DESIGN OF PI-CONTROLLER FOR STAND-ALONE HYDROKINETIC ENERGY HARNESSING

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Thesis submitted in fulfillment of the requirements
for the award of the degree of
Bachelors of Engineering Technology (Electrical) with Honours

Faculty of Electrical & Electronics Engineering Technology

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FEBRUARY 2022

ACKNOWLEDGEMENTS

Alhamdulillah, all praise belongs to Allah the most gracious and the most merciful for giving me strengths, blessing and opportunity in completed our senior design project. We managed to finish our individual task with some help and effort by the person around us.

First and foremost, I would like to convey my highest gratitude to our advisor, Dr. Wan Ismail Bin Ibrahim for his full supportive and encouragement from the start until the end of with productive knowledge and experience throughout this project.

Moreover, a golden appreciation also goes to Universiti Malaysia Pahang (UMP) which provided us equipment and facility for our group to conduct this senior design project smoothly. Then, my greatest appreciation sincere thanks to all of my fellow members, Muhammad Aliff Rasydan Bin Ruhatan and Nurfarizathul Akma Binti Roslan for their idea, support, discussion, passion and cooperation to make the project possible. Their continuous supports do help me to overcome the entire obstacle that I have faced during this SDP.

Not to forget, my deepest gratitude goes to my precious and beloved family for their prayers, support and help to provide assistance in mental and physical state in executed this SDP project. Finally, I would like to thanks everyone had involved in these studies or project either directly or indirectly.

ABSTRAK

Terdapat banyak jenis turbin yang boleh dilaksanakan sebagai penukaran tenaga. Walau bagaimanapun, kebanyakannya digunakan pada empangan yang memerlukan kadar aliran air yang tinggi. Dalam projek ini, turbin aliran silang untuk memanfaatkan tenaga hidrokinetik direka untuk mengekstrak tenaga untuk halaju air berkelajuan rendah. Pengawal PI direka untuk menjejak dan mengawal kerana corak dan variasi dalam aliran air, halaju air tidak linear dan tindak balas penjejakan yang perlahan. Selain itu, sistem pemantauan juga direka bentuk untuk memeriksa nilai kuasa dan arus untuk memanfaatkan tenaga hidrokinetik. Penambahbaikan mekanisme ini akan diaplikasikan di kawasan luar bandar. Turbin air aliran silang dilaksanakan dalam projek ini. Hasilnya menunjukkan bahawa kuasa keluaran yang cukup yang dihasilkan oleh turbin adalah mencukupi untuk membekalkan tenaga elektrik untuk peralatan penggunaan rendah.

ABSTRACT

There are many types of turbines that can be implemented as an energy conversion. However, most of them were applied on dam that need high water flow rates. In this project, the cross flow turbine for hydrokinetic energy harnessing is designed to extract the energy for low speed water velocity. PI-controller is designed to tracking and control due to pattern and variation in water flow, non-linear water velocity and slow tracking response. Besides, monitoring system also designed to check the value of power and current for the hydrokinetic energy harnessing. The improvement of this mechanism will be applied the in rural area. The cross flow water turbine is implemental in the project. The result is show that the output power enough produced by the turbines is sufficient to provide electrical energy for low consumption appliances.

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LIST OF SYMBOLS

%	Per cent
H	Henry
u	Micro
V	Voltage

LIST OF ABBREVIATIONS

PWM	Pulse Width Modulation
LCD	Liquid Crystal Display
IDE	Integrated Development Environment
IoT	Internet of things
PID	Proportional Integral Derivative

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CHAPTER 1

INTRODUCTION

1.1 Project Background

Hydroelectric energy is used to create electricity through water movement. Water runs over a turbine and rotates a generator blade. Strom is then supplied to the electricity grid, a customer or a storage device (Kim & Bernitsas, 2016). A dam where water is kept until power has to be generated is the most frequent form of hydroelectric plant. Hydrokinetic energy conversion systems are machines that can transform the kinetic energy of river streams, tidal tides, or man-made waves into electricity water transforms into usable energy (Lago et al., 2010).

Three forms of energy can utilise hydrokinetic power, inland (rivers), tidal (estuary) and ocean (currents). Most of the HEC technology research and development too far has been targeted to tidal systems, and development of internal or ocean current devices has been rather low (Lee et al., 2011). Inland locations usually confront more user strife than coastal and tidal locations. Current makers of sea equipment have an important challenge in the creation of cheap deep water mooring systems (Valentine & Von Ellenrieder, 2015).

Two methodologies are generally used to use water energy, namely hydrostatic and hydrokinetic ways. Hydrostatic technique is the traditional method of storing water in reservoirs for generating a pressure head and obtaining potential energy from water by means of appropriate turbo-machinery. The benefits of hydro-kinetic energy technologies are the standard ways of manufacturing. Hydrokinetic systems need little civil labour. An electromechanical device is a hydrokinetic system which transforms the kinetic energy of water flow into electric energy through a generator and power electronic converter, as shown in Figure 1.1 (Khan et al., 2008).

Furthermore, a hydrokinetic system is built on free flowing water without building a reservoir or a floor. Because of the compact size of the plant, the system is easy to move and transfer (Ibrahim et al., 2021). There are many types of hydrokinetic turbines that can be implementing as an energy conversion to extract the energy. Nevertheless most of them were applied in conventional hydropower and wind energy conversion system (WECS). Hydrokinetic turbines may fundamentally be classified as horizontal and vertical axes. Two groups can divide the horizontal axis turbines. The initial rotary axis is parallel to the direction of the water stream. The other axis is perpendicular to the direction of the water stream. The perpendicular horizontal axis turbines, which will be no longer available since the technology is ancient and well-known, can be categorised as water wheel or cross-flow turbines (Güney & Kaygusuz, 2010).

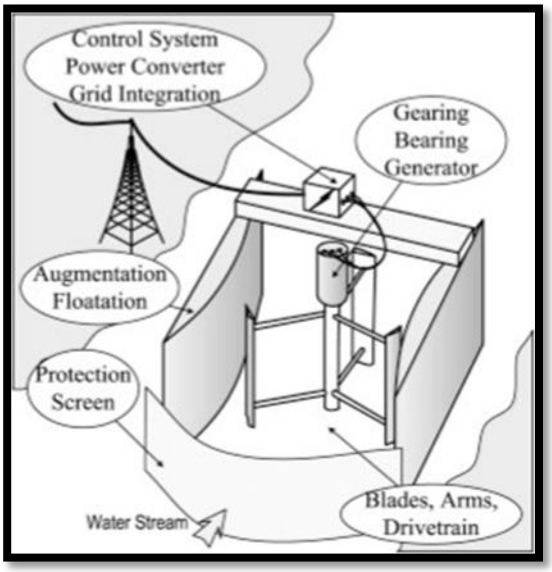

Figure 1.1: The hydrokinetic system is converting to electrical energy

Source: (Khan et al., 2009)

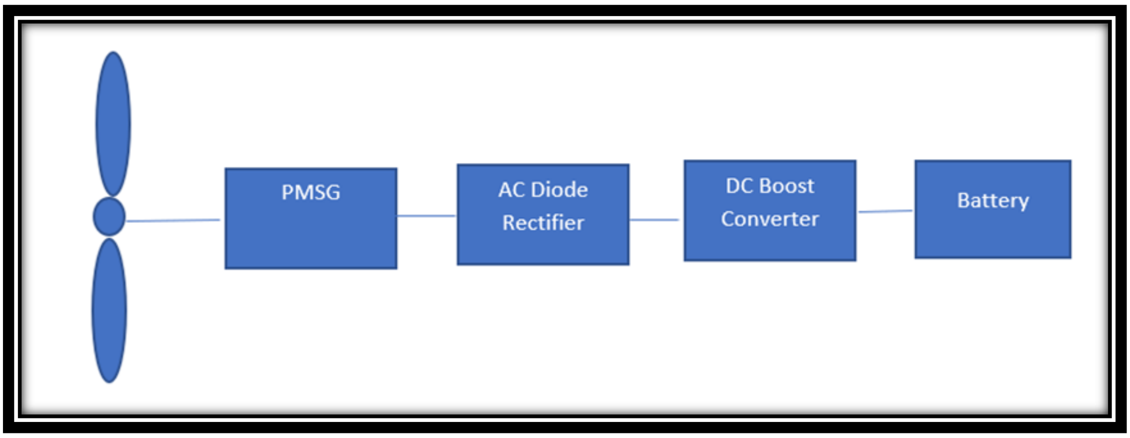

Figure 1.2: Operation of Stand-alone hydrokinetic

Source: (Ibrahim et al., 2021)

Figure 1.2 is shows the operation of Stand-Alone of Hydrokinetic Design. The system consists of the generator (PMSG), Ac Diode Rectifier, DC converter and 12V battery.

The aim of the controller is to control to optimize its energy efficiency, since the optimum hydrokinetic turbine power is achieved at different turbine rotor speeds at different water speeds.

Hydrokinetic studies are not only evaluations and the enhancement of turbines, but also non-turbine conversion of energy and environmental study (Arias & De Las Heras, 2019). Several organisations have studied various concepts for hydrokinetic hydropower conversion systems, such as a membrane a flapping foil and two tandem flapping hydrofoils (Duarte et al., 2019).

The kinetic energy can be captured directly in the speed of flowing water by hydrokinetic equipment instead of the possible energy of falling water. This is a new hydropower type with little environmental impact (Ginter & Pieper, 2011). Various methods, such float or boom systems and oscillate water column devices, are being developed to collect hydrokinetic energy. Hydrokinetic turbines are one of the most often utilised of these technologies. The physical principles of use, the electrical hardware and the variable speed capability for optimum energy extraction are closely like hydrokinetic turbines with wind turbines (Kuschke & Strunz, 2011). Even at low current speed, water turbines are more effective than wind turbines. Furthermore, the technology of wind turbines requires a big land area, whereas hydrokinetic turbines may function under water (Wind, 2011).

The pitch angle control is typically used in medium to large turbine systems to maximize power output and to minimize torque and power output changes for high water speeds. The mechanical arrangement limitations, however, make the pitch angle control unreal for small-size turbine systems. Therefore, a power converter in small-scale turbine systems such as the boost converter is generally implemented for the MPPT control. A microcontroller is needed to control the operation of the power converter (Kim et al., 2021).

In order to run at the highest power stage, the signature turbine power versus rotating speed is preserved in memory for one particular turbine. The difference between the maximum power available and the actual output power can be found by measuring the rotational speed of the turbine. Therefore, a dynamic control strategy for a small-scale hydrokinetic turbine system is proposed in this project (Sun & Bernitsas, 2019).

1.2 Problem Statement

Hydrokinetic technology is one of the best options to provide the electricity at the remote area near to the river, nevertheless several issues need to consider such as low water velocity and shallow water depth.

Second, low energy extraction due to pattern and variation of water flow which is non-linear water velocity and required a control strategy for max energy harnessing. Lastly, not able to monitor the status of devices because operate in the river.

1.3 Objectives

Therefore in this project, the control strategy for hydrokinetic energy harnessing:

- To develop PI-controller for stand-alone hydrokinetic energy harnessing.

- To develop Maximum Power Point Tracking (MPPT) for stand-alone hydrokinetic energy harnessing.
- To design a basic boost converter circuit for stand-alone hydrokinetic energy harnessing.

1.4 Scope

The scope of the development of stand-alone hydrokinetic energy harnessing:

- The focus of this study is on harnessing hydrokinetic energy, by using nature flow of the water, we will use the turbine to generate kinetic energy.
- By using vertical axis turbine, the water will flow direct onto the turbine and generate the electricity.
- This project will use the rectifier to convert AC to DC to charge the battery, then the project will use boost converter to step up the voltage and finally, by using the rectifier, it's will charge battery for consumer.
- Output power is limited to 200W
- The depth of river is limited to 5m
- The width of river is limited to 5m
- Monitoring system using ESP8266 wifi connect to the blynk

CHAPTER 2

LITERITURE REVIEW

2.1 Introduction

The availability of the hydrokinetic generated power depends on the speed of the river, ocean, or tidal current which is expressed as a function of the density of the water multiplied by the speed of the water current cubed (Ding et al., 2019).

As the need for reliable sources of energy production continues to increase, studies suggest that hydrokinetic energy projects based in rivers and oceans can one day supplement over ten percent of our energy needs. As a result, projects are well under way around the world to assess the potential of this seemingly limitless supply of water based energy (Lv et al., 2021).

Unlike more traditional hydro power generating projects, hydrokinetic energy projects do not require large dams, impoundments of water or canals and diversions of the water. Instead, hydrokinetic projects produce electricity by harnessing the power of moving water in waves, river currents, and tidal channels. Hydrokinetic technologies can be classified based on the main ways that they harness the hydrokinetic energy and their location (Zhang et al., 2019).

Generally hydrokinetic turbines are modelled to have a fixed speed rotor in which propeller turns with a constant rotational speed (rpm). More professional systems use variable speed mechanisms for better efficiency. Similarly, the performance of hydrokinetic turbines can also be increased by assigning variable pitch mechanism to the propeller (Kirke & Lazauskas, 2011).

The power output of rotating current energy conversion systems are evaluated as follows;

$$p = \frac{1}{2} p \times A \times Cp \times V^3 \qquad (2.1)$$

Where; P is the total power output from the turbine in Watts, ρ is the density of the fluid, A is the swept area of the rotor blades (m2), V is the flow velocity (m/s) and CP is the power coefficient of the turbine which also represents the overall efficiency.

In-stream hydrokinetic projects generate energy from the horizontal flow of. These energy-generating projects use a variety of technologies, including:

- Horizontal axis turbines
- Vertical axis turbines

2.2 Horizontal axis turbines

The horizontal axis-type turbines shown in Figure 2.1 are used because the rotors are more efficient in translating the water into rotational energy. All grid-connected commercial wind turbines today are built with a propeller-type rotor on a horizontal axis (i.e. a horizontal main shaft). The purpose of the rotor, of course, is to convert the linear motion of the water into rotational energy that can be used to drive a generator. The same basic principle is used in a modern wind turbine, where the flow of wind is parallel to the rotational axis of the turbine blades. Horizontal Axis Water Turbine' is a rotary machine having a horizontal axis of rotation used for electric power generation using the kinetic (flow) energy of water. Water Current Turbine (WCT), Ultra-low-head Hydro Turbine, Free Flow/Stream Turbine, Zero Head (Ladokun et al., 2018).

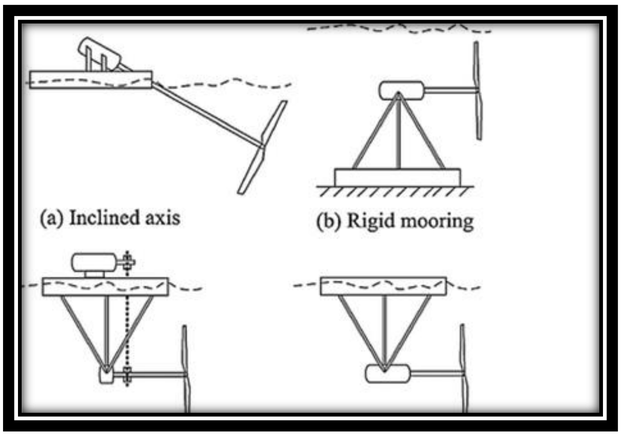

Figure 2.1: Type Horizontal-axis turbine arrangements

Source: (Ladokun et al., 2018)

2.3 Vertical axis turbines

In recent years, many researchers are very interesting to develop vertical-axis turbine because it has many advantages, but also has some drawbacks. (Khan et al., 2009) tried to give illustration in Figure 2.2 about various arrangements under this type.

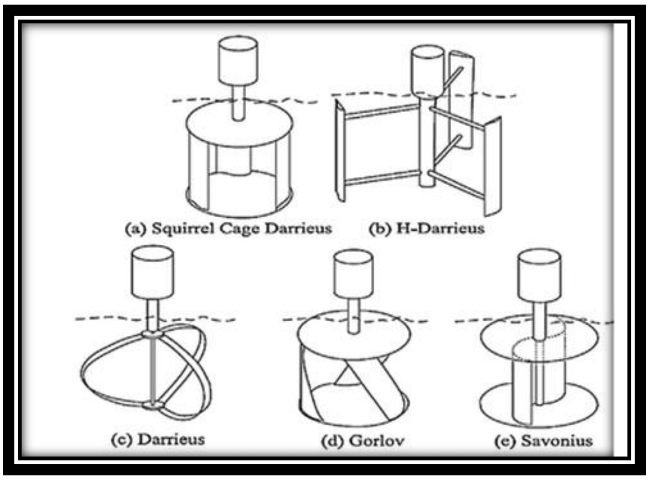

Figure 2.2: Vertical-axis turbine arrangements

Source: (Möllerström et al., 2019)

Darrieus turbines are most known in vertical type. Darrieus turbine arrangements are divided in two categories, they are straight blade (Squirrel Cage Darrieus and H-Darrieus) and curved blade (Darrieus). Gorlov turbine is an innovation from modified darrieus turbine for getting better performance (Möllerström et al., 2019). Its blade shape is helical structure. Darrieus turbines and gorlov turbine are lift type devices. Differ with savonious turbine, it is a drag device.

2.4 Diffuser-augment turbines

The diffuser-augmented turbine technology presents enormous prospects for the development of conventional hydropower from low-speed currents with low head values, particularly due to improved performance in diffuser turbine technologies. It should be mentioned, though, that diffuser may have additional potential advantages, such as flow alignment, protecting rotors and generators from materials carried and supporting rotor loads. In comparison with dam-based hydroelectric technology, such technologies are an excellent alternative as an economic source of permanent energy, provided that a current is available.

Most diffuser-augmented turbine technology components are common as shown in Figure 2.3. The cycles, prices and standards of assembly development are therefore likely to be constrained. These technologies complement a solar system, do not need access to wide areas of flood or civil infrastructure and have little environmental consequences. Parameters of hydrodynamic performance of diffuser-augmented turbines are modelled and examined by changing cambers and attack angles in the cross section of the diffuser (El-Samanoudy et al., 2010).

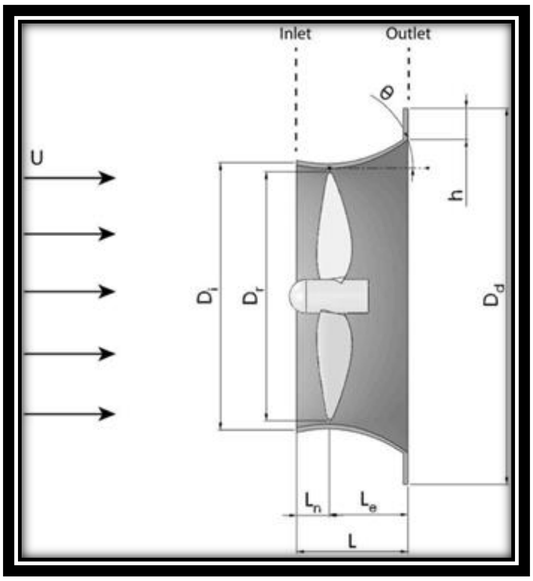

Figure 2.3: Parameters on a diffuser-augmented turbine

Source: (El-Samanoudy et al., 2010)

Whether the turbine is ducted or not is of great importance for the performance of the turbine. Ducts or diffusers are engineered structures that elevate the energy density of a water stream as observed by a hydrokinetic converter (Khan et al., 2009). The duct, or augmentation channel, increases the possible total power capture significantly. In addition, it may help regulate the speed of the rotor and reduce problems caused by low-speed drive train design. A consideration for these devices is of high significance primarily because of two opposing reasons. First, there is the potential of increasing the power capacity, and hence reduce the cost of energy. On the other hand, there may be a lack of confidence concerning their survivability and design (Khan et al., 2009). Figure 2.4 illustrates some of the diffuser types.

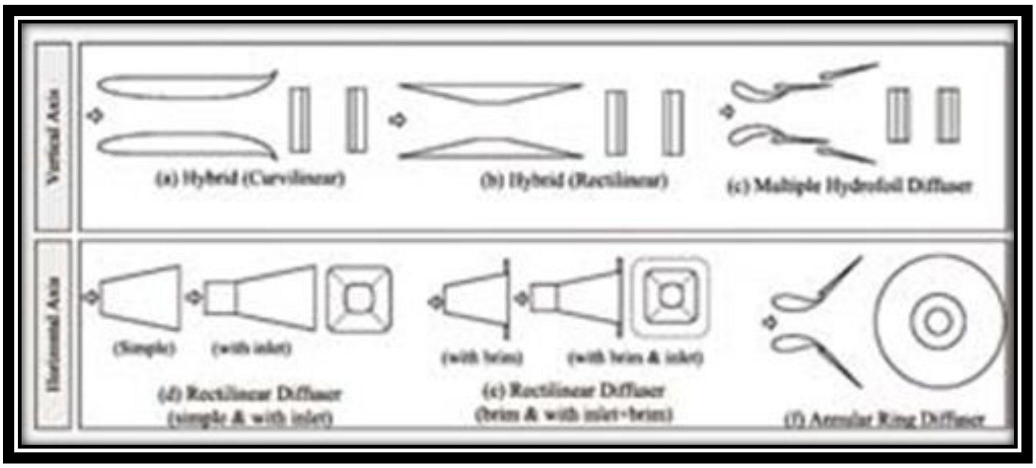

Figure 2.4: Example type of diffuser-augmented

Source: (El-Samanoudy et al., 2010)

Many investigations of diffuser-augmented or conducted turbines were carried out since diffusers may improve the amount of energy extracted and enhance the mass flow through the rotor in relative terms. These diffusers and duction turbines are based on the same idea, where the flowing fluid kinetic energies are used to rotate an electromechanical energy converter to create electricity. This diffuser uses wind turbines also, with the addition of a diffuser to a turbine achieving high performance.

2.5 Rotor design

Changing the shape of the rotor is frequent to boost the power coefficient of the basic turbine. Most works do not modify their current rotor project in the design of a diffuser and strive to fit the diffuser to that project. This is not an ideal procedure since the rotor was not meant to work by improving the diffuser. The optimization was carried out for the rotor blades in view of a diffuser design already described. By means of a one-dimensional analysis they identified ideal rotor load and used this as a base for the strength of a vortex cylinder in the actuator model. The model has resulted in the velocity distribution of the ideal loading factor that was employed by the blade element dynamic approach to build a new rotor (Maldonado et al., 2014).

Tests on the new rotor indicated a 15% improvement on the power coefficient (Cp) on the same diffuser over the prior rotor. The use of algorithms was based on multifocal genetic approaches. This approach processes the adjustment of numerous diffuser or blade shape parameters, evaluating thousands of design points for diffuser-enhanced turbines.

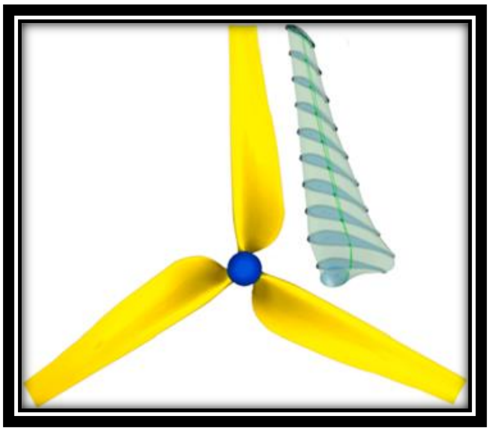

Figure 2.5: Example of rotor and hydrofoil

Source: (Aguilar et al., 2021)

Figure 2.5 shows the example of rotor and hydrofoil, it observe a rotor for optimize the maximum hydrodynamic efficiency does not necessarily result in a turbine with the highest annual energy production; this is rather related to maximizing the turbine efficiency (increasing approach angle/velocity).

A hydrofoils developed by the Fluid-Structure Coupling Innovation Team of KMUST are applied to design the rotor based on the BEM theory with tip loss correction. The rotor has three blades and its diameter is 1.98 m, as shown in Figure 2.5.

2.6 Debris protection

Several types and sizes of natural woody debris were prepared for use in the study to represent at scale the range of piece sizes and shapes that might be encountered in nature, from large trees to smaller branches. (Perry et al., 2018) found that creating model debris from real tree branches provides a more realistic simulation of conditions in nature. For added realism, the model debris pieces used in this study were created from real tree branches complete with knots and bends, and not from smooth, straight wooden dowel (Rochman et al., 2015). The properties of the three different classes of model debris (named small, medium and large) prepared for use in the study are summarized in Table 2.1 Each piece of debris was painted to make them more visible and make it easier to track their trajectory.

Table 2.1: Example of size debris

Debris class FS	Diameter (m)	FS Length (m)	MS Diameter	(m)MS Length
Small	0.01-0.05	0.9-1.1	0.001-0.005	0.09-0.11
Medium	0.1-0.2 4-6	4-6	0.01-0.02	0.4-0.6
Large	0.2-0.3	8-12	0.02-0.03	0.8-1.2

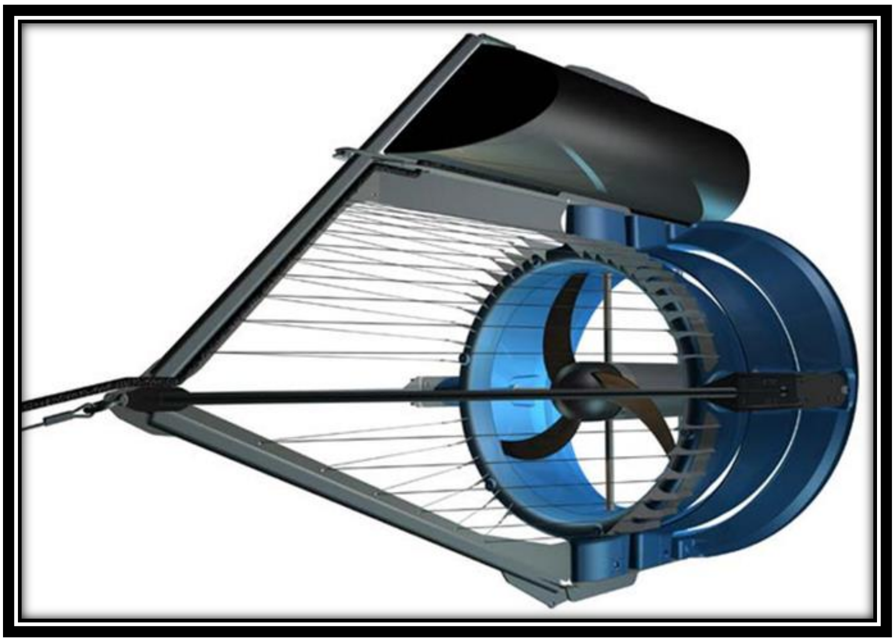

Figure 2.6: Example of debris protection attach

Source: (Rochman et al., 2015)

To protect the blade and maintain performance, a conical debris filter will be attached to the front of the shroud. A large ring (matching the diameter of the shroud opening) and a small ring (connecting to the main anchor line) will be connected with four load bearing bars in Figure 2.6. To filter smaller debris, Kevlar string will be routed longitudinally from ring to ring. Finite element analysis was used to validate the strength and stiffness of the debris filter. As shown in Figure 2.6 used stainless steel cables are carefully designed such that debris neither accumulates nor damages the blades.

2.7 Generator

The three-phase generator, run sequentially with an offset of 120° between them has taken two at a time. Thus, the generator produces three waves of AC voltage in one cycle facilitating the consistent supply of constant voltage. This type of generator is useful when the power requirement is high and constant.

Figure 2.7: YC-200W generator

Figure 2.7 shows the YC-200W generator which produces high efficiency, small size, and high power output. The speed at medium and low to generate the power, YC-200W performance well and can significantly extend the battery life, reduce battery maintenance. Permanent magnet generator brushless, no slip ring structure, eliminating the carbon brush and slip ring friction generated radio interference, but also reduces the generator on the ambient temperature requirements.

2.8 Maximum Power Point Tracking (MPPT)

MPPT is a most popular tool that helps us to use renewable energy source in an efficient way. This project must need to move towards clean energy which is called Renewable Energy (Energy we can get from natural resources) like solar, hydro, wind, water, otherwise this project will directly move toward Global Warming.

In this research, the state of the art Maximum Power Point Tracking (MPPT) of TECS is review such as optimal tip speed ratio (TSR) method; optimum relation based (ORB) method, and perturbs and observes (P&O) method. Based on the reviewed methods, users summarize the principles, advantages and limitations of the methods, and show the performance of MPPT based on P&O in TECS with simulated results. A series of algorithms that tracks the maximum power point (MPP) known as MPP tracking (MPPT) is developed in recent years. Many studies have been carried out on approaches of MPPT. The block diagram of the TECS with MPPT algorithm is shown as below in Figure 2.8. The tidal turbine is coupled with the permanent magnet synchronous generator (PMSG) through a gear box. Compared with other generators, PMSG has higher power density and does not need excitation current from additional devices. The rectifier is a three phase diode rectifier for converting three phase AC voltage to DC voltage. The buck converter is a DC-DC step-down converter that the voltage input-output ratio is controlled by a pulse width modulation (PWM) signal from the MPPT controller. The controller reads the output voltage and current of the tidal generator to modulate the PWM signal (Hsieh et al., 2013).

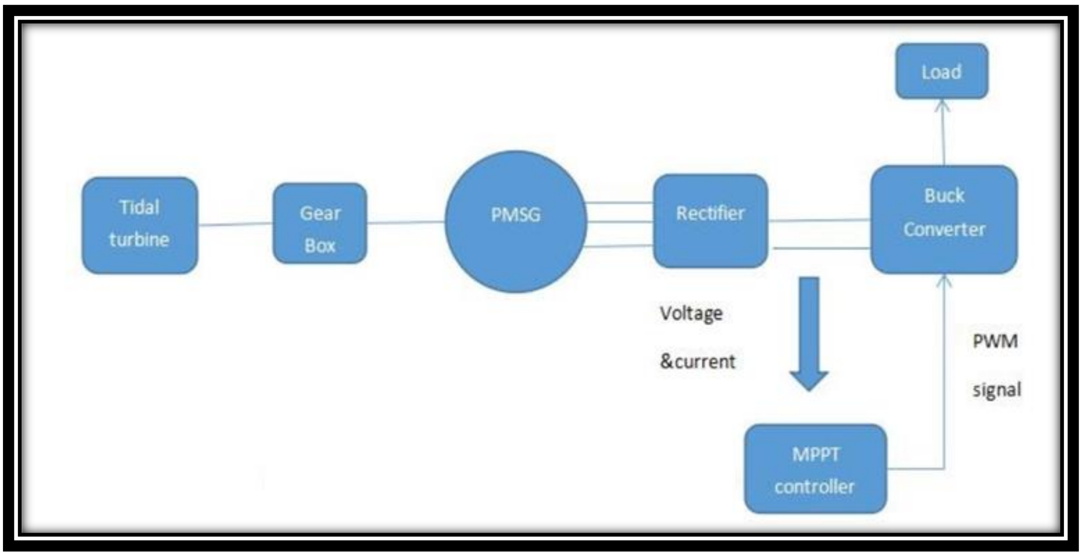

Figure 2.8: Block diagram of a Tidal Energy Conversion System

Source: (Hsieh et al., 2013)

2.8.1 Type of Maximum Power Point Tracking (MPPT)

Generally, MPPT methods can be mainly classified into two categories: sensor based methods and sensor less methods. The sensor based methods are dedicated to develop the MPPT by control of turbine rotating speed at specific tidal current speed, commonly known as TSR (tip speed ratio). TSR control regulates directly the turbine speed or torque to maintain the TSR at an optimum value by measuring the turbine speed. The other sensor method of MPPT is optimum relation based method (ORB) and it requires real-time monitoring of tidal stream speed as well as prior knowledge of tidal turbine characteristics.

Sensor less methods rely on monitoring of the power variation. The most well-known sensor less method is perturb and observe (P&O) algorithm, because it does not need sensors and without the dependency on the system characteristics. It reduces the cost and improves the reliability (Safari & Mekhilef, 2011).

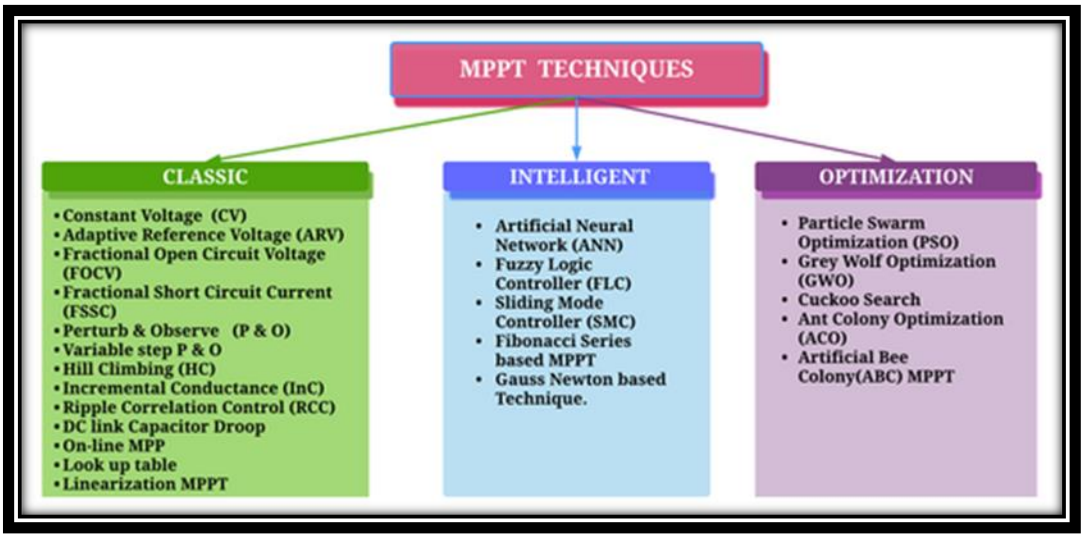

Figure 2.9: Classification of MPPT

Source: (Safari & Mekhilef, 2011)

MPPT techniques are equipped with proper controllers to extract maximum available power from PV configurations. There are various types of MPPT techniques used to run PV modules on maximum power. Nevertheless, the efficiency of the particular technique depends on its tracking ability in instantaneously changing weather conditions. So, depending on the tracking nature in PSC's, these techniques are classified. Discussion is done on all classified techniques and categorised into the following classification, as shown in Figure 2.9.

2.9 PID controller

A proportional–integral–derivative controller (PID controller or three-term controller) is a control loop mechanism employing feedback that is widely used in industrial control systems and a variety of other applications requiring continuously modulated control. A PID controller continuously calculates an error value e(t) as the difference between a desired set point (SP) and a measured process variable (PV) and applies a correction based on proportional, integral, and derivative terms (denoted P, I, and D respectively).

In practical terms, PID automatically applies an accurate and responsive correction to a control function. An everyday example is the cruise control on a car, where ascending a hill would lower speed if constant engine power were applied. The controller's PID algorithm restores the measured speed to the desired speed with minimal delay and overshoot by increasing the power output of the engine in a controlled manner.

The first theoretical analysis and practical application of PID was in the field of automatic steering systems for ships, developed from the early 1920s onwards. It was then used for automatic process control in the manufacturing industry, where it was widely implemented in at first pneumatic and then electronic controllers. Today the PID concept is used universally in applications requiring accurate and optimized automatic control (Åström & Hägglund, 2001).

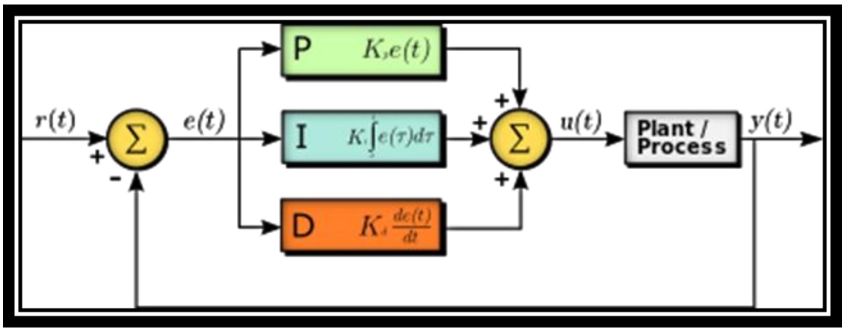

Figure 2.10: The block diagram of PID controller

Source: (Kadu & Patil, 2016)

The distinguishing feature of the PID controller is the ability to use the three control terms of proportional, integral and derivative influence on the controller output to apply accurate and optimal control. The Figure 2.10 shows the principles of how these terms are generated and applied. It shows a PID controller, which continuously calculates an error value e(t) as the difference between a desired set point SP=r(t) and a measured process variable PV=y(t): e(t)=r(t)-y(t), and applies a correction based on proportional, integral, and derivative terms. The controller attempts to minimize the error over time by adjustment of a control variable u(t), such as the opening of a control valve, to a new value determined by a weighted sum of the control terms.

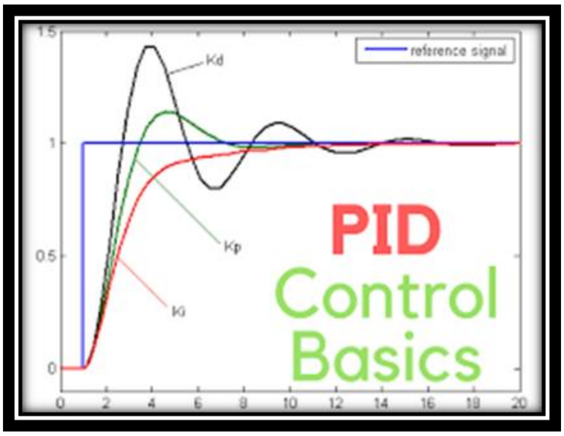

Figure 2.11: Graph of PID controller

Source: (Kadu & Patil, 2016)

In Figure 2.11 shows the graph for PID controller. The graph will maintain at the set point. The PID controller will set the formula in Arduino IDE in coding and combine with another components coding.

2.10 Boost converter

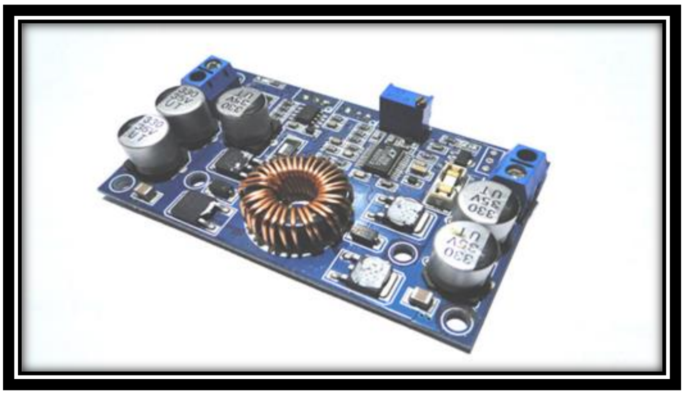

Figure 2.12: Boost converter

A boost converter is one of the simplest types of switch mode converter as shown in Figure 2.12. As the name suggests, it takes an input voltage and boosts or increases it. All it consists of is an inductor, a semiconductor switch (these days it's a MOSFET, since user can get really nice ones these days), a diode and a capacitor. Also needed is a source of a periodic square wave. This can be something as simple as a 555 timer or even a dedicated SMPS IC like the famous MC34063A IC.

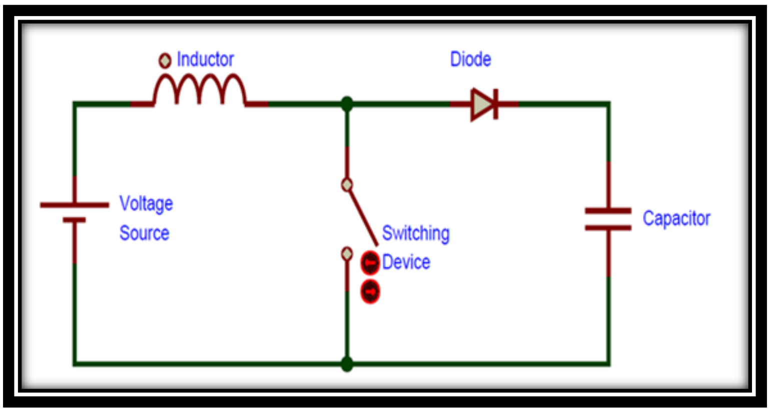

Figure 2.13: Circuit of boost converter

There are only a few parts required to make a circuit boost converter as shown in Figure 2.13. It is less cumbersome than an AC transformer or inductor. They're so simple because they were originally developed in the 1960s to power the electronics systems on aircraft. It was a requirement that these converters be as compact and as efficient as possible. The biggest advantage boost converters offer is their high efficiency – some of them can even go up to 99%! In other words, 99% of the input energy is converted to useful output energy, only 1% is wasted.

2.11 Rectifier

A rectifier is an electrical device that converts an Alternating Current (AC) into a Direct Current (DC) by using one or more P-N junction diodes such as Figure 2.14.

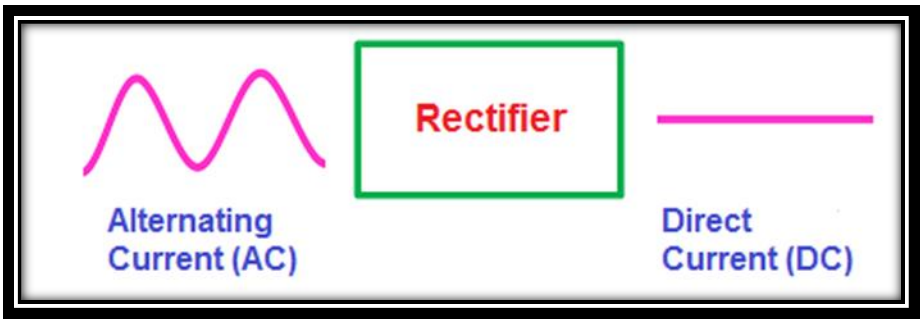

Figure 2.14: AC convert to DC

The voltage is applied to the P-N junction diode in such a way that the positive terminal of the battery is connected to the p-type semiconductor and the negative terminal of the battery is connected to the n-type semiconductor, the diode is said to be forward biased.

2.11.1 Type of rectifier

- Half wave rectifier

  The half wave rectifier is a type of rectifier which converts half of the AC input signal (positive half cycle) into pulsating DC output signal and the remaining half signal (negative half cycle) is blocked or lost. In half wave rectifier circuit, we use only a single diode.

- Full wave rectifier

  The full wave rectifier is a type of rectifier which converts the full AC input signal (positive half cycle and negative half cycle) to pulsating DC output signal. Unlike the half wave rectifier, the input signal is not wasted in full wave rectifier. The efficiency of full wave rectifier is high as compared to the half wave rectifier.

2.12 MOSFET transistor, switching

The transistor field-effect metal-oxide–semiconductor (MOSFET, MOSFET or MOSFET) is a form of field-effect transistor produced by controlled oxidation in a semiconductor, commonly silicone. It is also known as the metal–oxide–silicon transistor (Mosfet transistor, or MOS). The voltage of the cover gate determined the electrical conductivity of the device, for amplifying or switching electronic signals it is possible to adjust the conductivity with the amount of voltage supplied.

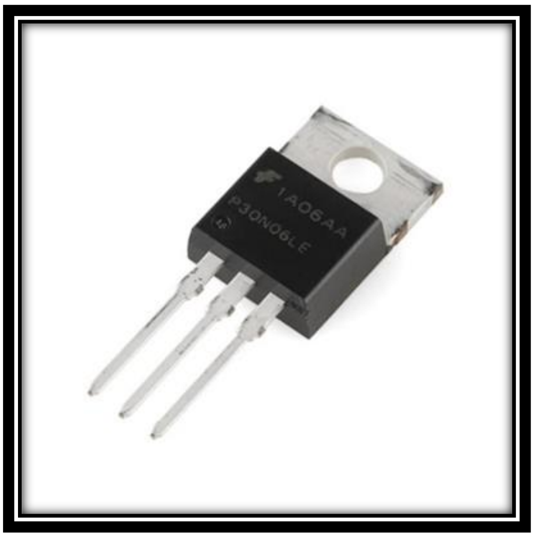

Figure 2.15: Transistor

The transistor as shown in Figure 2.15 is field-effect metal-oxide–semiconductor (MOSFET, MOSFET or MOS FET) is a form of field-effect transistor produced by controlled oxidation in a semiconductor, commonly silicone. It is also known as the metal–oxide–silicon transistor (Mosfet transistor, or MOS). The voltage of the cover gate determined the electrical conductivity of the device, for amplifying or switching electronic signals it is possible to adjust the conductivity with the amount of voltage supplied.

2.13 ESP8266

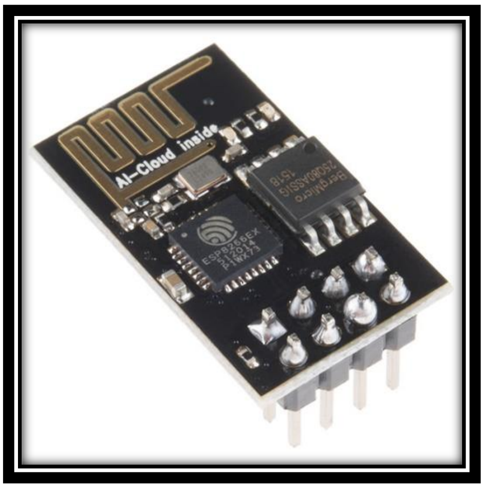

Figure 2.16: ESP8266 wifi module

Figure 2.16 shows the low-cost Wi-Fi microchip, with built-in TCP/IP networking software, and microcontroller capability. The chip made by a third-party manufacturer Ai-Thinker. This small module allows microcontrollers to connect to a Wi-Fi network and make simple TCP/IP connections using Hayes-style commands. However, at first, there was almost no English-language documentation on the chip and the commands it accepted. The very low price and the fact that there were very few external components on the module, which suggested that it could eventually be very inexpensive in volume, attracted many hackers to explore the module, the chip, and the software on it, as well as to translate the Chinese documentation.

2.14 LCD Display (20x4 12C)

This is a new high-quality 4 line 20 character LCD display module with on-board I2C interface such as Figure 2.17. Adjust the contrast, switch on the backlight, and use the I2C communication interface. There's no need for a complicated LCD driver circuit link for Arduino beginners. The true value of this I2C Serial LCD module will be shown, simplify circuit connections, save some I/O pins on the Arduino board, and make firmware creation easier with readily available libraries Arduino library is currently open.

Figure 2.17: LCD Display (20x4 12C)

2.15 Voltage sensor

Voltage Sensor as shown in Figure 2.18 is a precise low-cost sensor for measuring voltage. It is based on the principle of resistive voltage divider design. It can make the red terminal connector input voltage to 5 times smaller.

Voltage Detection Sensor Module is a simple and very useful module that uses a potential divider to reduce any input voltage by a factor of 5. This allows us to use the analog input pin of a microcontroller to monitor voltages higher than it capable of sensing. For example, with a 0V - 5V analog input range, you are able to measure a voltage up to 25V. This module also includes convenient screw terminals for easy and secure connections of a wire.

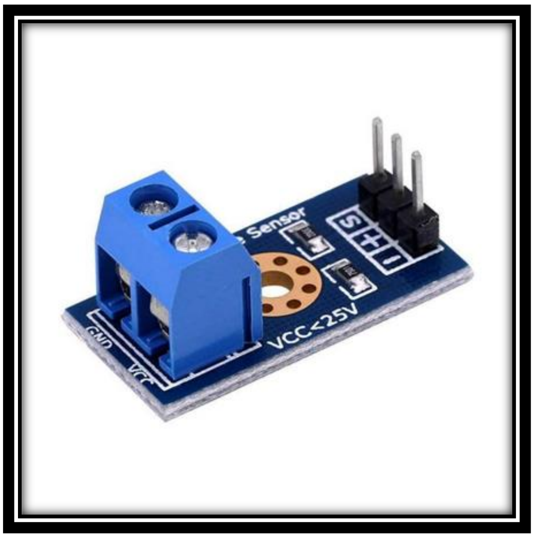

Figure 2.18: Voltage Sensor

2.16 Current sensor

The ACS712 Module uses the famous ACS712 IC as shown in Figure 2.19 to measure current using the Hall Effect principle. The module gets its name from the IC (ACS712) used in the module, so for you final products use the IC directly instead of the module.

These ACS712 module can measure current AC or DC current ranging from +5A to -5A, +20A to -20A and +30A to -30A. You have to select the right range for your project since you have to trade off accuracy for higher range modules. This modules outputs Analog voltage (0-5V) based on the current flowing through the wire; hence it is very easy to interface this module with any microcontroller. So if you are looking for a module to measure current using a microcontroller for you project then this module might be the right choice for you.

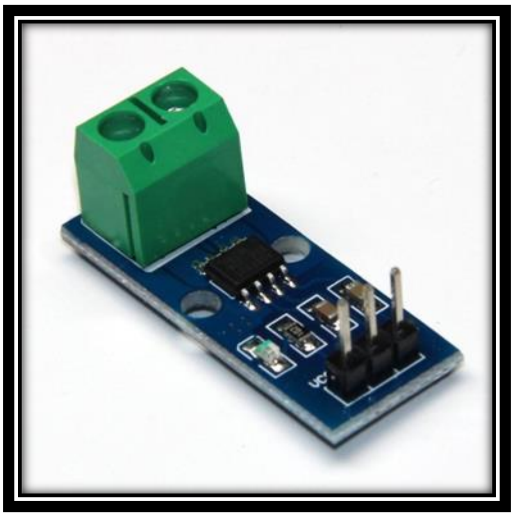

Figure 2.19: Current Sensor

2.17 Arduino Mega

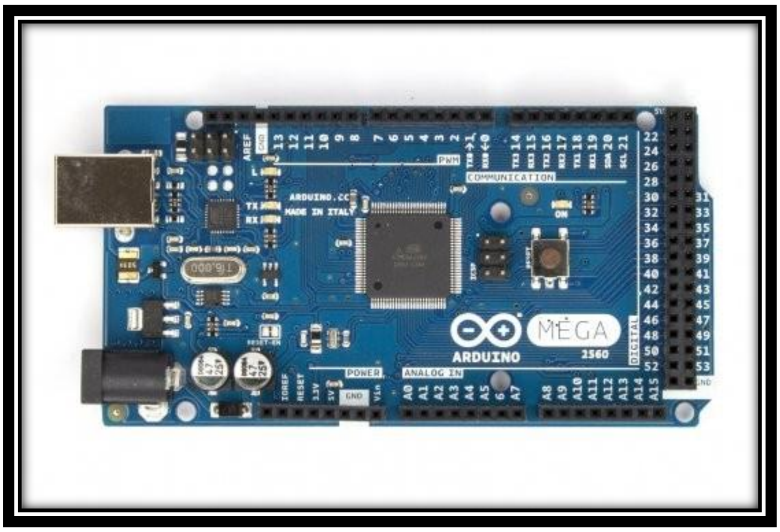

Figure 2.20: Arduino Mega

The Arduino Mega as shown in Figure 2.20 is a microcontroller board based on the ATmega2560. It has 54 digital input/output pins (of which 14 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. Arduino Mega contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started. Never fear for accidental electrical discharge, either since since the Mega also includes a plastic base plate to protect it.

2.18 PWM MOSFET module

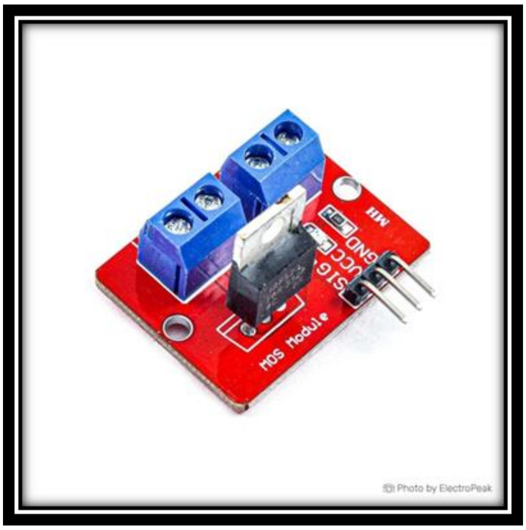

Figure 2.21: PWM MOSFET module

The Figure 2.21 is designed to switch heavy DC loads from a single digital pin of your microcontroller. Its main purpose is to provide a low cost way to drive a DC motor for robotics applications, but the module can be used to control most high current DC loads. The IRF520 in Figure 2.21 is a Power Mosfet with 9.2A collector current and 100V breakdown voltage. The mosfet has a low gate threshold voltage of 4V and hence commonly used with microcontrollers like Arduino for switching high current loads.

2.19 Software description

2.19.1 Arduino IDE

Figure 2.22: Arduino IDE

Arduino IDE in Figure 2.22 is used to control and display for Stand-Alone Hydrokinetic Energy. A text editor for code writing, a massage area, a text terminal, a button toolbar with common actions, and a set of menus are included in the Arduino Integrated Development Environment (IDE) software. It links to the hardware of Arduino and genuino for the uploading and communication of programmes. The hardware of your sketchbook directory can be supported by third-party hardware. There may be board definitions, core libraries, bootloaders and software definitions for installed platforms, which show in the menu.

2.19.2 Proteus simulation

Figure 2.23: Proteus simulation

Figure 2.23 shows the Proteus Design Suite that is a Windows application for schematic capture, simulation, and PCB layout design. The suite combines mixed mode SPICE circuit simulation, animated components and microprocessor models to facilitate co-simulation of complete microcontroller based designs. Proteus has also the ability to simulate the interaction between software running on a microcontroller and any analogue or digital electronics connected to it. It simulates input/output ports, interrupts, timers, USARTs and all other peripherals present on each supported processor.

2.20 IoT (Internet of Things) Operations

2.20.1 Blynk

Figure 2.24: Blynk Apps

Figure 2.24 shows the BlynkApp that supports hardware platforms such as Arduino, Raspberry Pi, and similar microcontroller boards to build hardware for your projects. The following in Figure 2.25 a list of some microcontroller boards that can be coupled with Blynk:

- Espressif (ESP8266, ESP32, NodeMCU, WeMos D1, Adafruit HUZZAH, SparkFun Blynk Board, SparkFun ESP8266 Thing)
- Linux (C++) (Raspberry Pi, Ubuntu)
- Arduino (Arduino UNO, Arduino MKR1000, Arduino MKRZero, Arduino Yun, Arduino 101, Arduino Zero, Arduino M0, Arduino M0 Pro, Arduino Nano, Arduino Leonardo, Arduino Due, Arduino Mega 2560, Arduino Mega 1280, Arduino Mega ADK, Arduino Micro, Arduino Pro Micro, Arduino Mini, Arduino Pro Mini, Arduino Fio, Arduino Decimilia, Arduino Duemilanove, Arduino Pro, Arduino Ethernet, Arduino Leonardo ETH, Arduino Industrial 101)
- Particle (particle core, particle photon, particle electron)

Figure 2.25: List of microcontroller boards with Blynk

2.20.2 The Connection type for Blynk Apps

Blynk supports the following connection types to connect your microcontroller board (hardware) with the Blynk Cloud and Blynk's personal server:

- Ethernet
- Wi-Fi

- Bluetooth
- Cellular
- Serial

Blynk was designed for the Internet of Things. It can control hardware remotely, it can display sensor data, it can store data, vizualize it and do many other cool things. There are three major components in the platform:

- Blynk App - allows to create amazing interfaces for your projects using various widgets provide.
- Blynk Server - responsible for all the communications between the smartphone and hardware. Can use our Blynk Cloud or run private Blynk server locally. It's open-source, could easily handle thousands of devices and can even be launched on a Raspberry Pi.
- Blynk Libraries - for all the popular hardware platforms - enable communication with the server and process all the incoming and outcoming commands.

2.20.3 How the Blynk Apps work

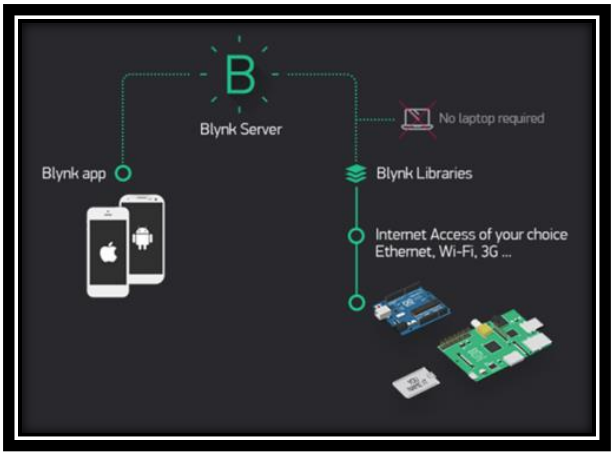

Figure 2.26: How the Blynk Apps work

The Blynk App is a well-designed interface builder. It works on both iOS and Android. The hardware you choose should be able to connect to the internet. Some of the boards, like Arduino Uno will need an Ethernet or Wi-Fi Shield to communicate, others are already Internet-enabled: like the ESP8266, Raspberri Pi with WiFi dongle, Particle Photon or SparkFun Blynk Board. Figure 2.26 is shows how the Blynk Apps work using the smartphone:

- Set of easy-to-use Widgets
- Direct pin manipulation with no code writing
- Easy to integrate and add new functionality using virtual pins
- History data monitoring via SuperChart widget
- Device-to-Device communication using Bridge Widget
- Sending emails, tweets, push notifications, etc.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter will elaborate in details about components and software development such as coding, procedure and design of implementation of control stand-alone hydrokinetic energy harnessing.

3.2 Flowchart

Based on the Figure 3.1, shows the flowchart of the whole process of the project.

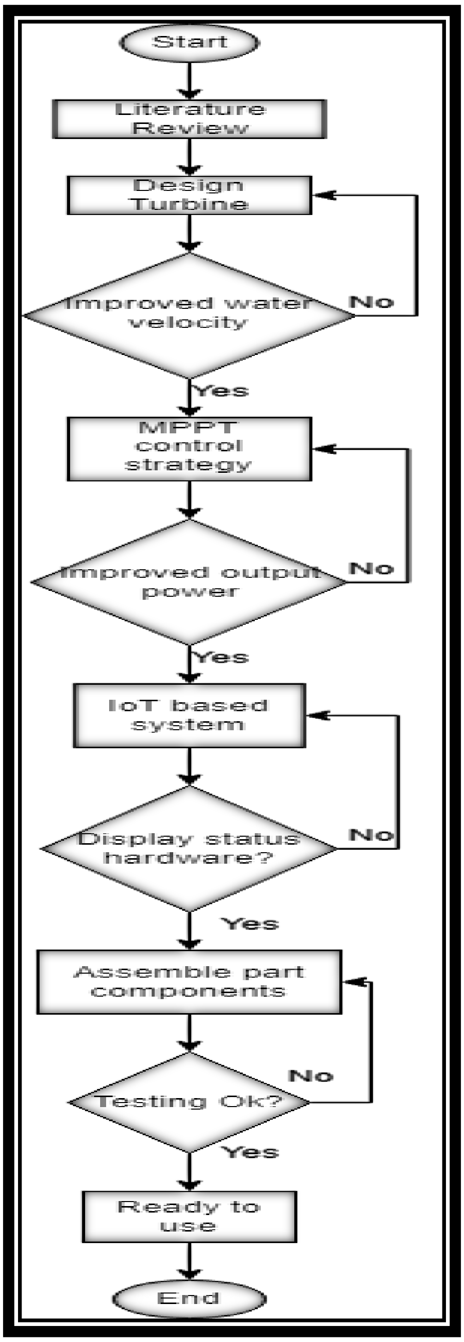

Figure 3.1: The flowchart for whole project

3.3 Material selection

3.3.1 Boost converter

Boost converter have 3 types which is boost converter, buck converter and buck boost converter. In this project, the boost converter builds by our own. The basic boost converter in Figure 3.2 is the circuit in this project.

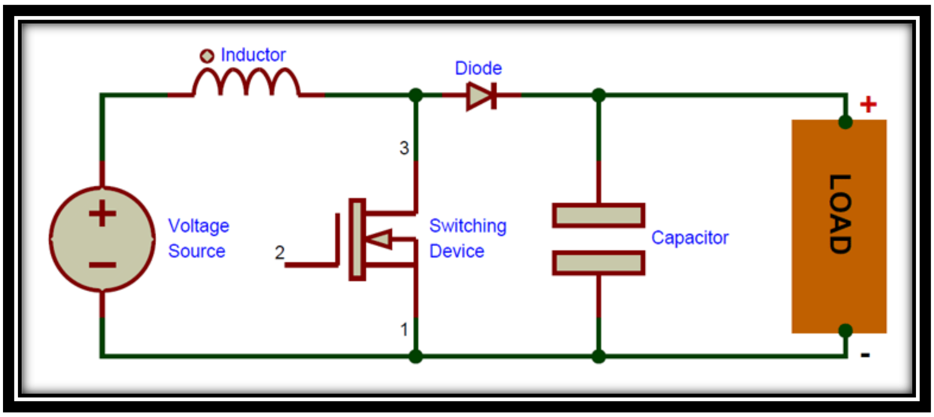

Figure 3.2: Basic boost converter

3.3.1.1 Components of boost converter

- Inductor – the inductor in this project is toroid coil inductor. The value of inductor is 3A 100uH.
- Diode – the diode in this project is SB540 high performance Schottky Diode. The value of the diode is 40V 5A.
- Capacitor – the capacitor in this project is electrolytic capacitor. The value of capacitor is 47uF 50V.
- Resistor – the value of resistor is 10k ohm.

3.3.2 Coding of PI-contoller

```
boost_converter_pid
#define pwmPin 6
#define ANALOG_IN_PIN A0

float adc_voltage = 0.0;
float in_voltage = 0.0;
float R1 = 30000.0;
float R2 = 7500.0;
float ref_voltage = 5.0;
int adc_value = 0;
float voltTotal = 0;
float voltArray[11] = {0,0,0,0,0,0,0,0,0,0,0};
float volt = 0.0;

// PID constant value seting sini
float Kp = 0.0000;
float Ki = 0.001;
float Kd = 0.1;

float input = 0;
float output = 0;
float setPoint = 13.0; // << set voltage output berapa nk kat sini
float cumError = 0;
float rateError = 0;
float error = 0;
float lastError = 0;

unsigned long currentTime = 0;
unsigned long previousTime = 0;
unsigned long elapsedTime = 0;
```

Figure 3.3: Coding of PID

```
boost_converter_pid
void setup() {
  Serial.begin(115200);
  pinMode(pwmPin, OUTPUT);
  analogWrite(pwmPin, 0);
}

void loop() {
  // Read the Analog Input
  adc_value = analogRead(ANALOG_IN_PIN);

  // Determine voltage at ADC input
  adc_voltage  = (adc_value * ref_voltage) / 1024.0;

  // Calculate voltage at divider input
  in_voltage = adc_voltage / (R2/(R1+R2));

  voltArray[10] = in_voltage;
  for (int i = 0; i < 10; i++) {
    voltArray[i] = voltArray[i + 1];
    voltTotal = voltTotal + voltArray[i];
  }

  volt = voltTotal / 10;
  voltTotal = 0;


  currentTime = millis();
  elapsedTime = currentTime - previousTime;
```

Figure 3.4: Coding of PID

```
boost_converter_pid

  input = volt;
  error = setPoint - input;

  cumError += error * elapsedTime;

  rateError = (error - lastError)/elapsedTime;

  output = (Kp * error) + (Ki * cumError) + (Kd * rateError);

  lastError = error;
  previousTime = currentTime;

  if (output >= 30) {
    output = 30;
  } else if (output <= 0) {
    output = 0;
  }

  analogWrite(pwmPin, output);

  // Print results to Serial Monitor to 2 decimal places
  // Serial.print("voltOut: " + String(volt,2) + " | outputPid: " + String(output,2));
  // Serial.print(" | input: " + String(input,2));
  // Serial.println("");

  Serial.println(volt);
}
```

Figure 3.5: Coding of PID

Figure 3.3, 3.4 and 3.5 shows the coding of PID. Start from declare and put the formula from PID. Try and error to see the result from graph at the serial monitor from Arduino IDE. Find the best graph maintain at the set point.

3.3.3 Coding of PWM

```
basic_pwm
#define pwmPin 6

void setup() {
  Serial.begin(115200);
  pinMode(pwmPin, OUTPUT);
}

void loop() {
  analogWrite(pwmPin, 1);
}
```

Figure 3.6: Coding of PWM

Figure 3.7 shows the basic coding of PWM. The coding set 10% from 100% PWM. The coding not set 100% because of safety which may damage the circuit. 100% from PWM is 225. In this project use 10% which is 30.

3.4 Cost analysis for controller

The Table 3.1 below shows the total cost for controller that be used in this project. The price of each will changes depends on the availability and stock in the market. This price also had been included with shipping price because the item buys in the online shopping platform.

Table 3.1: The cost for components and other material used in controller

Component	Quantity	Price
Inductor	1	RM 7.10
Diode	1	RM 7.85
Capacitor	1	RM 4.95
PWM MOSFET	1	RM 9.00
Battery	1	RM42.80
Breadboard	1	RM 3.90
Jump wire	2	RM 9.20
Total		RM 84.80

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

After completing the method from the previous methodology chapter. In this chapter shows all the results that obtained from the experiment and all the study. Figures are included and more explanation of figures is also provided. The programming of the Arduino will be coded by using Arduino IDE.

The Arduino IDE software is user friendly and reliable. It makes the process of compiling and uploading the code to the Arduino easier. After uploading all the programming into the Arduino, it will be connected to the PCB as a PWM to the MOSFET to try whether the circuit for boost converter are function or not. The analysis and discussion were more focused on the programming. The results from the figured based on the final testing of the whole system.

4.2 Testing result

In order to control the Arduino Uno input and output, coding had made in the Arduino IDE software as shown in the Figure below. From the coding, PWM is set at PIN D3 in the Arduino. The function of the PWM in this circuit is to give an impulse to the MOSFET which is bring the MOSFET to ON STATE and OFF state to produce charging the capacitor to produce larger output voltage.

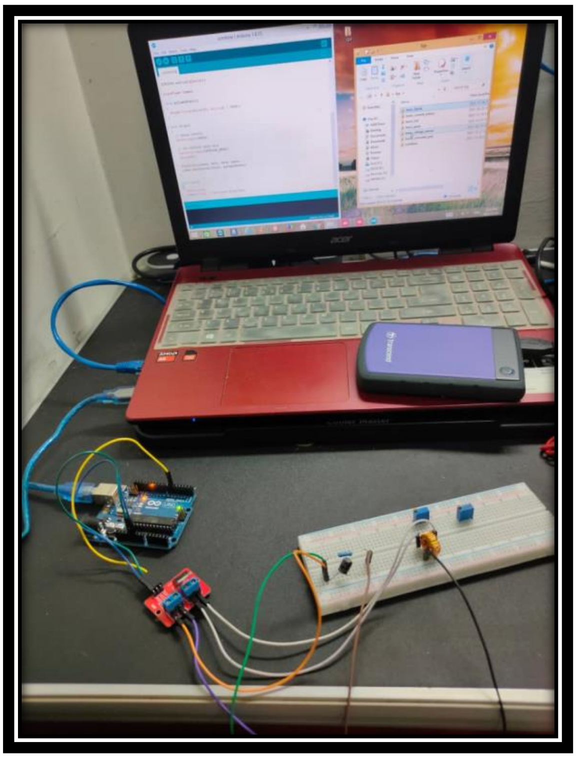

Figure 4.1: Circuit boost converter with PWM

Figure 4.1 shows the procedure circuit boost converter and PWM connected with Arduino and link with Arduino IDE to get the result. Figure 4.2 below shows the results from serial monitor from Arduino IDE. The result maintain at 12V because the set point set 12V.

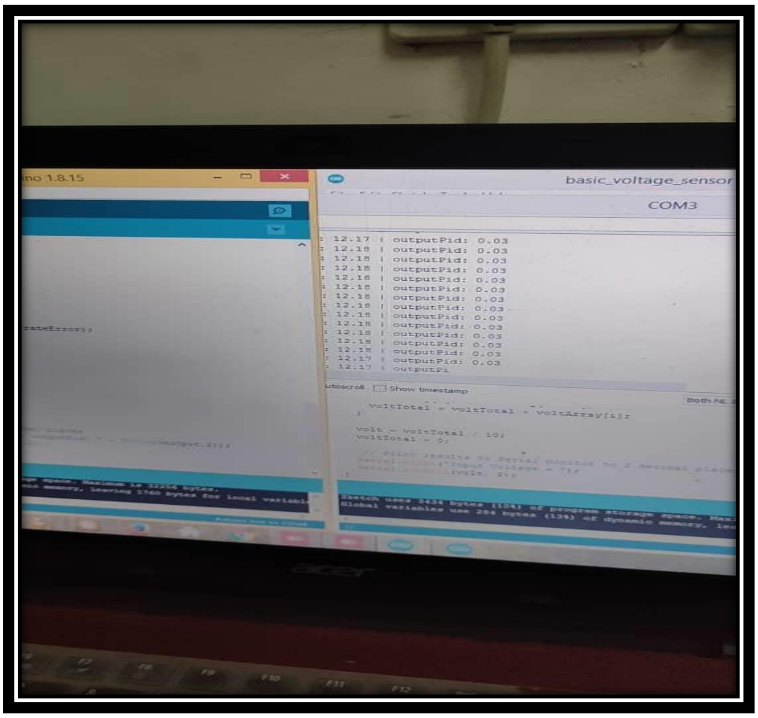

Figure 4.2: Results from arduino IDE

Table 4.1: Results from boost converter

Input	Output
8V	15.8V
10V	16V
10.1V	16.1V
9.9V	15.9V

Table 4.1 show the results from output boost converter. The results maintain at 15V because the set point fixed which is 15V. The value input from the generator randomly because of water flow.

CHAPTER 5

CONCLUSION

5.1 Introduction

This chapter summarised the research's most important findings. The research's findings provided an overview of this case study. The limitations or issues identified throughout the study process were also reported, along with recommendations for future research.

5.2 Conclusion

In a nutshell boost converter is an efficient step-up DC-DC converter used I numerous electronic devices. It is design and simulated using Arduino as PWM. A closed loop and used successfully for simulation. There are advantages for this converter which is reduced hardware, high performance, less weight and accuracy. The simulation results are in line with the predictions.

The same was accomplished as a hardware project, and with a 24V AC supply from the generator, an output voltage of 8V-12V in range was attained. Waveforms were also acquired, examined, and compared with theoretical waveforms across capacitors at various test sites. The waveforms were discovered to be quite close to theoretical waveforms.

5.3 Recommendation

There are a few recommendations for improvement of this project. First and foremost, the boost converter can change with buck boost converter. The buck boost converter can step up and step down the voltage from generator.

Besides, this project can test with 100% PWM because the circuit in this project use low current circuit. This project can test with component high circuit to gain 100% PWM.

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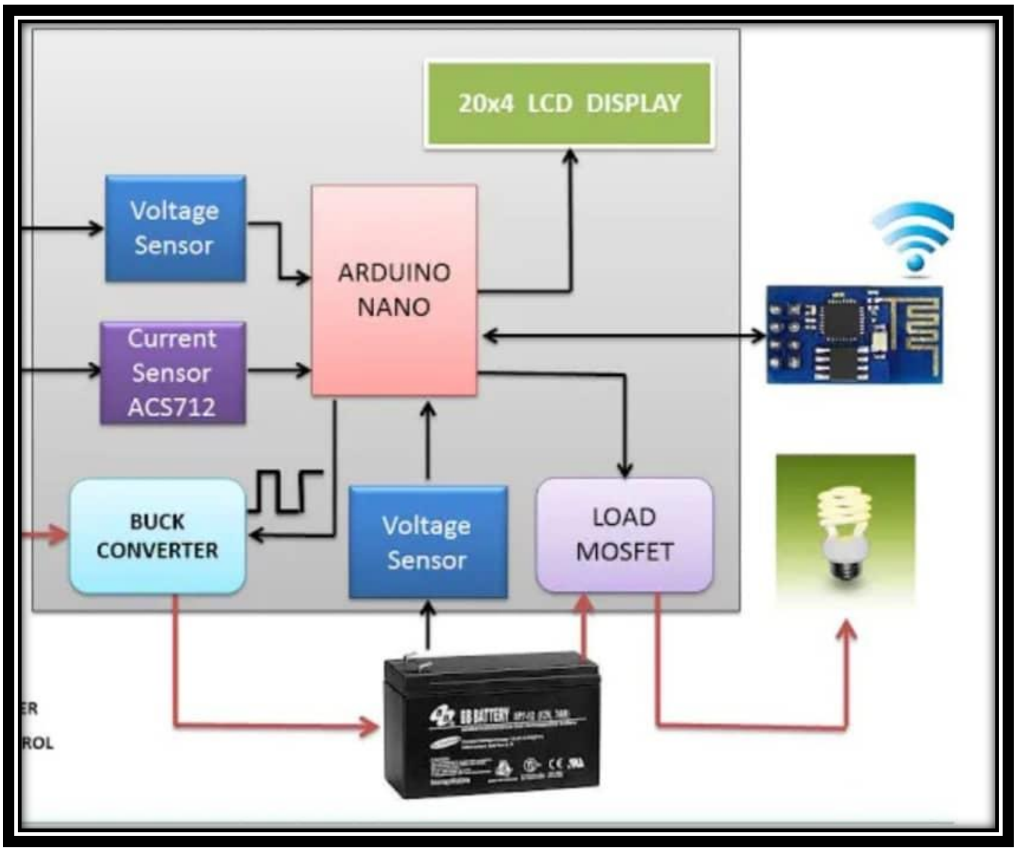
APPENDICES

Appendix A: The block diagram of the whole circuit



Appendix B: The results from output boost converter


16.0
DCV
OFF
ACV
DCA
10A
hFE
DT-830B
DIGITAL
MULTIMETER
COM
PRECISION
TOUCHPAD
SKYPE
CERTIFIED


15.9
DCV
OFF
ACV
DCA
10A
hFE
Skype
PRECISION
TOUCHPAD
SKYPE
CERTIFIED