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DEVELOPMENT OF IoT SYSTEM FOR HYBRID HYDROKINETIC AND WIND ENERGY HARNESSING

MUHAMMAD LUQMAN HAKIM BIN ZAHIR SHAH

Thesis submitted in fulfillment of the requirements
for the award of the
Bachelor of Engineering Technology (Electrical) With Hons.

Faculty of Electrical & Electronics Engineering Technology

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ABSTRAK

Dalam projek ini, sistem IoT untuk hidrokinetik hibrid dan tenaga angin untuk peranti memanfaatkan tenaga mudah alih telah dicadangkan. Hibrid hidrokinetik dan angin adalah teknologi alternatif untuk menjana elektrik melalui tenaga angin dan air. Dalam projek ini, tenaga hidrokinetik hibrid dan tenaga angin telah direka bentuk untuk digunakan dalam keadaan air dan angin. Walau bagaimanapun, beberapa isu perlu dipertimbangkan seperti, saiz yang sesuai dan mobiliti untuk turbin mesti dipertimbangkan, pengekstrakan turun naik yang rendah dan kelajuan angin dan ketidakbolehcapaian untuk memantau status pengesan. Aplikasi blynk digunakan untuk memantau nilai voltan dan arus. Walaupun pengesan telah dipantau, ESP32 mesti digunakan untuk membaca nilai pengesan dan menghantar data ke aplikasi blynk. Untuk hasilnya, sistem IoT untuk projek ini telah mencapai sasarannya. Sistem ini boleh memantau kedua-dua pengesan arus dan voltan dengan hanya menggunakan telefon bimbit.

ABSTRACT

In this project, the IoT system for hybrid hydrokinetic and wind energy for portable energy harnessing devices has been proposed. Hybrid hydrokinetic and wind is an alternative technology to generate electricity through wind and water energy. In this project, the hybrid hydrokinetic energy and wind energy has been designed to be used in both water and wind condition. However, some issues need to consider such as, the suitable size and the mobility for the turbine must be considered, the low extraction of fluctuation and wind speed and inaccessibility to monitor the status of devices. The blynk application is used to monitor the voltage and current value. Although the sensors have been monitored, the ESP32 must be used to read the sensor value and send the data to blynk application. For the results, the IoT system for this project has been achieved its target. The system can monitor both current and voltage sensors only using a mobile phone.

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LIST OF SYMBOLS

σ	solidity of the turbine
Z	number of the blades
C	chord (width) of the blade
R	radius of the rotor
P	power from HEED
D	density of the fluid (water)
A	frontal area of the hydrokinetic turbine
Cp	turbine power coefficient
V0	fluid's outflow velocity
Vi	fluid's input velocity.

LIST OF ABBREVIATIONS

IoT	Internet of Things
kW	Kilowatts
MPPT	Maximum Power Point Tracking
MW	Megawatts
PV	Photovoltaic
PWM	Pulse Width Modulation
RCECS	River current energy conversion systems

CHAPTER 1

INTRODUCTION

1.1 Project Background

Hydrokinetic energy is often recognized as the cleanest and most efficient renewable energy. The energy created by the movement of water is rivers, canals, waterways, and others. As the water stream pass through the turbine, it rotates on a shaft connected to a generator. The rotational speed of the turbine are determined proportional to the velocity of the water.

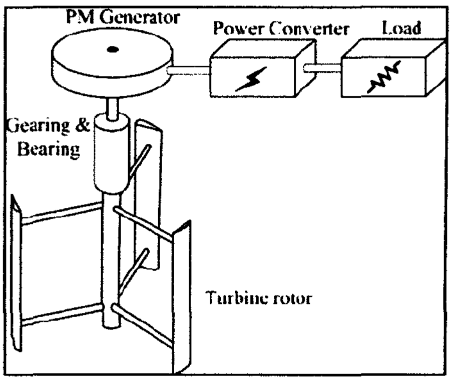

Figure 1.1 Simplified structural component in hydrokinetic system

Source: (Khan, Iqbal & Quaicoe, 2010)

Figure 1.1 shows a device with a hydrokinetic turbine to extract kinetic energy from water flow, a generator, a power electronic converter, and a load/battery/grid-tie connection system (Ibrahim, Mohamed, Ismail, Leung, Xing & Shah, 2021). For three various scenarios, such as a river, tidal, and wave energy, the resource potential for hydrokinetic energy has been explored. A river was chosen for this project. Temporal and geographical flow assessments are required to predict the amount of electricity available in a river. Area, depth, velocity, and other associated parameters are all taken into account.

Hydrokinetic energy is a cost-effective type of renewable energy since water resources are abundant. Furthermore, hydrokinetic is a long-lasting technology with a low cost of production (Kusakana, 2014). In terms of sustainability, the energy available can be predicted with ease, and power is usually available on-demand at all times. The hydrokinetic plant's efficiency is considered satisfactory, making it one of the most efficient energy conversion technologies.

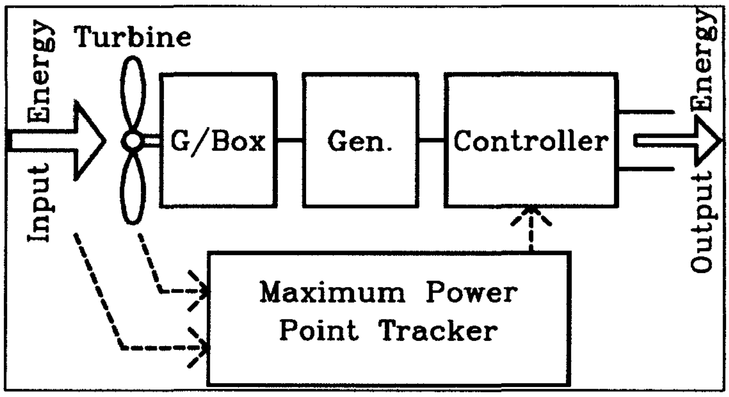

Figure 1.2 Block diagram of hydrokinetic or wind harnessing system
Source: (Tuckey, Patterson & Swenson, 1997)

Due to the size of the turbines and mechanical elements, renewable energy harvesting systems must improve efficiency. As a result, it's critical to capture as much energy as possible as it passes through the turbine by making all stages of the conversion system very efficient (Tuckey, Patterson & Swenson, 1997). A block diagram of a wind or in-stream generator system, including the turbine, gearbox, generator, and controller, as shown in Figure 1.2. Maximum Power Point Tracker is a term used to describe a control system that is used to harness maximum power (MPPT).

An in-stream type hydrokinetic turbine's power output can be compared to that of a wind turbine of comparable size. A hydrokinetic turbine with a rated speed of 2 - 3 m/s can produce four times the energy of a wind turbine with a similar rated speed (Yuce, Muratoglu, 2014). Figure 1.3 shows a comparison of power densities for wind and water turbines. As a result, energy collecting systems based on free-flowing waterways or wind have the ability to supply long-term energy in locations without grid power.

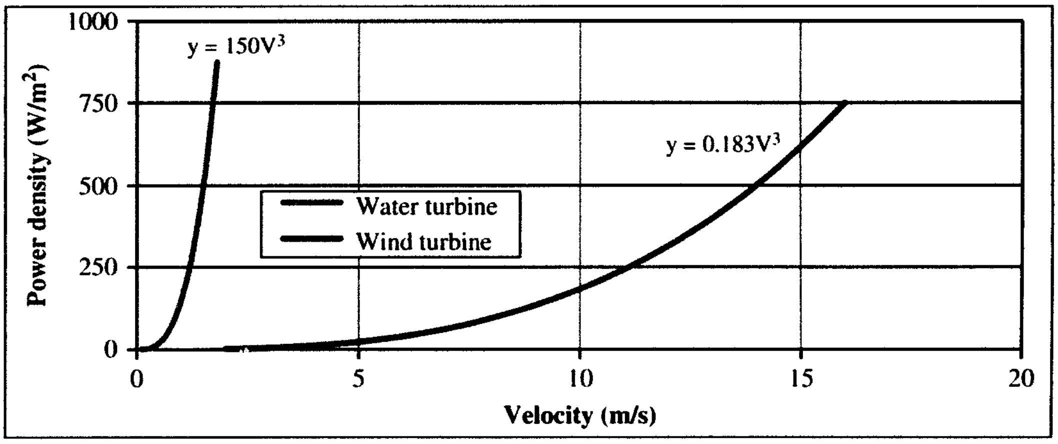

Figure 1.3 Power densities comparison between water (in-stream) and wind turbine
Source: (Gaurav & Saini, 2019)

This project will look at harvesting electric energy using a turbine, which can be used to generate hydrokinetic or wind energy. These two forms of energy transform kinetic energy into electrical energy. The most common approach is to employ a turbine to transfer power from moving wind and water to a shaft, which may include a gearbox and a generator to convert mechanical torque on the shaft to electricity that can be transported and stored. The goal of this project is to create a portable energy capturing device that combines hydrokinetic and wind energy. The turbine and energy collecting system may be employed in both hydrokinetic and wind energy.

1.2 Problem Statement

i. Renewable energy devices such as PV panels, Wind Turbine generators, Hydro-generator are too bulky and heavy. Besides, the system is firmly fixed and not easy to move or relocate to another place.

ii. The characteristic of wind speed and fluctuation of water velocity causing a low energy extraction.

iii. Inaccessibility to monitor the status of devices because of the operation is in the middle of a running river.

1.3 Objectives

The main objectives of this of the development of hybrid hydrokinetic and wind energy for portable energy harnessing devices are:

i. To design and develop a vertical axis turbine for portable hybrid energy harnessing.
ii. To design a Maximum Power Point Tracker (MPPT) controller for maximum energy extraction.
iii. To develop an energy monitoring system based on the Internet of Things (IoT) system.

1.4 Scopes

i. The size of the turbine is limited and not exceeding 15cm in diameter and 20cm in length.

ii. The output power is 15 watt and output current 1 ampere.

iii. The boost converter is using Maximum Power Point Tracker (MPPT).

iv. The Arduino IDE is supported by ESP32 for the monitoring system.

CHAPTER 2

LITERATURE REVIEW

This chapter will discuss the introduction of wind energy and hydrokinetic energy, advantages and disadvantages of wind energy and hydrokinetic energy, and some related works. The examples of hardware and software used in this project will also mentioned in this chapter.

2.1 Wind Energy

Windmills were used to pump water for farms and ranches, and later, to generate power for houses and businesses, according to the book by (Donald & Molly 11 May 2010). Windmills were gradually phased out as a result of industrialization. The steam engine replaced the ECU's water-pump windmills, and by the 1930s, the Rural Electrification Management's applications had brought cheap electric power to most rural areas in the United States (Donald et al. 2010).

Windmills first arose in the Middle Ages in Holland, Spain, Portugal, France, and Italy. Windmills were used in Holland to control flow from regions where the ground surface was lower than the sea level (Manwell, McGowan & Rogers, 2009). The multi-bladed Wind Turbine is depicted in Figure 2.1.

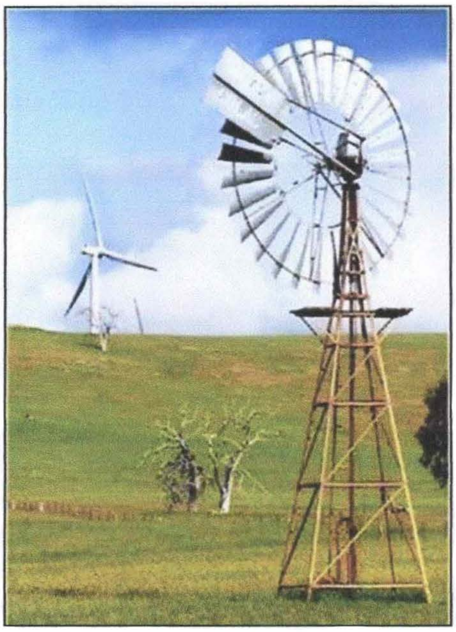

Figure 2.1 Multi blade of Wind Turbine
Source: (Jain, 2011)

Windmills with a metallic construction were selected to produce energy in Denmark around the turn of the century, but turbines with a made of wood were being used in America. Chicago was the world's largest windmill manufacturing centre between 1870 and 1930, manufacturing an estimated 6 million windmills. Under the guidance of professor P.La.Cour, an innovative wind turbine with two electric generators and a rotor blade with a diameter of 22.8 metres was operated in Denmark in 1891. In addition, under the design supervision of Sabanin and Yuriev, the Baltic machine with a power potential of 100 KW was created in 1930. Finally, in 1940, a 1.25 Mw experimental two-bladed wind turbine was erected in Vermont, USA, at a speed of around 30 mph (Jain, 2011).

In the years following WWII, the use of atomic energy, combined with low oil prices, drastically diminished interest in wind energy research. Environmental pollution and the energy crisis, on the other hand, have sparked the interest of developed countries of the world in this clean and ancient energy source (Wagner & Mathur, 2009).

2.1.1 Structure of Wind Turbine

A wind turbine is made up from of the following structure:

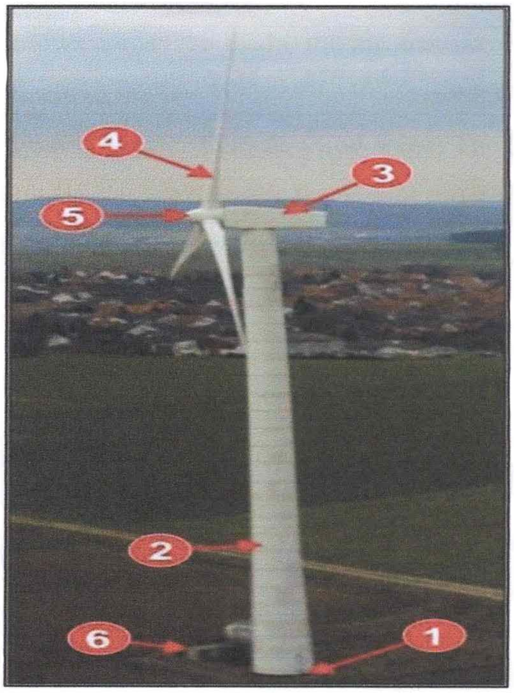

Figure 2.2 Wind Turbine
Source: (Wagner & Mathur, 2009)

1. Tower
2. Foundation
3. Nacelle
4. Rotor Blade
5. Hub (generator inside)
6. Transformer

2.1.2 Concept and Operation

Wind energy is converted into electricity in a wind turbine by the aerodynamic force of the rotor blades, which work similarly to an aeroplane wing or helicopter rotor blade. When the wind blows across the blade, the air pressure on one side drops. The difference in air pressure across the two sides of the blade creates lift and drag. The rotor spins because the lift force is greater than the drag force. The rotor is either directly connected to the generator (if it's a direct drive turbine) or through a shaft and a series of gears (a gearbox), which speeds up the rotation and allows the generator to be physically smaller. Power is generated by converting aerodynamic force to generator rotation.

2.1.3 Wind Turbine Classification

Wind turbines are machines that use the wind's energy to generate electricity. The orientation of the axis of wind turbines in relation to the wind flow is used to classify them. Horizontal axis turbines and vertical axis turbines are the two types of modern wind turbines. Modern wind turbines can be classified as high rotation speed or low rotation speed based on a non-dimensional quantity known as the tip speed ratio, which is defined as the ratio of the speed of the extremities of a windmill rotor to the speed of the free wind and is illustrated below. This ratio serves as a useful baseline against which to compare the various characteristics of wind turbines as shown in Equation (2.1).

$$\lambda = \frac{\omega \text{ x R}}{v} \tag{2.1}$$

Where is the rotor radius in metres, R is the wind velocity in metres per second and is the angular acceleration in radians per second. A wind turbine's rotation speed is also influenced by its aerodynamic qualities and the size of its wind blades.

Furthermore, the turbine's connections to the electric grid are crucial, as all modern grid-connected wind generators output electric current at the same frequency as the central grid (Manwell et al. 2009). Finally, the solidity parameter is used to determine the presence of wind turbines. The fraction of the rotor's total area that is made up of material rather than air is known as solidity (Tzanakis, 2006).

Horizontal axis:

$$\sigma = \frac{(z \times c \times R^2)}{\pi \times R} \tag{2.2}$$

Vertical axis:

$$\sigma = \frac{(z \times c)}{R} \tag{2.3}$$

Where parameter σ is the solidity of the turbine, z is the number of the blades, R is the radius of the rotor and c is the chord (width) of the blade.

2.1.3.1 Vertical Axis Wind Turbine

Unlike regular wind turbines, the main axis of the vertical axis wind turbines is perpendicular to the axis. Their design allows them to be used in both rural and urban settings, and it allows the owner to offset rising power bills while simultaneously protecting the environment. Furthermore, unlike typical horizontal axis turbines, they do not require the complex head mechanics of traditional horizontal-axis wind turbines (Fernando, Hernán & Ricardo, 2007).

The wind direction has little effect on vertical axis wind turbines, which is advantageous in areas where the wind changes direction frequently or quickly. Turbulent airflow over buildings and other barriers is best captured by vertical axis wind turbines. In residential areas, this is a more common occurrence. The vertical axis wind turbine can be used in both rural and urban settings, including on rooftops.

Installation and maintenance are simplified because the generator and other components can be placed at ground level. Birds and other animals are not killed by vertical axis wind turbines since they are slow-moving and very visible. A vertical axis wind turbine can be built for a fraction of the cost of a horizontal axis wind turbine. They produce less noise when compared to horizontal ones. The vertical axis wind turbine is more visually pleasing.

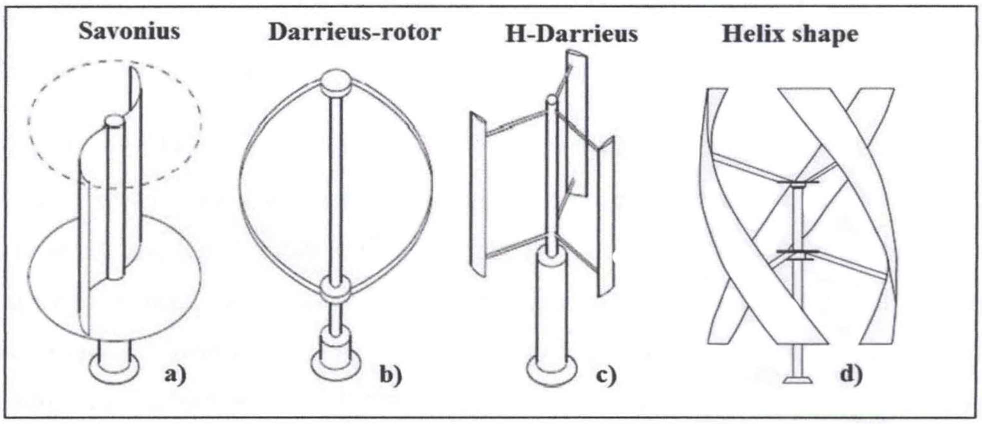

Figure 2.3 Vertical axes wind turbine
Source: (Francesco, Davide, Mauro & Alexander, 2019)

2.1.3.2 Horizontal axis turbine

Horizontal axis turbines can be upwind (the blades are struck by the wind before the tower) or downwind (the blades are struck by the wind after the tower) (the wind hits the tower before the blades). Upwind turbines have a yaw drive and motor components that move the nacelle to keep the rotor towards the wind when the wind direction changes.

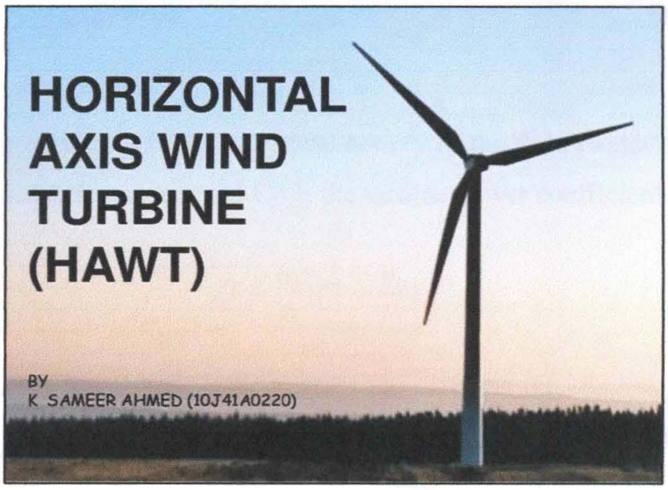

Figure 2.4 Horizontal axis wind turbines
Source: (Sameer, 2014)

2.2 Hydrokinetic energy

A hydrokinetic system is an electromechanical device that converts the kinetic energy of water flow into electrical energy using a generator and a power electronics converter (Close Khan, Iqbal & Quaicoe, 2008). An array of modular construction can be used to increase output capacity even if the expectancy-value is limited (Alvarez, Rico-Secades, Corominas & Guitart, 2018). Furthermore, because it is based on free-flowing water, a hydrokinetic system does not necessitate the construction of a reservoir or impoundment. The system is easy to transfer and relocate due to its small size. The system can also be tethered to a fixed structure or put on a floating pontoon along a riverbank (Anyi & Kirke, 2010).

2.2.1 The principles of hydrokinetic energy conversion

An ideal power calculation, as shown in Equation (2.4), is often used in the field to assess a hydrokinetic power production system's power extraction capability. Since both systems use liquids and either airfoils or hydrofoils, the power equation for a hydrokinetic turbine is comparable to that of a wind turbine (Kirke, 2008; Khan, Iqbal & Quaicoe, 2006). A hydrokinetic turbine's power equation is shown as in Equation (2.4).

$$p_{ideal} = \frac{1}{2}\rho AV3Cp \qquad (2.4)$$

P is the power from HEED, D is the density of the fluid (water), A is the frontal area of the hydrokinetic turbine, and Cp is the turbine power coefficient.

$$C_p = \frac{(1+\frac{v_0}{v_i})(1-\frac{v_0}{v_i})}{2} \qquad (2.5)$$

Where V0 is the fluid's outflow velocity and Vi is the fluid's input velocity.

It's a guess at how much energy a wind turbine can capture, but a more thorough analysis of blade form and surface, as well as the fluid interactions that accompany them, could produce more precise results (Alvarez et al. 2018). Cp is a mass conservation factor when using a fluid stream tube technique. In an infinite free stream, Cp tends to reach a Betz limit of 0.59 for an ideal turbine. The Betz limit refers to a fluid-based hydrokinetic turbine's maximum power output potential (Alvarez et al. 2018).

The technology for transforming tidal energy into power, which works similarly to river turbines, has progressed significantly. RCECS (river current energy conversion systems) are small, floating power units that may be easily deployed in a river channel. Tidal turbines, on the other hand, are larger, permanently anchored, and operate in reaction to periodic tide action. However, understanding tidal energy systems is necessary for understanding river turbine technology.

2.2.2 Vertical axis turbines

Vertical axis turbine design includes Darrieus, SC- Darrieus, H- Darrieus, Gorlov, and Savonius. The most noticeable of the vertical axis turbines are Darrieus turbines. There are no examples of Darrieus (curved or parabolic blades) turbines, despite the extensive use of H-Darrieus (straight-bladed) turbines in hydro applications.

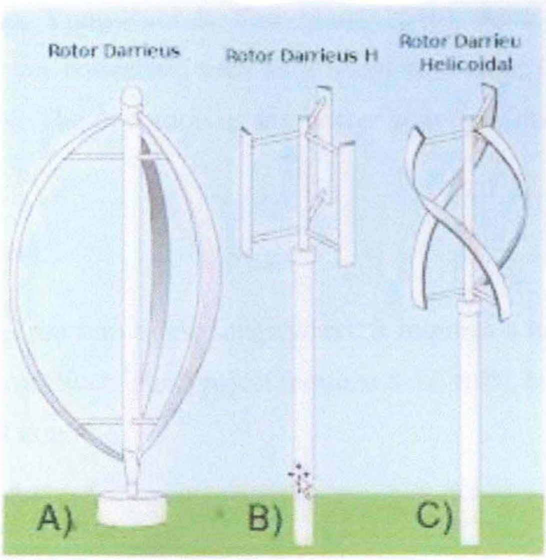

Figure 2.5 Vertical axis hydrokinetic turbines
Source: (linquip, 2021)

2.3 Control strategies for portable hybrid energy harnessing

2.3.1 MPPT

This study looks at past and present MPPT controllers for extracting the most power from WECS that use permanent magnet synchronous generators (PMSG), squirrel cage induction generators (SCIG), and doubly-fed induction generators (DFIG) . These controllers use three main control methods: tip speed ratio (TSR) control, power signal feedback (PSF) control, and hill-climb search (HCS) control (Jogendra & Mohand , 2016).

Furthermore, because the highest power point for a hydrokinetic (or wind) turbine occurs at various turbine rotor speeds and varying water (or wind) velocity, the purpose of running a turbine system is to maximise energy production (Khan, Iqbal & Quaicoe, 2011). At high water (or wind) speeds, pitch angle control is often employed in medium and large turbine systems to improve output power and reduce torque and output power fluctuation (Senjyu, Sakamoto, Urasaki, Funabashi, Fujita & Sekine,). Pitch angle control, on the other hand, is problematic for small turbine systems due to mechanical constraints (Kuo-Yuan, Yung-Ruei & Yaw-Ming, 2010). As a result, in small-scale turbine systems, a power converter, such as a boost converter, is typically utilised to provide MPPT control. The operation of the power converter must be controlled by a microcontroller.

2.3.2 Boost Convertor

The project has run into a few snags where it requires a bit greater voltage than our power supplies can deliver. This project requires 8-12 volts, but the motor or turbine only produces a 5-volt output.

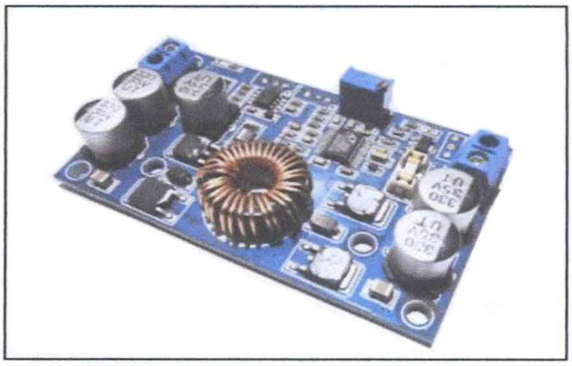

Figure 2.6 Boost convertor
Source: (components101, 2019)

As the name implies, switched-mode supplies can be used for a variety of reasons, including DC to DC converters. A boost converter is one of the simplest types of the switch-mode converter.

Apart from batteries, a boost converter's DC input can originate from a variety of sources, including rectified AC from the mains or DC from photovoltaic panels, battery storage, dynamos, and DC generators. There are two sorts of converters: boost converters and buck converters.

2.4 Monitoring system

The purpose of using a monitoring system in this project is to keep track of the devices' voltage and current output. Aside from that, this monitoring system is quite useful for ensuring that the gadgets are functioning properly. There was a component and interface that was used for system monitoring:

2.4.1 IoT

Alternative energy sources such as wind and hydrokinetic energy are used to meet the increased energy demand. To successfully utilise wind energy, a windmill must be maintained. When a wind or hydrokinetic turbine malfunctions, re-configuring it becomes a difficult task. As a result, a good strategy for completing this project is required. Certain information is required to manage the maintenance schedule for easy maintenance. It was formerly manually monitored. If the data needed for proper maintenance could be obtained remotely, the method may be simplified. It also helps if the device can be programmed to turn off (in an emergency) or turn on based on the data collected. It saves a lot of time and effort for people (manual monitoring).

Because of the Internet of Things, all of this is possible (IoT). The Internet of Things (IoT) is a worldwide network of interconnected computing devices that can send and receive data without the need for human intervention. Near-real-time analysis of data from the Internet of Things is possible. Furthermore, various actions can be taken based on the evaluated data. The purpose of the project is to develop an "IoT-based hybrid hydrokinetic and wind energy Monitoring System" that collects data needed to monitor a windmill and uses that data to anticipate and automate its maintenance schedule. The data is used to obtain a variety of other useful information.

2.4.2 Blynk

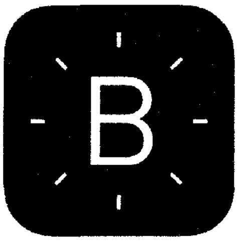

Figure 2.7 Blynk application
Source: (onion.io, 2017)

Blynk is an iOS and Android platform that allows you to create interfaces for controlling and monitoring hardware projects. Blynk is ideal for small applications like keeping track of the temperature or turning lights on and off. Most Arduino boards, Raspberry Pi versions, the ESP32, and other mainstream microcontrollers and single-board computers are also supported by Blynk. Wi-Fi and Ethernet shields for Arduino are supported, and the devices can also be controlled via a computer's USB interface. This program can set up a local Blynk server, allowing you to keep everything on your home network.

2.5 List of hardware components

2.5.1 Hardware list:

1. Arduino Uno
2. ESP32 Wi-Fi
3. ACS712 Current Sensor
4. B25 Voltage Sensor
5. Boost Convertor
6. Maximum Power Point Tracking (MPPT)
7. Generator
8. Turbine

2.5.2 Software list:

1. Arduino IDE
2. Blynk application
3. Tinkercad

2.5.3 Hardware Description

2.5.3.1 Arduino Uno

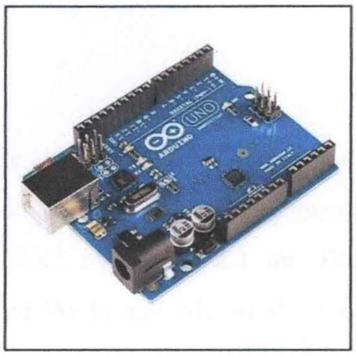

Figure 2.8 Arduino Uno
Source: (flyrobo.in, 2019)

The Arduino Uno is a microcontroller board that uses the Atmega328P microcontroller. It has 14 digital input output pins, six of which are PMW outputs, six analog inputs, a 16 MHZ quartz crystal, and a reset button. The Arduino computer program can be used to load these Arduino applications onto it.

2.5.3.2 ESP32 Wi-Fi

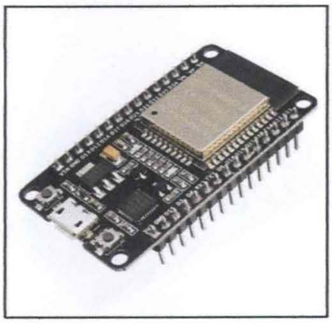

Figure 2.9 ESP32 Wi-Fi
Source: (iotespresso, 2021)

Espressif Systems, the company behind the ESP8266 SoC, has released the ESP32, a low-cost System on Chip (SoC) Microcontroller. This Wi-Fi module is a successor to the ESP8266 SoC and is based on Tensilica's 32-bit Xtensa LX6 Microprocessor with integrated Wi-Fi and Bluetooth. It is available in single-core and dual-core versions.

2.5.3.3 ACS712 Current Sensor

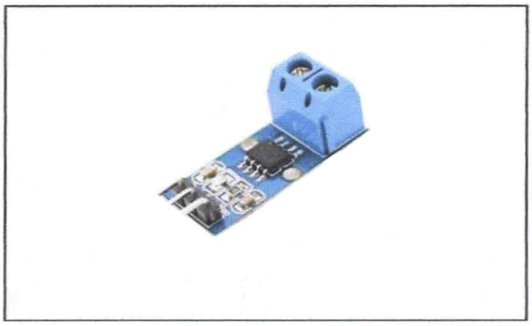

Figure 2.10 ACS712 Current Sensor
Source: (elecrow, 2016)

With 2.1kVRMS voltage isolation and an integrated low-resistance current conductor, the ACS712 is a fully integrated hall effect-based linear current sensor. It is simply described as a current sensor that calculates and measures the amount of current applied through its conductor.

2.5.3.4 B25 Voltage Sensor

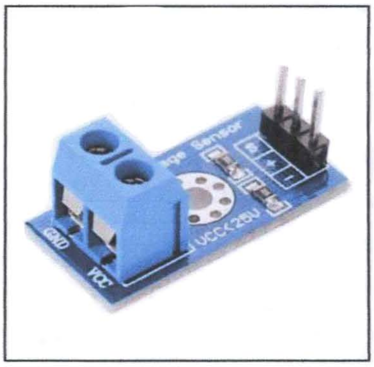

Figure 2.11 B25 Voltage Sensor
Source: (cytron.io, 2016)

A voltage sensor is a low-cost voltage sensor that measures voltage precisely. The resistive voltage divider method is used to create this voltage sensor.

2.5.3.5 Generator

The power generator is a critical component of any energy harvesting device. A direct current DC generator was chosen because the goal of this project is to capture energy for low-power applications. A DC generator is a revolving machine that generates an electric output with unidirectional voltage and current and operates on the same principles as synchronous generators.

When a current-carrying conductor is put in a changing magnetic field, an electromagnetic field is induced in the conductor, according to Faraday's law of electromagnetic induction (Cheng-Hong Chang, 1995). As a result of Fleming's right-hand rule, the induced current direction changes in response to conductor motion (Honnell, 1953).

Because of the low cost of rectifier systems supplied by alternators, a DC generator was employed extensively. A DC generator is often employed in electrical devices to charge batteries and supply low-power loads. DC generators, on the other hand, have an advantage over alternators in some applications because they can run motors and reverse the direction of power flow.

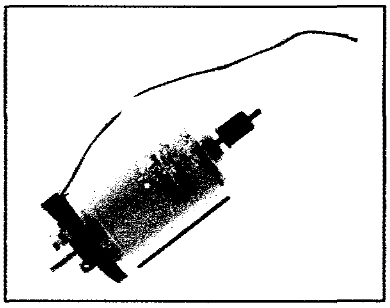

Figure 2.12 DC Generator
Source: (aliexpress, 2015)

2.6 Software Description

2.6.1 Arduino IDE

Figure 2.13 Arduino IDE

The Arduino Integrated Development Environment (IDE) software includes a code editor, a massaging area, a text console, a toolbar with buttons for common tasks, and a series of menus. It communicates with the Arduino and ESP32 hardware by connecting to them and uploading programs. Third-party hardware support can be added to your sketchbook directory's hardware directory. Board definitions (which are display in the menu), core libraries, bootloaders, and programmer definitions are some of the platforms that can be found there.

2.6.2 Blynk application

Figure 2.14 Blynk application
Source: (onion.io, 2017)

Blynk is an iOS and Android platform for building interfaces for controlling and monitoring hardware projects. It is used to use a mobile phone to monitor the voltage and current sensor.

2.6.3 Tinkercad

Figure 2.15 Tinkercad

Tinkercad is a free online collection of software tools that enable people to think, create, and produce things all over the world. Tinkercad is a leading provider of 3D design, engineering, and entertainment software. It is utilised to create our project's turbine prototype.

CHAPTER 3

METHODOLOGY

A methodology is a set of basic concepts or guidelines from which specific methods or procedures for interpreting or solving problems can be formed. This chapter detailed the technique for implementing the control system in the Development of a Hybrid Hydrokinetic and Wind Energy for Portable Energy Harnessing Devices, allowing for easy monitoring and portability. The approaches utilised in this chapter are targeted at achieving the project's objectives and providing satisfactory results on the control system's performance in the Development of a Hybrid Hydrokinetic and Wind Energy for Portable Energy Harnessing Devices.

3.1 General Flowchart

The Development of a Hybrid Hydrokinetic and Wind Energy for Portable Energy Harnessing Devices workflow is depicted in Figure 3.1. Wind or hydro turbines create current and voltage. The voltage and current from the MPPT were then amplified by the convertor. The converter converts the load to a battery and then stores the energy to return to the load. The ESP32 is used to monitor IoT installations as a controller.

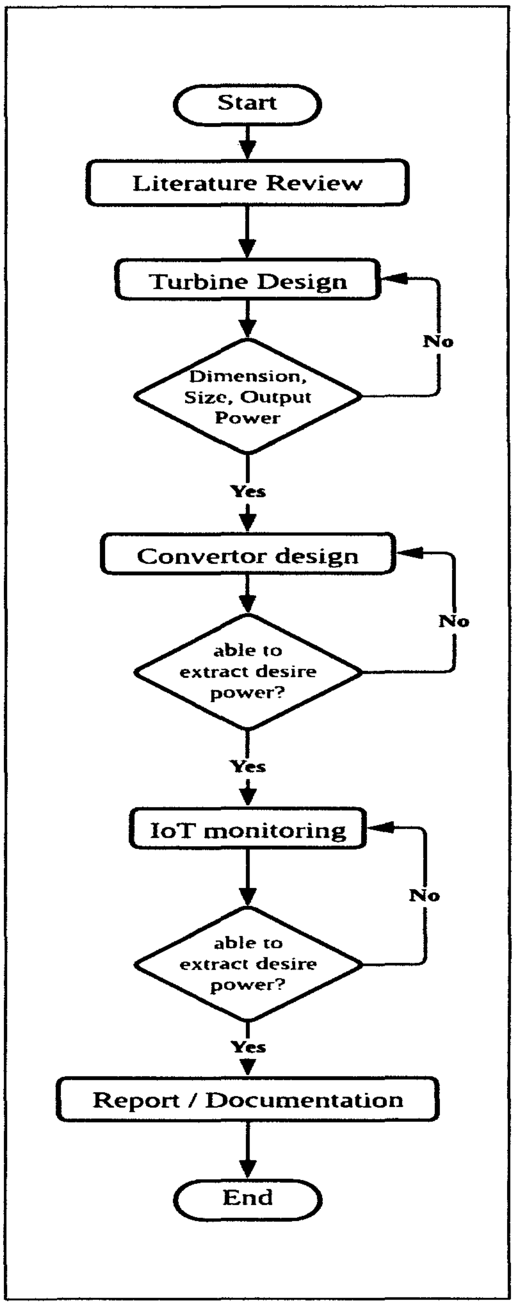

Figure 3.1 General Flowchart

3.2 System Description

The suggested system's design is depicted in Figure 3.2. The main controller of this system is the ESP32, which has a dual-core processor, built-in Wi-Fi, and Bluetooth Low Energy compatibility. This architecture is built on the Internet of Things. ESP32 controllers are used to interface sensor outputs. For both analogue and digital communications, the ESP32 is primarily utilised to deploy IoT technology.

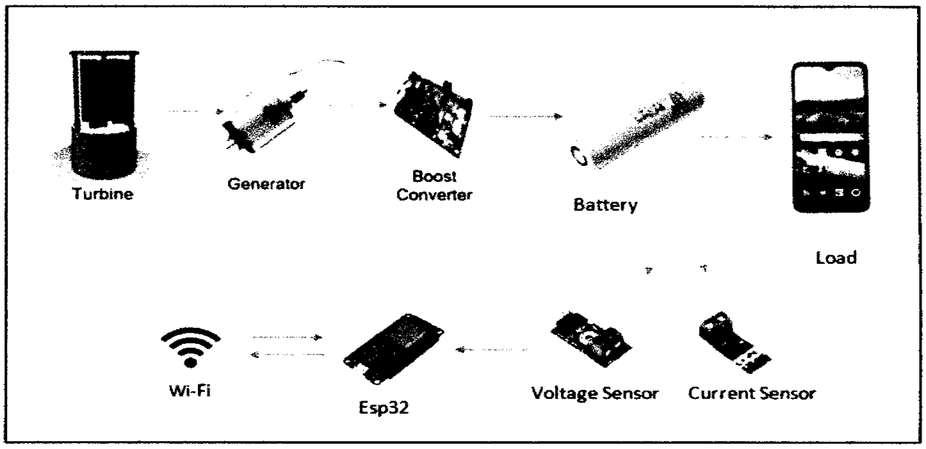

Figure 3.2 Architecture of Hybrid Hydrokinetic and Wind Energy for Portable Energy Harnessing Devices

3.3 Block Diagram

The general Block diagram of the proposed project is shown in Figure 3.3. A sensing unit, a monitoring unit, and a control unit make up the suggested system. The sensor unit's job is to sense the output and input voltages; the monitoring unit's job is to compare the sensed voltage input and output values to the reference limits and send commands to the control unit.

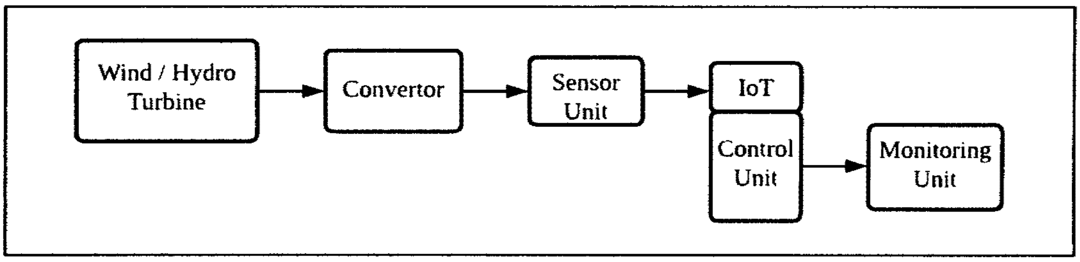

Figure 3.3 Overall Block diagram

3.4 System Flowchart

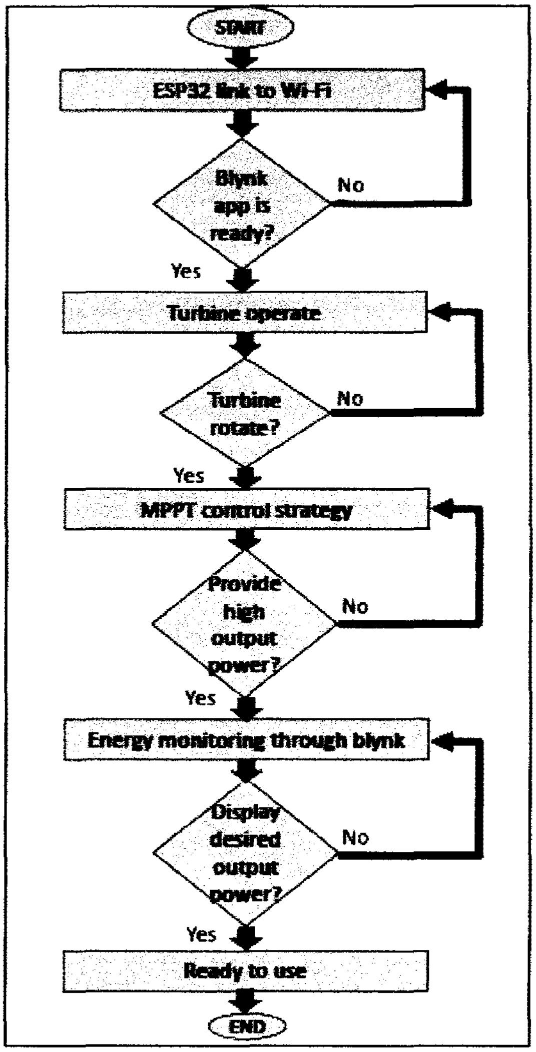

Figure 3.4 System Flowchart

The whole system of hybrid hydrokinetic and wind energy for portable energy harnessing devices is depicted in Figure 3.4. To begin, connect the esp32 to Wi-Fi and ensure that the blynk programme is installed and ready to use. The turbine will then generate electricity from either wind or water. The boost convertor boosts the voltage to the desired voltage when the turbine rotates. A mobile phone connected to the battery will be charged by the output voltage. A mobile phone may display the voltage and current output.

3.5 Turbine

A suitable turbine is required for the suggested devices to harness any kinetic energy. Turbines are frequently classified according to their axes in relation to wind and/or water flow. In the last decade, various types of modern turbines have been produced, which are divided into two categories: vertical axis and horizontal axis turbines (Fernando, Hernán & Ricardo, 2007).

Based on the existing Savonius turbine, the turbine presented in this research was idealised. Savonius turbines are well-known for their simplicity, and they are among the most basic turbines. The basic Savonius turbine has two vertical blades (half cylinder) with a cross section that resembles the letter "S." However, several improvements have been made to this design in order to fully exploit and exert the possibilities of these blades (Golecha, Eldho & Prabhu, 2012; Kumar & Saini, 2015).

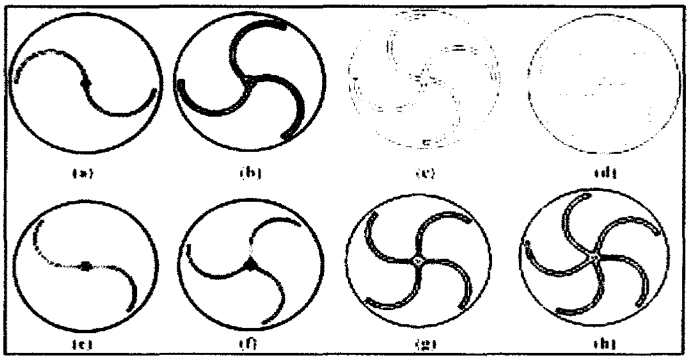

Figure 3.5 A Savonius blade on modified hydrokinetic turbine
Source: (Prabowoputra, Prabowo, Hadi & Sohn, 2021)

The savonious turbine has been utilised to harness renewable energy in both hydrokinetic and wind applications (Prabowoputra, Prabowo, Hadi & Sohn, 2021; Bachtiar, 2019). The differential in forces exerted on each blade is what makes the savonious turbine work. When travelling against wind/water flow, a half cylinder feels less drag than the other due to its blade curvature, while the other half experiences more drag. The variations in these forces drag the turbine and cause it to spin (Abraham & Plourde, 2012).

A thorough investigation has been conducted to determine the blade's efficiency in both water and wind flow. Prior to this, a design for the turbine was created using Tinkercad, a computer-aided design (CAD) programme. A vertical savonius turbine with four blades, as depicted in Figure 3.6, is the concept behind this suggested turbine design.

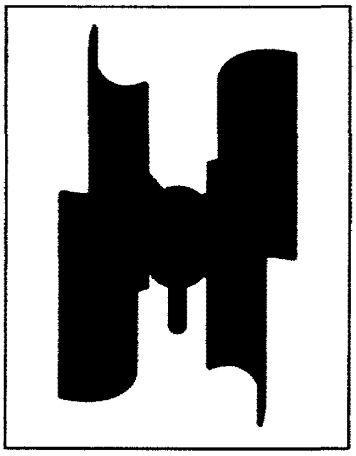

Figure 3.6 Designated turbine using Tinkercad designing tool

3.6 IoT Monitoring

In the development of hybrid hydrokinetic and wind energy for portable energy harnessing devices, two sensors are employed. A voltage sensor comes first, followed by a current sensor. Users may verify the voltage and current input to the charging phone using a mobile phone, which is a great concept. To run the IoT for the system, you'll need a Wi-Fi connection. The phone is connected to the ESP32 Wi-Fi module via the microcontroller. Once the device is attached to the module, it can be used to display sensor data.

3.6.1 Current sensor

The ACS712's Vcc is connected to the ESP32's 5v pin, while the ground for both components is connected, and the current sensor's out is attached to pin 35. A series connection is used to connect the load and battery for the current sensor readout.

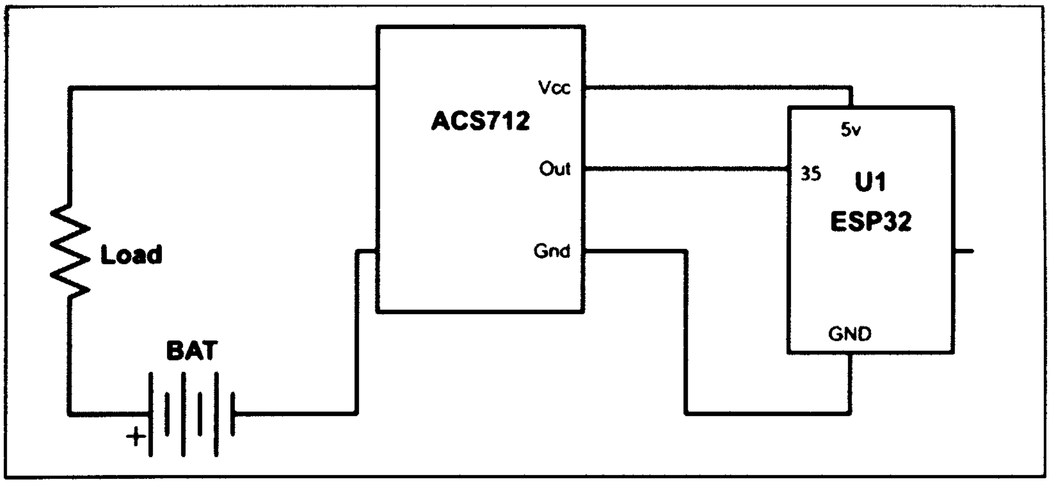

Figure 3.7 Circuit Diagram for ESP32 and ACS712

The connection between the ACS712 current sensor and the ESP32 with load and battery is shown in Figure 3.7. The load and battery are linked in series, allowing for the measurement of current flowing through the load.

3.6.1.1 Current sensor coding

```
void sensor()
{
  sensorValue1 = analogRead(volt);
  volt1 = (sensorValue1 * 5.0)/1024.0;
  for (int i = 0; i < averageValue; i++)
  {
    sensorValue += analogRead(amp);

    // wait 2 milliseconds before the next loop
    delay(2);
  }
  sensorValue = sensorValue / averageValue;
  voltage1 = sensorValue * 5.0 / 1024.0;
  current1 = (voltage1 - 2.5) / 30.185;
  Blynk.virtualWrite(V1, volt1);
  Blynk.virtualWrite(V2, current1);

}
```

Figure 3.8 Coding for current sensor

The current sensor is an analog read sensor. From Figure 3.8, the current sensor coding needs to divide by 1024 since the reading is analog. The coding explains that the sensor needs to multiply by 5 and divide by 1024 to get the exact value in ampere. The pin for current sensor is virtual pin 2 that connect the sensor and the blynk application to read the sensor data accurately.

3.6.2 Voltage sensor

The B25 voltage sensor ground is connected to the ESP32 ground pin, and the voltage sensor is attached to pin 36 of the ESP32 for analog readout. For voltage reading via a mobile phone, a parallel connection is used to link the load to the voltage sensor.

3.6.2.1 Voltage sensor coding

```
void sensor()
{
  sensorValue1 = analogRead(volt);
  volt1 = (sensorValue1 * 5.0)/1024.0;
  for (int i = 0; i < averageValue; i++)
  {
    sensorValue += analogRead(amp);

    // wait 2 milliseconds before the next loop
    delay(2);
  }
  sensorValue = sensorValue / averageValue;
  voltage1 = sensorValue * 5.0 / 1024.0;
  current1 = (voltage1 - 2.5) / 30.185;
  Blynk.virtualWrite(V1, volt1);
  Blynk.virtualWrite(V2, current1);

}
```

Figure 3.9 Coding for voltage sensor

The voltage sensor also an analog read sensor. From Figure 3.9, the voltage sensor coding needs to divide by 1024 since the reading is analog. The coding explains that the sensor needs to multiply by 5 and divide by 1024 to get the exact value in volt. The pin for voltage sensor is virtual pin 1 that connect the sensor and the blynk application to read the sensor data accurately.

3.6.3 Blynk Coding

```
#define BLYNK_PRINT Serial
#include <WiFi.h>
#include <WiFiClient.h>
#include <BlynkSimpleEsp32.h>
BlynkTimer timer;

char auth[] = "wuu9QVAIxZfUPAhlqip_NyKMxi_Nd0Gc";
char ssid[] = "Reddmi 9";
char pass[] = "luqman21";
```

Figure 3.10 Blynk setup coding

The software for configuring the blynk application with ESp32 is shown in Figure 3.10. The authentication will be delivered to you through email after you sign up. The ssid, on the other hand, is the name of a gadget that will connect the blynk and the ESp32 via a mobile phone. The password that has been set on the mobile phone is the pass.

3.7 Cost

Table 3.1 Total cost of components

No.	Description	Quantity	Price per Unit (RM)	Total (RM)
1.	3.7V 3800mah Lithium Battery	1	39.80	39.80
2.	Voltage sensor	2	1.90	3.80
3.	ACS712 current sensor	2	7.40	14.80
4.	9V Battery Connector with DC	2	0.90	1.80
5.	9V Battery Connector without DC	2	0.80	1.60
6.	NodeMcu V2 ESP32	1	32.90	32.90
7.	Arduino Uno	1	35.90	35.90
8.	Current Ampere Amp Load	1	8.50	8.50
9.	MPPT	1	80.73	80.73
10.	IRF540N Mosfet	1	2.50	2.50
11.	Potentiometer	1	1.00	1.00
12.	Stainless Steel Stud Bolt Rod	2 meter	24.55	24.55
13.	DC 12-18V Motor	1	47.42	47.42
14.	Mini Wind Turbine Blade	10	34.48	34.48
Total (RM)				329.78

3.7.1 IoT components cost

Table 3.2 Total cost for IoT components

No.	Description	Quantity	Price per Unit (RM)	Total (RM)
1.	3.7V 3800mah Lithium Battery	1	39.80	39.80
2.	Voltage sensor	2	1.90	3.80
3.	ACS712 current sensor	2	7.40	14.80
4.	9V Battery Connector with DC	2	0.90	1.80
5.	9V Battery Connector without DC	2	0.80	1.60
6.	NodeMcu V2 ESP32	1	32.90	32.90
8.	Current Ampere Amp Load	1	8.50	8.50
Total (RM)				103.20

CHAPTER 4

RESULTS AND DISCUSSION

Results and discussion will be more focus on about the system output. The hardware of turbine, boost convertor and IoT will be shown in this chapter.

4.1 Turbine prototype

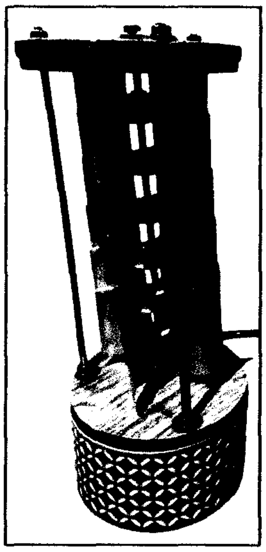

Figure 4.1 Prototype of turbine design

Figure 4.1 shows the prototype of the turbine. The material for the blade of the turbine is made up of Acrylonitrile butadiene styrene. The material is suitable for wind and water. The turbine will supply the voltage to the generator inside the compartment.

4.2 Boost convertor

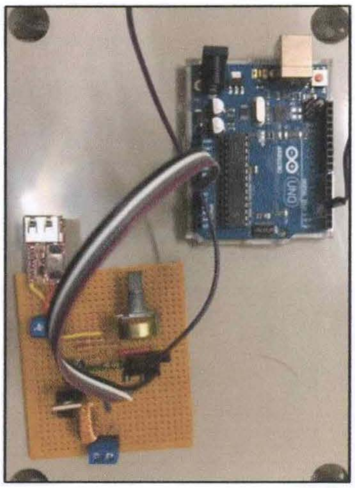

Figure 4.2 Circuit diagram for boost convertor

Figure 4.2 shows the circuit diagram for the boost convertor. The output of the boost convertor is from 8 to 10 volt with a supply of 5v DC. The Arduino Uno is used to control the PWM of the boost convertor. The output of the boost convertor is connected to a USB module to charge a couple of batteries.

4.3 IoT Monitoring

Figure 4.3 IoT monitoring circuit diagram

Figure 4.3 shows the complete circuit of IoT monitoring that includes a set of batteries, voltage sensor, current sensor, ESP32 and power supply for the ESP32. This circuit is used to measure voltage and current while connect to ESP32. The ESP32 wirelessly sends the data input from both sensors to the Blynk application through a mobile phone.

4.4 Circuit Architecture

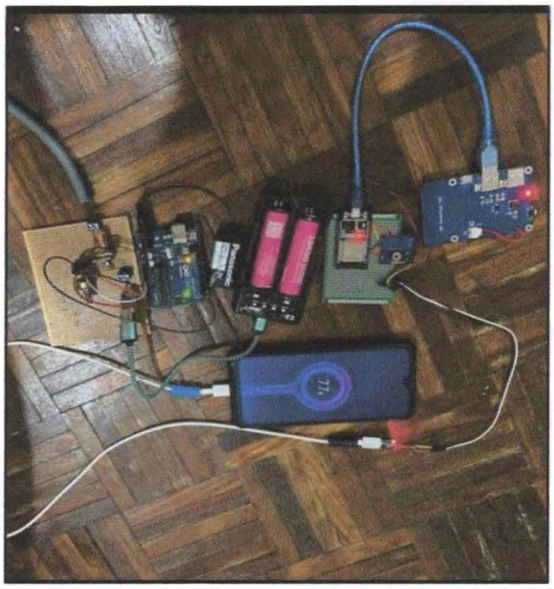

Figure 4.4 Complete circuit architecture

Figure 4.4 shows the complete circuit architecture of the development of a hybrid hydrokinetic and wind energy for portable energy harnessing devices. This figure also shows that the system is successfully running which the mobile phone is currently charging using the system.

4.5 Product Overview

Figure 4.5 complete product design

Figure 4.5 shows the complete product design for the development of a hybrid hydrokinetic and wind energy for portable energy harnessing devices. The turbine can operate in windy conditions to get the desired output from the generator. The box compartment is used to store the boost convertor circuit and ESP32 circuit.

4.6 Blynk monitoring

Figure 4.6 Snapshot from blynk application

Figure 4.6 shows the real time sensor reading data from both voltage sensor and current sensor. The voltage display value is the same as the given voltage from the battery supply and also for the current display value.

CHAPTER 5

CONCLUSION

This project aimed to design and develop a vertical axis turbine for portable hybrid energy harnessing, to design a Maximum Power Point Tracker (MPPT) controller for maximum energy extraction and to develop an energy monitoring system based on the Internet of Things (IoT) system. To summarise, all of the objectives have been met. The first goal was accomplished since a portable hybrid hydrokinetic and wind energy system was developed that is easier to handle and transport than existing goods. Aside from that, this project seeks to construct a controller for the devices using a boost converter, as well as monitoring utilising an IoT system, in which the user may monitor the device's activities using simply a mobile phone. This is a large sensor-based project using cutting-edge technology. IoT-enabled small sensors will have a huge impact on the industry.

To better understand the implications of these results, future studies could build a more stable turbine to be put in water conditions. Next, users need to do a real life simulation for about 1 hour or more to know how long will the battery need to be charged. This project can still help people to overcome their problems.

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APPENDIX A
SPECIFICATION

Arduino Uno

- Microcontroller: ATmega328P
- Operating Voltage: 5V
- Input Voltage (recommended): 7-12V
- Input Voltage (limit): 6-20V
- Digital I/O Pins: 14 (of which 6 provide PWM output)
- PWM Digital I/O Pins: 6
- Analog Input Pins: 6
- DC Current per I/O Pin: 20 mA
- DC current for 3.3V Pin: 50 mA
- Flash Memory: 32 KB (ATmega328P) of which 0.5 KB used by bootloader
- SRAM: 2 KB (ATmega328P)
- EEPROM: 1 KB (ATmega328P)
- Clock Speed: 16 MHz
- LED_BUILTIN: 13
- Length: 68.6 mm
- Width: 58.4 mm
- Weight: 25 g

ESP32 Wi-Fi

- Single or Dual-Core 32-bit LX6 Microprocessor with clock frequency up to 240 MHz.
- 520 KB of SRAM, 448 KB of ROM and 16 KB of RTC SRAM.
- Supports 802.11 b/g/n Wi-Fi connectivity with speeds up to 150 Mbps.
- Support for both Classic Bluetooth v4.2 and BLE specifications.
- 34 Programmable GPIOs.
- Up to 18 channels of 12-bit SAR ADC and 2 channels of 8-bit DAC
- Serial Connectivity include 4 x SPI, 2 x I2C, 2 x I2S, 3 x UART.
- Ethernet MAC for physical LAN Communication (requires external PHY).
- 1 Host controller for SD/SDIO/MMC and 1 Slave controller for SDIO/SPI.
- Motor PWM and up to 16-channels of LED PWM.
- Secure Boot and Flash Encryption.
- Cryptographic Hardware Acceleration for AES, Hash (SHA-2), RSA, ECC and RNG.

ACS712 Current Sensor

- Supply Voltage: 4.5V ~ 5.5V DC
- Measure Current Range: -20A ~ 20A
- Sensitivity: 100mV/A

B25 Voltage Sensor

- Input Voltage: 0 to 25V
- Voltage Detection Range: 0.02445 to 25
- Analog Voltage Resolution: 0.00489V

Boost Convertor

- Input Voltage: 10v – 32v DC
- Output Voltage: 12v – 35v DC
- Output Current: 6A MAX
- Input Current: 10A (MAX)
- Output Ripple: 2% MAX
- Working Temperature: Industrial – 40C to +85C
- Full-Load temperature: 45 degrees.
- No-load current: 25mA typical.
- Voltage regulation: ± 0.5%.
- Load regulation: ± 0.5%.
- Dynamic response speed: 200uS 5%.
- Size: 2.60 in (L), 1.85 in (W) , 1.1 in (H)

Turbine

- Material: Acrylonitrile butadiene styrene (ABS) filament
- Blade size: 60mm x 30mm x 11mm
- Joining parts diameter: 30mm ±
- Turbine assembled size: 130mm x 100mm x 100mm
- Generator hole diameter: 5mm

DC Generator

- Brand: MITSUMI
- Model: RM1-4617
- Categories: Direct-current (DC) generator
- Certification Certificate of Completion and Compliance (CCC)
- Voltage: 1.5V ~ 24V DC
- Wattage: 40W
- Torque: 2100 – 5000 RPM
- Dimension: 88mm x 35mm x 35mm

APPENDIX B
ARDUINO IDE CODING

```
#define BLYNK_PRINT Serial
#include <WiFi.h>
#include <WiFiClient.h>
#include <BlynkSimpleEsp32.h>
BlynkTimer timer;

#define volt 34
#define amp 35

char auth[] = "wuu9QVAIxZfUPAh1qip_NyKMxi_Nd0Gc";
char ssid[] = "Reddmi 9";
char pass[] = "luqman21";

float sensorValue1 = 0.0;
float volt1 = 0.0;
float sensorValue = 0.0;
const int averageValue = 500;
float voltage1 = 0;
float current1 = 0;
boolean state = false;

void setup()
{
 Serial.begin(115200);
 Blynk.begin(auth, ssid, pass);
 pinMode(volt, INPUT);
 pinMode(amp, INPUT);
 timer.setInterval(1000L,sensor);

}
void sensor()
{
 sensorValue1 = analogRead(volt);
 volt1 = (sensorValue1 * 5.0)/1024.0;
 for (int i = 0; i < averageValue; i++)
 {
  sensorValue += analogRead(amp);

  // wait 2 milliseconds before the next loop
  delay(2);
 }
 sensorValue = sensorValue / averageValue;
 voltage1 = sensorValue * 5.0 / 1024.0;
 current1 = (voltage1 - 2.5) / 30.185;
```

```
 Blynk.virtualWrite(V1, volt1);
 Blynk.virtualWrite(V2, current1);

}
void loop()
{
 Blynk.run();
 timer.run();
}
```