickel plated and serves as the negative output terminal.

## 2.2 History of Solar Cells

The basic principle of making solar cells is to utilize the photovoltaic effect, which is an effect that can convert sunlight directly into electrical energy. The photovoltaic effect was first recognized in 1839 by the French physicist Alexandre-Edmond Becquerel. However, the first solar cells were made only in 1883 by Charles Fritts, who covered the selenium semiconductor with a very thin

layer of gold to form the joints. The device only has an efficiency of 1%. Russell Ohl patented the modern solar cell in 1946 (U.S. Patent 2,402,662, "Light Sensitive Device"). The golden age of solar technology came in 1954 when Bell Laboratories, experimenting with semiconductors, accidentally discovered that silicon doped with other elements became very sensitive to light. This led to the start of a practical solar cell production process with a solar energy conversion capability of about 6 percent. The first use of solar cells was intended for space satellites in 1958 because they are light and reliable, durable, and the sun's energy in space is greater than the earth. But the use of solar cells in the general public has not been so widespread due to the high cost of installation.

Solar cell is a device that can convert solar energy into electrical energy. So directly the current and voltage generated by the solar cell depends on sunlight. In this solar cell, a material that can capture the sun is needed and that energy is used to provide energy to the electrons so that they can move through the band gap to the conduction band, and then can move to the outer circuit. Through this process the electric current can flow from the solar cell. Generally, the device from solar cells uses the PN junction principle. In practice, solar cells are not used alone, but usually assembled into Solar Modules. Solar module (photovoltaic) is a number of solar cells that are arranged in series and parallel to increase the voltage and current generated so that it is sufficient for the use of the load power supply system. To get the maximum output of electrical energy, the surface of the solar module must always point to the sun.

The main component of a photovoltaic solar system is a module which is an assembly unit of several photovoltaic solar cells. To manufacture photovoltaic modules, you can use crystal and thin film technology.

Crystal photovoltaic modules can be made with relatively simple technology, while high technology is required to make photovoltaic cells. The photovoltaic module is composed of several photovoltaic cells connected in series and parallel.

Utilizing solar energy has several advantages, namely:

1. The energy sources used are very abundant and free
2. The system developed is modular so that it can be easily installed and its capacity enlarged
3. Easy maintenance
4. Does not cause pollution
5. Designed to work automatically so that it can be applied in remote places
6. Relatively safe
7. Reliability is getting better
8. There is an aspect of the user community that controls the system itself
9. Easy to install
10. Solar radiation as a source of unlimited energy
11. Does not produce $CO^2$ and other exhaust emissions

This system uses a polycrystalline solar cell with a capacity of 20 WP (Wattpeak), producing a voltage between 8-20V with a maximum current of 1A. The use of this 20 WP solar cell was chosen because the voltage and current

generated were sufficient to charge the battery and it was efficient for its use in DC motors.

In this solar cell, the resulted voltage and current greatly affect the intensity of sunlight. This is also very influential, especially on the current generated by the solar cell. Therefore, due to the limited current generated by the solar cell, the charging current for the battery cannot be maximized.

### 2.3 Types of Solar Panels

The solar panel consists of an array of solar cells connected in series. Solar cells function to convert sunlight into electrical energy. Solar cells are generally made of silicon which is a semiconductor material. The power produced by a solar panel depends on the solar radiation received, the panel's surface area, and the temperature of the panel. The power generated is greater if the radiation and surface area are greater, while the increase in temperature causes a decrease in power. Therefore, when installing panels, need to pay attention for providing distance from the roof so that air can circulate under the panels (cooling effect). The latest type of solar panel has a power of 130 Wattpeak/$m^2$.

**Here are some types of solar panels:**

**1. Polycrystalline (Poly-crystalline)**

It is a solar panel that has a random crystal arrangement. The polycrystalline type requires a larger surface area than the monocrystal type to produce similar electrical power, but can generate electricity on cloudy days. This

type usually consists of 28-36 solar cells with a length of 8.5 cm, a width of 5 cm, and a thickness of 0.3 mm for one cell.

**2. Monocrystalline (Mono-crystalline)**

It is the most efficient panel, producing the highest electrical power per unit area. Having an efficiency of up to 15%. The disadvantage of this type of panel is that it will not function well in a place with less sunlight (shady), its efficiency will drop dramatically in cloudy weather.

**3. Amorphous**

Amorphous silicon (a-Si) has been used as a photovoltaic solar cell material in calculators. Even though his abilities are lower than c-Si type solar cells, this is not important in calculators, requiring little energy.

**4. Thin Film Photovoltaic**

It is a solar panel (two layers) with a microcrystalline-silicon and amorphous thin layer structure with a module efficiency of up to 8.5% so that the required surface area per watt of power generated is greater than monocrystalline & polycrystalline. The latest innovation is Thin Film Triple Junction PV (with three layers) can function very efficiently in very dirty air and can produce up to 45% more electrical power than other types of panels with equivalent rated power.

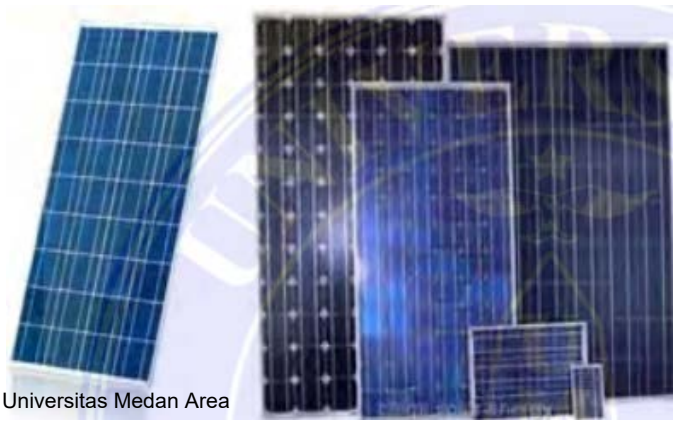
Wattpeak shows the maximum power produced under conditions of 1000 W/m2 solar radiation and 25$^{o}$C of panel temperature. Solar panels are manufactured in various sizes (installed power). The solar panel construction consists of solar cells, a glass cover, a special aluminium frame and a socket.

Solar panels have a relatively long life of at least 20 years, and generally solar panel suppliers provide an output power guarantee of up to 10-25 years. when the light intensity is reduced (cloudy, rainy, cloudy), therefore the electric current generated will also decrease.

By adding solar panels (expanding) means increasing the conversion of solar power. Generally, solar panels with a certain size give certain results as well. For example, the size of a cm x b cm produces DC (Direct Current) electricity of x Watt per hour.

**Table 1.1 Comparison of the advantages of each type of solar panel**

| | Efficiency | Durability | **Cost** | Information | Use |
|---|---|---|---|---|---|
| Mono | Power Change | Very good | good | Wide Usage Use | Daily |
| Poly | Very good | Very good | Very good | Suitable for mass production in the future | Daily |
| Amorphous | Well | Pretty good | Good | Working in lighting | Everyday commercial device (calculator) |
| Compound (GaAs) | Pretty good | Very good | Pretty good | good fluorescent | Use in space |



## 2.4 Solar applications

The solar energy absorbed by the earth is as much as 120 thousand terawatts. In principle, solar power is used to generate electricity in two ways:

- Steam production with mirror fields used to drive turbines. Large solar power plant.
- Converting sunlight into electricity with solar panels / photovoltaic solar cells. Portable/small solar power plant.

Solar power can be applied as follows:

1. Solar power for lighting at home.
2. Solar power for street lamp lighting (PJU)
3. Solar power for garden lighting
4. Solar power as a power source for CCTV cameras.
5. Solar power as a source of electricity for wireless installations (WIFI), radio transmitters, communication devices.
6. Solar power for signal devices for trains, ships.
7. Solar power for swiftlet house, irrigation, water pump.
8. Solar power as a portable power supply
9. Solar power as a heater to drive a turbine as a solar power plant like in Nevada, America.
10. Solar power as a power source for satellite devices.

## 2.5 Advantages of Solar Panels

It could supply electricity to locations that have not been reached by the PLN electricity network so that it can be used for remote areas. Solar electricity is a quick solution, because the installation process is relatively quickly to produce electricity, lighting and others. Solar power is a very clean energy, because it is physically nature and can absorb UV radiation (from the sun), does not produce the slightest emission, does not make noise and does not require fuel that needs to be purchased every day. Solar power systems have proven to be more reliable. more than 50 years of supporting the space program, where no other source of energy, not even nuclear, can survive the extreme conditions in outer space. Solar Panel is one of the tools that can utilize the potential of solar radiation energy of 4.8 Kwh/m2/day (* BPPT data in 2005) which is a fairly large power potential and has not been maximally utilized in Indonesia. Solar Panels have a modern and futuristic impression and have the impression of caring for the environment and clean. It is suitable for the world of modern architecture that combines these important elements.

## 2.6 Specifications of 20 WP Poly Polycrystalline Solar Cell Panels

20 WP Polycrystalline Solar Panel is a Solar Cell Module with the best efficiency, using solar cells with a SiN layer that provides solutions for rural and even urban electricity needs for electrical energy saving solutions and other applications such as Solar Home Systems, Solar Water Pumps, Solar CCTV or

also Centralized PLTS. The 20 WP Solar Cell module offers increased efficiency by using the latest Polycrystalline cells, making it ideal for battery charging applications. It is proven that the device owns high temperature performance and a robust design that makes the product durable and easy to install.

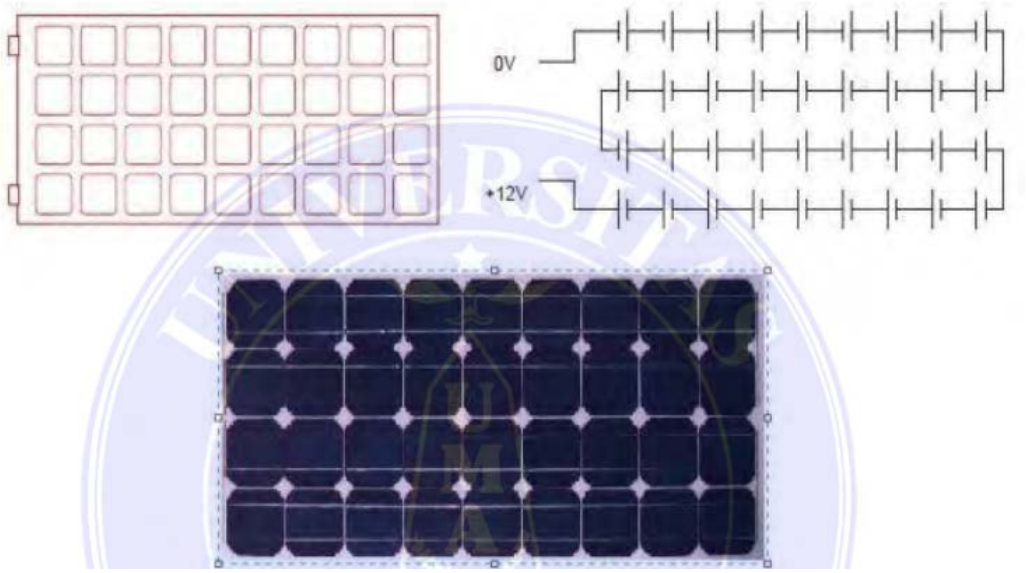
| Specifications | Description |
|---|---|
| Maximum Power (Pmax) | 20 WP |
| Maximum voltage (Vmp) | 17.2 V |
| Maximum Current (Imp) | 1.16 A |
| Open circuit voltage (Voc) | 21.6 V |
| Short Circuit (Isc) | 1.3 A |
| Nominal Cell Operating Temperature (NOCT) | 45±2°C |
| Maximum System Voltage | 1000 V |
| Maximum Series Fuse | 16 A |
| Weight | 2.0 Kg |
| Size | 530 x 350 x 25 mm |

Table 2.1 Specifications of 20 WP Solar Cell Polycrystalline

**2.7 Structure and working method**

Solar cells or also often called photovoltaics are devices that can convert sunlight directly into electricity. Solar cells can be called the main actor to maximize the enormous potential of solar energy that reaches the earth. Apart from generating electricity, energy from the sun can also be maximized through a solar thermal system.

Solar cells can be analogous to devices with two terminals or connections. When conditions are dark or not enough light functions like a diode, irradiating sunlight can produce a voltage. When irradiated, generally a commercial solar cell produces a dc voltage of 0.5 to 1 volt, and a short-circuit current in the scale of milliampere per $cm^2$. This voltage and current is not sufficient for various applications, so that generally a number of solar cells are arranged in series to form a solar module. One solar module usually consists of 28-36 solar cells, and produces a total dc voltage of 12 V under standard irradiation conditions (Air Mass 1.5). These solar modules can be combined in parallel or in series to increase the total output voltage and current according to the power required for a particular application. The image below shows an illustration of a solar module.




**2.8 Solar Cell Structure**

In accordance with the development of science & technology, the types of solar cell technology are also developing with various innovations. There are so-

called solar cells of generation one, two, three and four, with different structures or cell constituent parts (Types of solar technology will be discussed in the article "Solar Cells: types of technology"). In this paper, it will be discussed the structure and workings of solar cells that are commonly on the market today, namely solar cells based on silicon material which also generally includes the structure and working method of the first generation (silicon solar cells) and second generation (thin film).


Figure 2.2 Structure of a commercial solar cell using silicon as a semiconductor.

The picture above shows an illustration of a solar cell and its parts. In general, it consists of:

1. Substrate/Metal backing

Substrate is a material that supports all components of solar cells. The substrate material must also have good electrical conductivity because it also functions as a positive terminal contact for solar cells, so that metal or metal materials such as aluminium or molybdenum are generally used. For dye-sensitized solar cells

(DSSC) and organic solar cells, the substrate also functions as a place where light enters so that the materials used are not only conductive but also transparent materials such as indium tin oxide (ITO) and fluorine doped tin oxide (FTO).

2. Semiconductor materials

Semiconductor material is the core part of solar cells which usually has a thickness of up to several hundred micrometres for first generation solar cells (silicon), and 1-3 micrometres for thin layer solar cells. This semiconductor material serves to absorb light from sunlight. For the case of the above picture, the semiconductor used is silicon material, which commonly used in the electronics industry. As for thin-layer solar cells, semiconductor materials that are commonly used and have entered the market are for example Cu(In, GA)(S, $Se)_2$ (CIGS), CdTe (cadmium telluride), and amorphous silicon materials, in addition to other potential semiconductor materials are under intensive research are Cu2ZnSn(S, $Se)_4$ (CZTS) and $Cu_2O$ (copper oxide).

The semiconductor part consists of a junction or a combination of two semiconductor materials, namely p-type semiconductors (the materials mentioned above) and n-type (n-type silicon, CdS, etc.), forming a p-n junction. This p-n junction is the key to the working principle of solar cells. Understanding p-type, n-type semiconductors, as well as the principle of p-n junctions and solar cells will be discussed in the section "how solar cells work".

3. Metal contacts / grid contacts

In addition to the substrate as a positive contact, at the upper part of partial semiconductor materials usually coated with metal or transparent conductive material as negative contact.

4. Anti-reflective layer

Light reflection must be minimized in order to optimize the light absorbed by the semiconductor. Therefore, solar cells are usually coated with an anti-reflection layer. This anti-reflection material is a thin layer of material with a large optical refractive index between the semiconductor and air that causes light to be bent towards the semiconductor to minimize the reflected light.

5. Encapsulation/cover glass

This section serves as an encapsulation to protect the solar module from rain or dirt.

## 2.9 How Solar Cells Work

Conventional solar cells work using the p-n junction principle, which is a junction between p-type and n-type semiconductors. This semiconductor consists of atomic bonds in which there are electrons as the basic constituent. The n-type semiconductor has an excess of electrons (negative charge) while the p-type semiconductor has an excess of holes (positive charge) in its atomic structure. The condition of excess electrons and holes can occur by doping the material with dopant atoms. As for example in order to obtain p-type silicon material, silicon is doped by boron atoms, while to obtain n-type silicon material, phosphorus atoms

dope silicon. The illustration below depicts p-type and n-type semiconductor junctions.

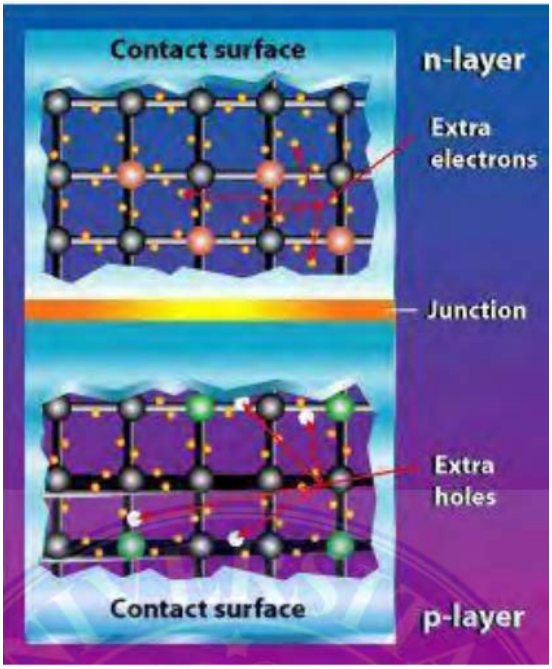



Figure 2.3 Junction between p-type (excess holes) and n-type semiconductors (excess electrons)

The role of the p-n junction is to form an electric field so that the contact material can extract electrons (and holes) to generate electricity. When p-type and n-type semiconductors are in contact, the excess electrons will move from the n-type semiconductor to p-type so as to form a positive pole on the n-type semiconductor, and vice versa the negative pole on the p-type semiconductor. As a result of the flow of electrons and holes, an electric field is formed which when

sunlight hits the p-n junction, it will push electrons to move from the semiconductor to the negative contact, which is then used as electricity, and vice versa the hole moves towards a positive contact waiting for the electrons to come, such as illustrated in the image below.

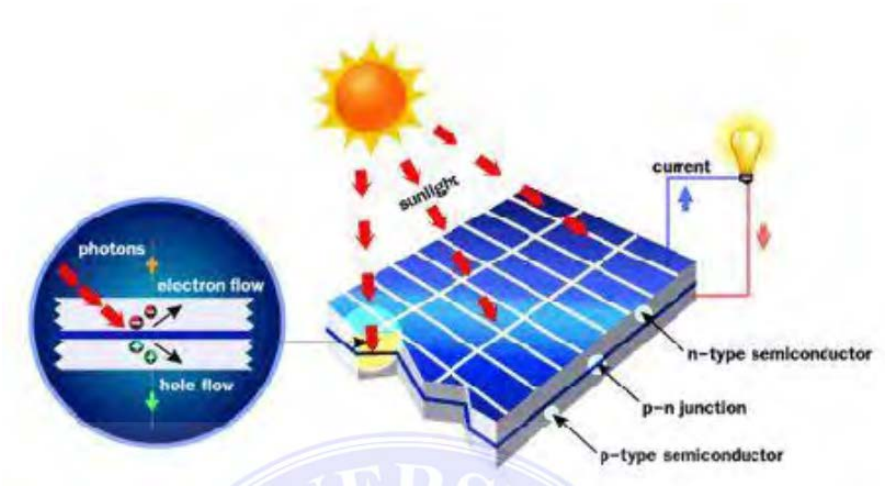



Figure 2.4 Illustration of how a solar cell works with the p-n junction principle.

## 2.10 Conversion Process, Application and Solar Cell

### How to Utilize Solar Energy

Solar cells, photovoltaic, or photovoltaic since the 1970s have changed our way of view to energy and provide new ways for humans to obtain electrical energy without need to burn fossil fuels as in oil, natural gas or coal, no also by taking option with nuclear fission. Solar cells can operate well in almost all parts of the world that are exposed to the sun, from Morocco to Merauke, from Moscow to Johannesburg, and from the mountains to sea level.


Figure 2.5 The use of solar panels on space satellites

Solar cells can be used without pollution, both air and noise pollution, and in any weather. Solar cells have also long been used to power all the satellites orbiting the earth for nearly 30 years. Solar cells have no moving parts, but are easy to move as needed. The advantages of solar cells above are due to their distinctive characteristics of solar cells that directly convert sunlight into electricity.

**1. Conversion process**

The process of converting sunlight into electricity is possible because the materials that make up solar cells are in the form of semiconductors. More precisely composed of two types of semiconductors; i.e., type n and type p.

The n-typed semiconductor is a semiconductor that has an excess of electrons, so it has an excess of negative charge, (n = negative). While the p-type semiconductor has an excess of holes, so it is called p (p = positive) due to the excess positive charge. By adding other elements into the semiconductor, the method can control the type of semiconductor, as illustrated in the figure below.

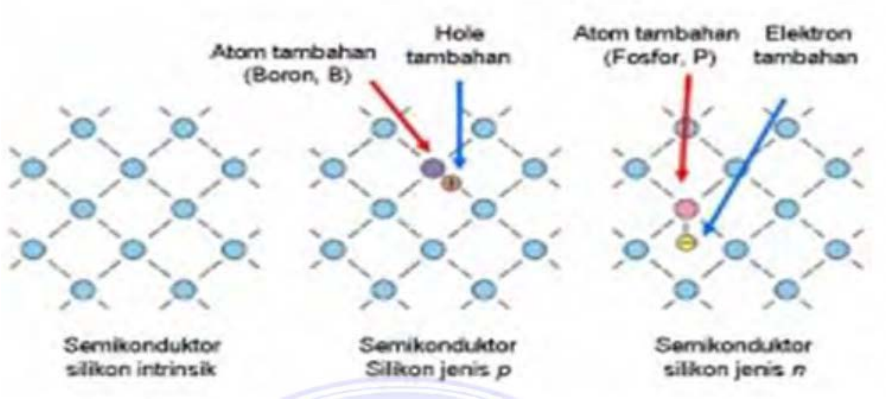



Figure 2.6 Types of semiconductors

Initially, the manufacture of these two types of semiconductors was intended to increase the level of conductivity or the level of electrical conductivity and heat of natural semiconductors. In this natural semiconductor (called intrinsic semiconductor), electrons and holes have the same number. Excess electrons or holes can increase the electrical and thermal conductivity of a semiconductor.

For example, the intrinsic semiconductor intended is silicon (Si). P-type semiconductors are usually made by adding boron (B), aluminium (Al), gallium (Ga) or Indium (In) into Si. These additional elements will increase the number of holes. While the n-type semiconductor is made by adding nitrogen (N), phosphorus (P) or arsenic (As) into Si. From here, additional electrons can be obtained. Meanwhile, intrinsic Si itself does not contain additional elements. The effort to add this additional element is called with doping which amount is not more than 1% compared to the weight of Si to be doped.

These two types of semiconductors of n and p when put together will form p-n junction or p-n diode (other terms call it a metallurgical junction / metallurgical junction) which can be described as follows.

1. P and n type semiconductors prior to be connected.

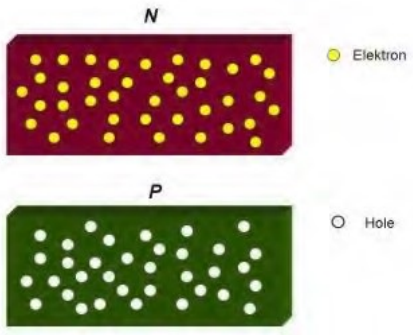



Figure 2.7 Semiconductors of p and n types prior to be connected

2. Immediately after these two types of semiconductors are connected, there is a transfer of electrons from semiconductor n to semiconductor p, and hole displacement from semiconductor p to semiconductor n. The transfer of electrons and holes is only up to a certain distance from the initial connection boundary.

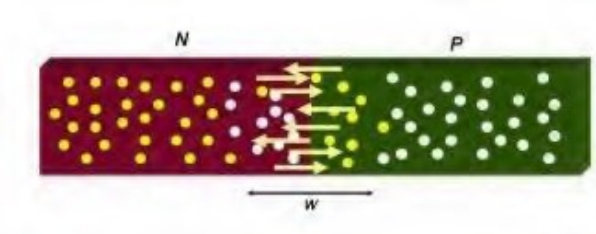



Figure 2.8 Semiconductors of p and n types after being connected

3. Electrons from semiconductor n unites with holes at p semiconductor which causes the number of holes in the p semiconductor to decrease. This area eventually turns out to be more positively charged. At the same time. The holes of the p semiconductor unite with the electrons in the n semiconductor which causes the number of electrons in this region to decrease. This area ends up being more positively charged.

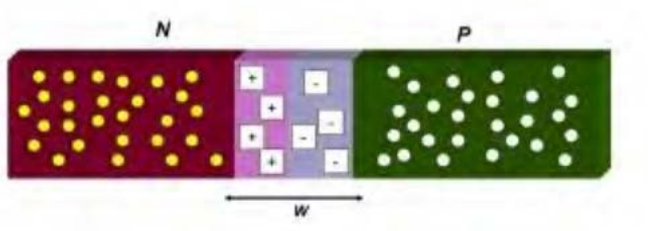



Figure 2.9 Electrons from semiconductor n unite with holes in semiconductor p

4. This negative and positive region is called the depletion region marked with the letter W.
5. Both electrons and holes in the depletion region are called minority charge carriers because of their presence in different types of semiconductors.
6. Due to the difference in positive and negative charges in the depletion region, an internal electric field E naturally arises from the positive side to the negative side, which tries to attract holes to the p semiconductor and electrons to the n semiconductor. This electric field tends to oppose the displacement of holes and electrons at the beginning of the depletion region (number 1 above).

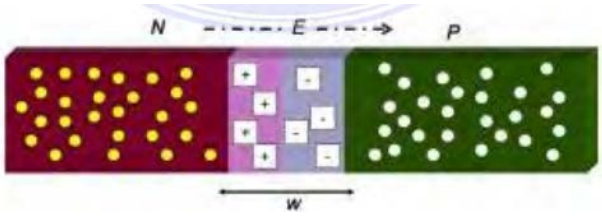



Figure 2.10 Withdrawal of holes to the p semiconductor and electrons to the n semiconductor

7. The presence of an electric field causes the p-n junction to be at the equilibrium point, i.e., the moment where the number of holes that move from p semiconductor to n semiconductor is compensated by the number of holes pulled back towards the p semiconductor due to the electric field E. Likewise,

the number of electrons that move from n to p-semiconductors is compensated by the flow of electrons back into the n-semiconductor due to the attraction of the electric field E.

In other words, the electric field E prevents all electrons and holes from moving from one semiconductor to another.

It is at this p-n junction that the process of converting sunlight into electricity occurs. For the purposes of solar cells, the n semiconductor is on the top layer of the p junction facing the direction of the sun's rays, and is made thinner than the p semiconductor, so that sunlight falling on the surface of the solar cell can continue to be absorbed and enter the depletion region and the p semiconductor.

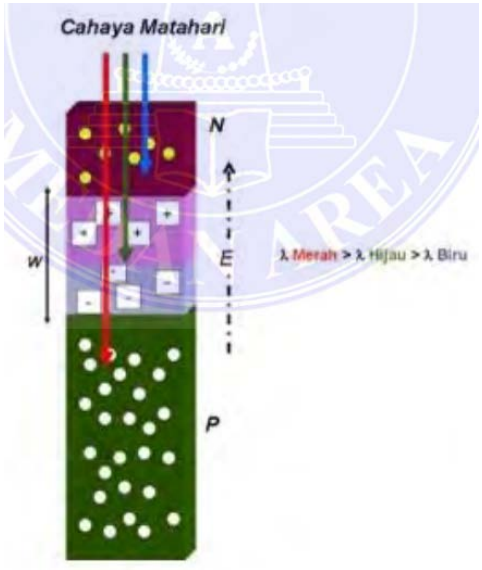



Figure 2.11 The process of converting solar energy to electrical energy

When this semiconductor junction is exposed to sunlight, the electrons get energy from sunlight to escape from the n semiconductor, the depletion region and the semiconductor. The release of these electrons leaves holes in the area left by electrons which is called electron-hole photogeneration (electron-hole photogeneration), that is, the formation of electron-hole pairs due to sunlight.

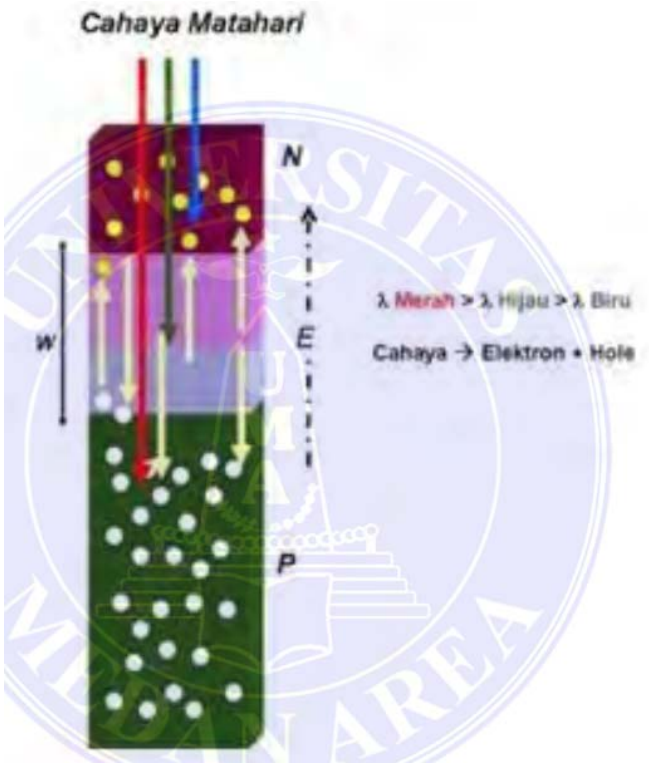



Figure 2.12 Photo of electron hole generation

Sunlight with different wavelengths (denoted by the symbol “lambda” as in the picture above), makes photogeneration on the pn junction at different parts of the pn junction as well.

The red spectrum from sunlight, which has a longer wavelength, is able to penetrate the depletion region until it is absorbed in the p semiconductor which eventually results in the photogeneration process there.

The blue spectrum with a much shorter wavelength is only absorbed in the n-semiconductor region.

Furthermore, because the pn junction has an electric field E, the photogenerated electrons are attracted to the n semiconductor, as well as the holes are attracted to the p semiconductor.

When a series of wires are connected to two parts of the semiconductor, electrons will flow through the wires. If a small lamp is connected to a wire, the lamp lights up because it gets an electric current, where this electric current arises due to the movement of electrons.

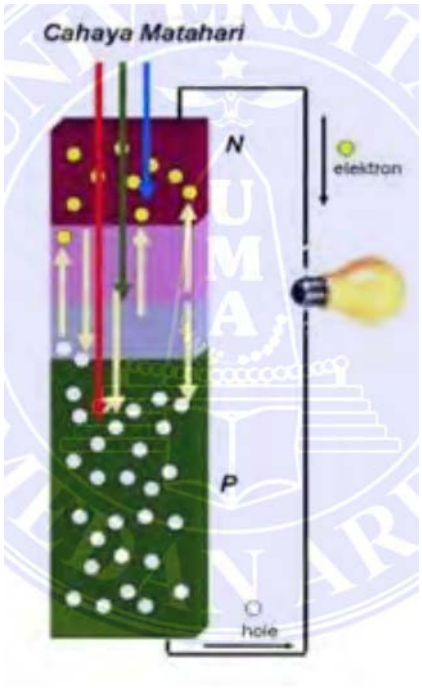



Figure 2.13 The movement of electrons can light up a lamp

## 2.11 Distribution of Electrical Energy from Solar Cells to Batteries

Solar cell is a type of power plant that does not produce pollution so it is environmentally friendly, in addition, it does not produce noise, and durable. As in the previous explanation that solar cells are very dependent on the intensity of sunlight entering its surface.

What happens is that the power supplied by this solar cell varies and is unstable depending on the lighting conditions at that time, so that if the solar cell is connected directly to the load, it can damage the load. The solution is to use an energy storage system that stores the electrical energy and then connects it to the load, so that when the sun's irradiation is in cloudy conditions, the energy storage system can still supply the load in stable condition.

The energy storage system that is often used is the battery/accumulator. Solar cells that have a nominal voltage of 12 V, usually can produce a voltage that changes from 8 - 20 V, while the battery used has a nominal voltage of 12 V. The difference between the output voltage of the solar cell and the battery, obviously, it has an impact, namely damage to the battery, which will reduce the lifetime of the battery. Therefore, a voltage regulator is needed to convert the solar cell voltage to 12 V. This regulator in addition to functioning as a voltage regulator, must also have a function as a protection diode, so that it only passes current to the battery and there is no backflow to the solar cell. In the afternoon, in the absence of irradiation from the sun, the voltage from the solar cell can be smaller than the battery, which allows for a reverse current from the battery to the solar cell, but with the presence of this protective diode this does not happen. This regulator is also referred to as a Charger.

## 2.12 The process of absorption and supply of solar energy

The electrical energy supplied to the battery can be directly used by the motor because the stored energy is in the form of DC current (Direct Current) and the motor used is a DC motor.

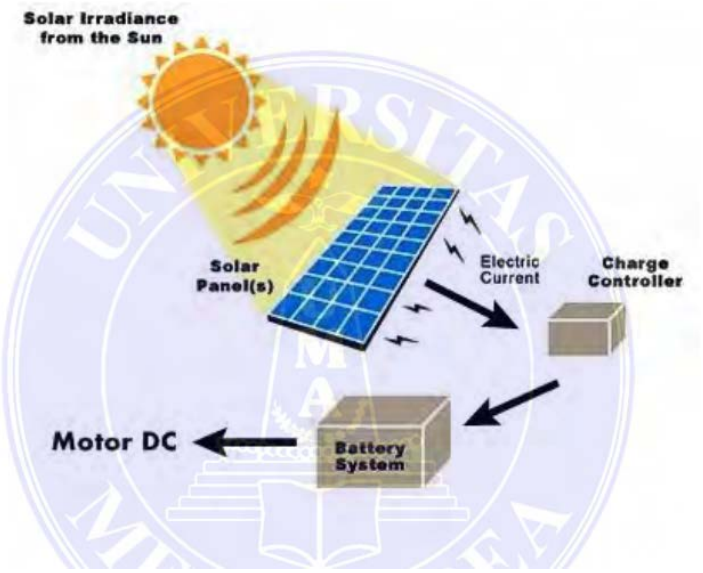



Figure 2.14 working system of solar panels

## 2.13. Hardware Design and Realization

The hardware of this tool consists of several modules:

### 2.13.1 Solar Cell Module

Solar modules (polycrystalline) are a number of solar cells arranged in series and parallel, usually consisting of 28-36 cells to increase the voltage and current generated so that it is sufficient for the use of the load power supply system. To get the maximum output of electrical energy, the surface of the solar module must always point to the sun. The main component of a photovoltaic solar system is a module, which is an assembly unit of several photovoltaic solar cells. To manufacture photovoltaic modules, you can use crystal and thin film technology. Crystal photovoltaic modules can be made with relatively simple technology, while high technology is required to make photovoltaic cells.

### 2.13.2 Battery Module

The battery functions as an energy storage medium, namely electrical energy from solar panels. The battery used is a dry lead acid-typed battery with a working voltage of 12 V, 7.2 AH. The use of this battery is due to the lack of

constant solar power in generating electricity. In cloudy conditions, the electricity generated is not enough to drive the circuit, so a battery is needed so that electrical energy is still available


Figure 2.16 Battery Module

### 2.13.3 Microcontroller Module

Microcontroller is a digital electronic device that has input and output as well as control with programs that can be written and erased in a special way. The microcontroller functions as a system controller where the microcontroller is programmed in C language, namely CVAVR, Version 2.04.9. The function of the controller in the circuit is to control the driving motor through sensor detection, in addition, the controller also regulates battery charging from the solar panel. The microcontroller used in the device is ATMega8, this type has 28 pins, which own their respective roles, whether as ports or other functions.

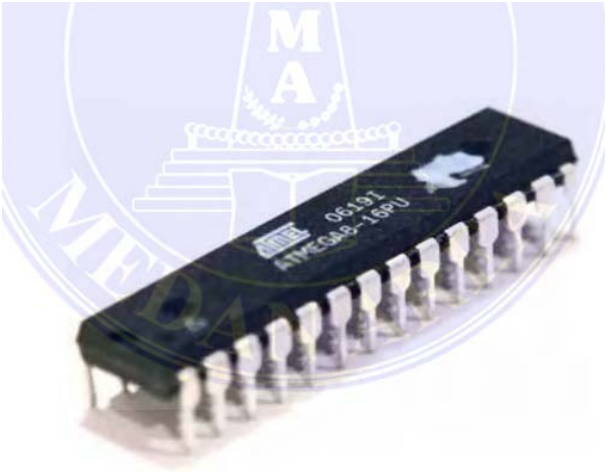



Figure 2.17 ATMega8 . Microcontroller

# CHAPTER III

# RESEARCH METHODOLOGY

## 3.1 Research Method

This study discusses the use of solar energy as an alternative energy to operate an automatic garbage scraper. In addition, in this study, testing and system performance will be carried out which will produce data for analysis.

## 3.2 Time and Place.

The design and research of the tool will be carried out at the Engineering Laboratory of Machinery in Medan Area University.

## 3.3 Research Procedure Flowchart

The following is flow chart of the research procedure as shown in Figure 3.1 :

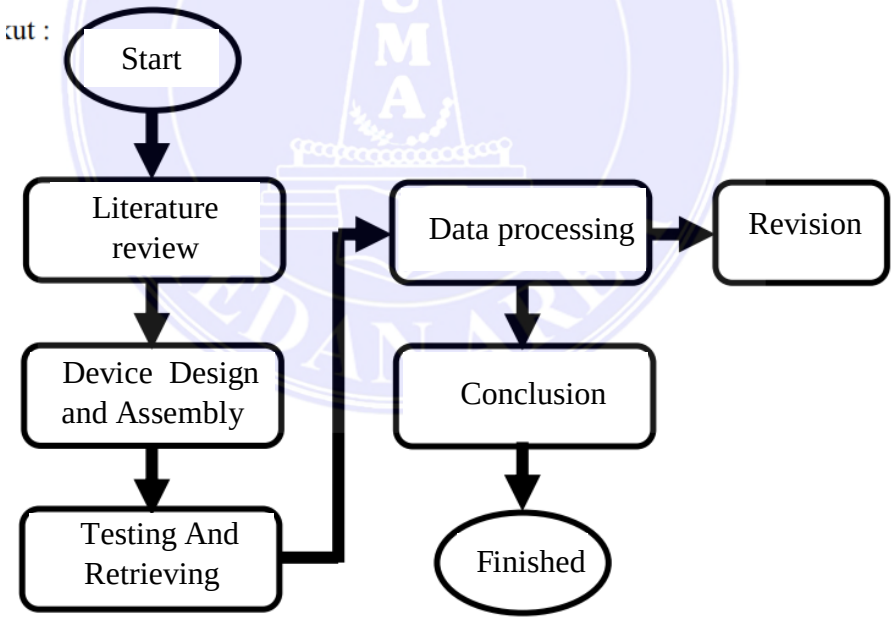


Figure 3.1 Work Procedure Flowchart

### 3.4 Testing Equipment

Here are some measuring tools used in this study:

**1. Thermometer**

The thermometer is used to measure temperature, it is also used to determine the temperature on the solar cell panel where the thermometer is placed at the top of the solar cell when measurements are taken every 20 minutes.

**Figure 3.2 Digital Thermometer**

**2. Anemometer**

Anemometer is used to measure wind speed which is widely used in the fields of metrology and geophysics or weather forecasting stations. The name of this tool comes from the Greek word anemos, which means wind. The first designer of this tool was Leon Battista Alberti in 1450. It can also measure the amount of wind pressure when measuring wind pressure, the anemometer position is directed at wind pressure.


Figure 3.3 Anemometer

**3. Digital Multimeter**

This tool serves as a measuring tool used to measure electric voltage, electric current, and resistance (resistance). while on its development, Multitester can still be used for several functions such as measure temperature, inductance, frequency, and so on. There are also people who call the multimeter as AVO meter, which means A (amperes), V(volts), and O(ohms).


Figure 3.4 Digital Multimeter

**4. Solar Power Meter**

This tool serves as means of testing and measuring the intensity of solar energy. Solar energy itself is energy that can be obtained by converting energy solar heat (the sun) through other devices into other form of energy sources. Solar energy itself is one of the energy resources other than water, steam, wind, biogas, coal, and petroleum. Solar power meter is a device that tests solar power where this solar power source is converted from sunlight into electricity, either directly by using photovoltaic.

Figure 3.5 Solar Power Meter

### 3.5 Block Diagram of Device Work Process

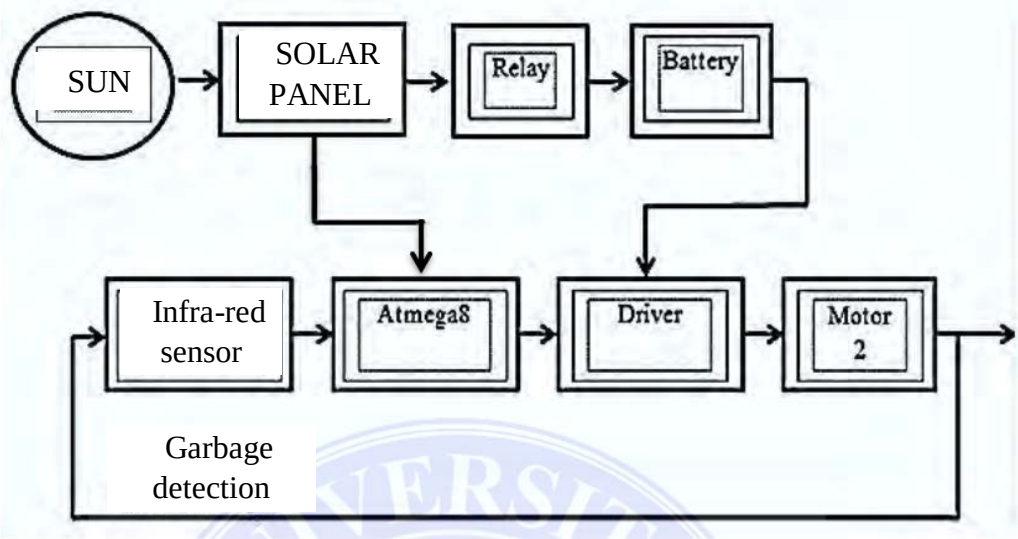



Figure 3.6 Block Diagram of Work Process

In Figure 3.7 above the block diagram describes the process flow, from input to output. There are 2 system inputs, namely solar energy and the condition of the presence or absence of waste. The energy input is converted by a solar panel from sunlight into electrical energy. The output of the solar cell is used for battery charging where the charging process is controlled by the microcontroller. The ATmega8 output battery is used to run the circuit including the driving motor. The input of the condition of the presence or absence of garbage is detected by the infrared sensor. Where if the sensor detects no obstruction between the infrared transmitter and the sensor logic, the sensor output will be zero. And vice versa if there is garbage between the sensors, it will be logical of 1, then sensor output is read by the microcontroller. If logic value is 1 and then sensor will cause the

microcontroller to activate the motor, through the current amplifier. In this sensor logic value 0 = 0 volts, and logic value 1 = 5 volts.

### 3.6 Flow Chart of Device Work System

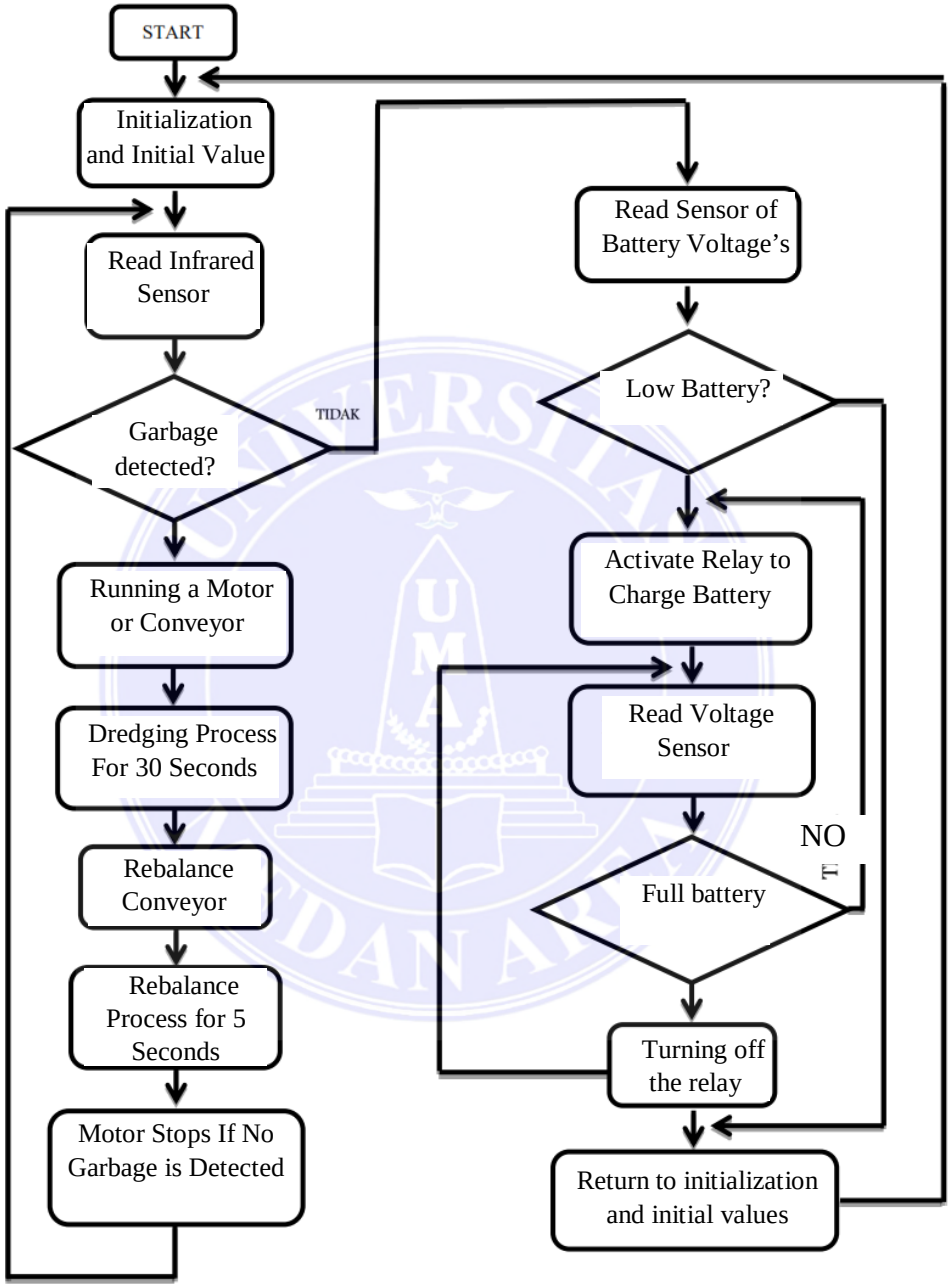


Figure 3.7 Flow chart of Device Work System

**Description of Device Work Flowchart**

From the flowchart above, a diagram that is seen in Figure 3.3 explaining the flow of the program created, namely the system working process flow, which starting from initialization and initial values, namely determining input and output and initial conditions, then the controller reads the infrared sensor, which is a sensor that detects the presence of garbage in the water flow. If the sensor is blocked by garbage, the sensor will be 1 or higher, so that the program will activate the conveyor motor to lift up the garbage. The conveyor work process is carried out in circulation within 30 seconds then will be continued in the rebalancing process to stabilize the conveyor within a time of 5 seconds. After that, the motor will be stopped. The program will also detect the condition of the battery if the battery is low, then the controller will also activate the relay charger to recharge the battery with solar power.

# CHAPTER V

# CONCLUSIONS AND SUGGESTIONS

## 5.1 Conclusion

From the results of the analysis above, several conclusions can be drawn to complete the results of the prototype design of a microcontroller-based garbage scraper with solar power as follows:

a. An analysis of the automatic garbage scraper using solar power has been carried out.
b. The analysis is carried out to find out and at the same time for testing whether this prototype can be used in everyday life.
c. The results of the testing proves that the power generated by the solar cell is sufficient for the operation of the device for approximately 1 hour.
d. The use of polycrystalline solar panels is very suitable for areas that have variable sunlight intensity.
e. Polycrystalline solar panels have an efficiency of 7.06%

## 5.2 Suggestions

a. It is hoped that this prototype can be designed and updated physically to make it stronger, tougher and of course more attractive.

b. Making additional to solar panels that are arranged in series so that the power generated is greater, thus, this prototype can charge the battery faster and work longer.
c. We recommend that the tilt position of the solar panel can be designed automatically so that it can follow the direction of the sun's motion.

PROOFREADING

| | | | |
|---|---|---|---|
| 1. | varies in extreme ways | : | varies in powerful ways |
| 2. | very cloudy air | : | very dirty air |
| 3. | today has been able to touch all aspects | : | has touched all aspects |
| 4. | Various programs have been implemented by the Indonesian government | : | The Indonesian government has implemented various programs |
| 5. | towards the use of alternative | : | towards using alternative |
| 6. | focuses on the utilization of solar energy | : | focuses on utilizing solar energy |
| 7. | The objectives of this research are to utilize | : | This research aims to utilize |
| 8. | there is an N-typed section which is nickel plated also | : | an N-typed section is nickel plated and serves |
| 9. | and the energy of the sun | : | and the sun's energy |
| 10. | which will produce | : | producing |
| 11. | a place where there is less sunlight | : | a place with less sunlight |
| 12. | consists of an array of solar cells | : | consists of solar cells |
| 13. | but also has the impression | : | and have the impression |
| 14. | efficiency through the use of the latest Polycrystalline cells | | efficiency by using the latest Polycrystalline cells |
| 15. | is durable in the field and easy to install | | durable and easy to install |
| 16. | Apart from being used to generate electricity | | Apart from generating electricity |
| 17. | and when irradiated with sunlight can prod`uce a voltage | | irradiating sunlight can produce a voltage |
| 18. | semiconductor so as to minimize | | semiconductor to minimize |
| 19. | silicon is doped by phosphorus atoms. | | phosphorus atoms dope silicon |
| 20. | Solar cells are able to operate well | | Solar cells can operate well |
| 21. | All the advantages of solar cells | | The advantages of solar cells |