DESIGN AND IMPLEMENTATION OF MINI WIND TURBINE AND CHARGER SYSTEM.

BY

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EEE/12/0843

A PROJECT REPORT SUBMITTED

TO

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING,

FACULTY OF ENGINEERING,

FEDERAL UNIVERSITY OYE EKITI.

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF

BACHELOR OF ENGINEERING (B.Eng.) [HONS] DEGREE IN ELECTRICAL AND ELECTRONICS ENGINEERING

NOVEMBER 2017

DEDICATION

This project is dedicated to God Almighty, most Gracious and most Merciful. Indeed all praise is due to God of the World, who created man and taught him what he knew not. It is by His grace and will that I have been able to attain where I am today. May His name be praised forever.

Also to my beloved father Late Reverend Emmanuel Ganiyu Fatolu. May his gentle soul continue to rest in perfect peace Amen.

Lastly to my siblings and my entire family.

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CERTIFICATION

This project work titled "Design and implementation of mini wind turbine and charger system" by Emmanuel Babatunde, meets the requirements for the award of Bachelor of Engineering (B.Eng.) degree in Electrical and Electronics Engineering Department, Federal University Oye-Ekiti.

for

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ABSTRACT

With high demand for electrical power to run appliances at home, offices and industries, electricity bills are increasing by the day, ozone layer is been depleted as a result of greenhouse gas emission by fossil fuel power generating station. This project presents an alternative to fossil fuel based power generators by implementing a renewable energy source in wind turbine for charging application. The wind turbine is a 3 blade horizontal axis design with a DC motor used as the generator. The generated power is used to charge a 6V battery through a charging circuit. In addition to a 6V outlet, 5V USB outlet was incorporated into the charger circuit for mobile phone charging application. The system was tested with mobile phone and result confirm the operation of the project.

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LIST OF PARAMETERS

P= Power.

T = Torque.

ω = Angular velocity of the turbine blades.

v = Velocity.

m = Mas of air density.

A = Rotor swept area.

P= the density of the air measure.

Cp = turbine power coefficient.

P_W = wind power.

P_T = turbine power.

N = Number of Blades.

A_B = Area of one blade.

A_s = Swept Area.

B_u = upper bredth of the blade.

B_l = lower bredth of thge blade.

h = height of the blade.

C_p = Rotor efficiency.

D = rotor diameter.

N = Efficiency of driven machine or generator.

A = Swept rotor Area.

V = Wind Speed.

TSR = Tip Speed Ratio.

R = Radius of rotor blade.

r = Radius at point of computation.

I = number of blades.

Li = life coefficient.

T_{high} = time period of HIGH.

T_{low} = time period of LOW.

(α) = angle of attack.

(β) = setting angle.

(Φ) = flow angle.

LIST OF ABBREVIATIONS

AC = Alternating Current

BEM = Blade Element Momentum

CFD = Computational Fluid Dynamics

CP = Coefficient of Performance

DC = Direct Current

EMI = Electromagnetic Interference

IC = Integrated Circuit

IGBT = Isolated Gate Bipolar Transistor

KE = Kinetic Energy

PV = Photo-voltaic

LED = Light-Emitting Diode

HAWT = Horizontal Axis Wind Turbine

TSR = Tip Speed Ratio

RPM = Revolution per Minute

VAWT = Vertical Axis Wind Turbine

PMDCG =Permanent Magnetic Direct Current Generator

WOCCS = Wireless Open-source Command and Control System

USB = Universal Serial Bus

ACKNOWLEDGEMENT

I wish to express my profound gratitude to God for giving me the time and opportunity to start and complete my Bachelor degree programme in good health.

I want to show my gratitude to my supervisors Dr. J.Y. Oricha and Engr. S. Sanni who took out time despite their tight schedules to listen, guide, encourage and provide me with necessary information to make this project a success, their constructive criticism immensely contributed to the success of this project, indeed I am so fortunate to have both of them as my supervisors.

Also my special thanks go to the Head of Department Dr. O.Akinsanmi for his fatherly advice and support, and also the entire staff of Electrical and Electronics Engineering department for the knowledge they impacted in me and their support throughout my stay.

I am indeed most grateful to my mother Mrs Omolade Emmanuel for her prayer, parental cares and financial support, may God continue to bless her with good health, long live and prosperity (AMEN). My sincere gratitude also go to my Uncle in person of Mr. A.K. Adewale, my siblings and the entire members of my family for their support morally, financially and spiritually, a very big thanks to you all.

My immeasurable gratitude go to my spiritual fathers Pastor David Joshua, Prophet S. Emmanuel, Prophet Arole Peter and Leaders of Chapel of Transformation (COT) FUOYE. More unction to function, your anointing will never run dry in Jesus name.

Lastly, my appreciation go to my course mates and my friends in person of Mogbadunola Tunde, Ogunremi Tope, Abereola Oluwaseun, Richard Aladesiun, Oyewole Tomisin and many that cannot be mentioned here, may God be with you all (Amen).

CHAPTER ONE

1.0 INTRODUCTION

Wind is a form of renewable sources of energy (Faddoul, 1981). It is caused by irregularities of the earth surface, rotational of the earth and the uneven heating of the atmosphere by the sun. Wind flow patterns are modified by the earth's terrain, vegetation and bodies of water. We use wind flow or motion energy, for many purposes, such as flying a kite, sailing and generating electricity. The term wind power or energy describes the process by which the wind is used to generate mechanical power or electrical power. The rate of power extracted from the wind is governed by Equation (1.1).

$$P = T\omega \qquad (1.1)$$

Where P is the power,

T is the torque, and

ω is the angular velocity of the turbine blades.

Wind turbine work is like a fan but fan using electricity to make wind, however wind turbines turns the blade which spin a shaft, then connects to generator and lastly it will makes electricity.

In 1930s, small wind turbines were widely used to generate electricity on farms in United States where distribution systems had not yet been installed. It's used to replenish battery storage banks, these machines typically had generating capacities of a few hundred watts to several kilo watts, besides providing farm power, and they were also used for isolated applications such as electrifying bridge structures to prevent corrosion. In this period high tensile steel was cheap, and wind turbines were placed atop prefabricated open steel lattice towers (Wind Energy Development Programmatic Environmental Impact Statement Information Center, 2016)

One of the frequently mentioned drawbacks of renewable energy technologies is that they cannot supply electricity consistently. Energy from the wind and sunlight are variable resources in the sense that they are non-dispatchable due to its fluctuating nature; it can only be decreased but not increased other than what a nature provides. While biomass and geothermal is completely dispatchable. It is possible to get wind power when the wind blows. That is the reason for the popularity of stand-alone systems by charging batteries, it can be ensured that electricity is present at the time it is needed, even if the wind is not blowing the turbine or the sun is not shining on the Photo-voltaic (PV) panels. Using several batteries connected to battery banks some homeowners have succeeded in taking their homes off grid, this means they are no longer connected to the electricity transmission grids. These homes generate electricity using wind turbines, solar panels, and or diesel generators. They store excess energy in battery banks to ensure that they have enough electricity to get them through days when renewable energy sources are not available.

1.1 BACKGROUND OF THE PROJECT

The increase in costs of fossil fuels has greatly lead to the development of alternative sources of Renewable Energy that are environmental friendly and cheaper to produce. The major resource in this category is wind energy. The exact origin of the first use of wind power is not known, however one of the earliest known uses dates back to 3500 B.C where they were used to drive sailboat using aerodynamic lift. The advancements of this design were adapted to China where the first mini wind turbine was developed and it was a vertical axis type that used sheet like wings to capture the wind. In the middle ages, wind energy was introduced in Northern Europe where Horizontal axis mini wind turbine were used where the sails connected to a horizontal shaft attached to a tower with gears and axles that were used to translate the horizontal motion into rotational motion. In the 19th Century, wind energy developed in the

United States where horizontal axis mini wind turbine were used for farms, ranches and to generate electricity. This is where the first multi-blade was developed for irrigation purposes.

The wind power technology has evolved greatly and this has been motivated by the incredible benefits resulting from wind energy. Very efficient and technologically up-to- date designs have been developed and are used all over the country. Viability of mini wind turbine is however practical only in areas with free flow of air and therefore site selection is very critical in the initial design process. The power generated from the wind can be supplied directly to the national grid system or used to drive other mechanical devices such as grinders. This has greatly reduced the levels of pollution resulting from the use of fossil fuels. This project is mainly based on the design and construction of 6v charger system using mini wind turbine.

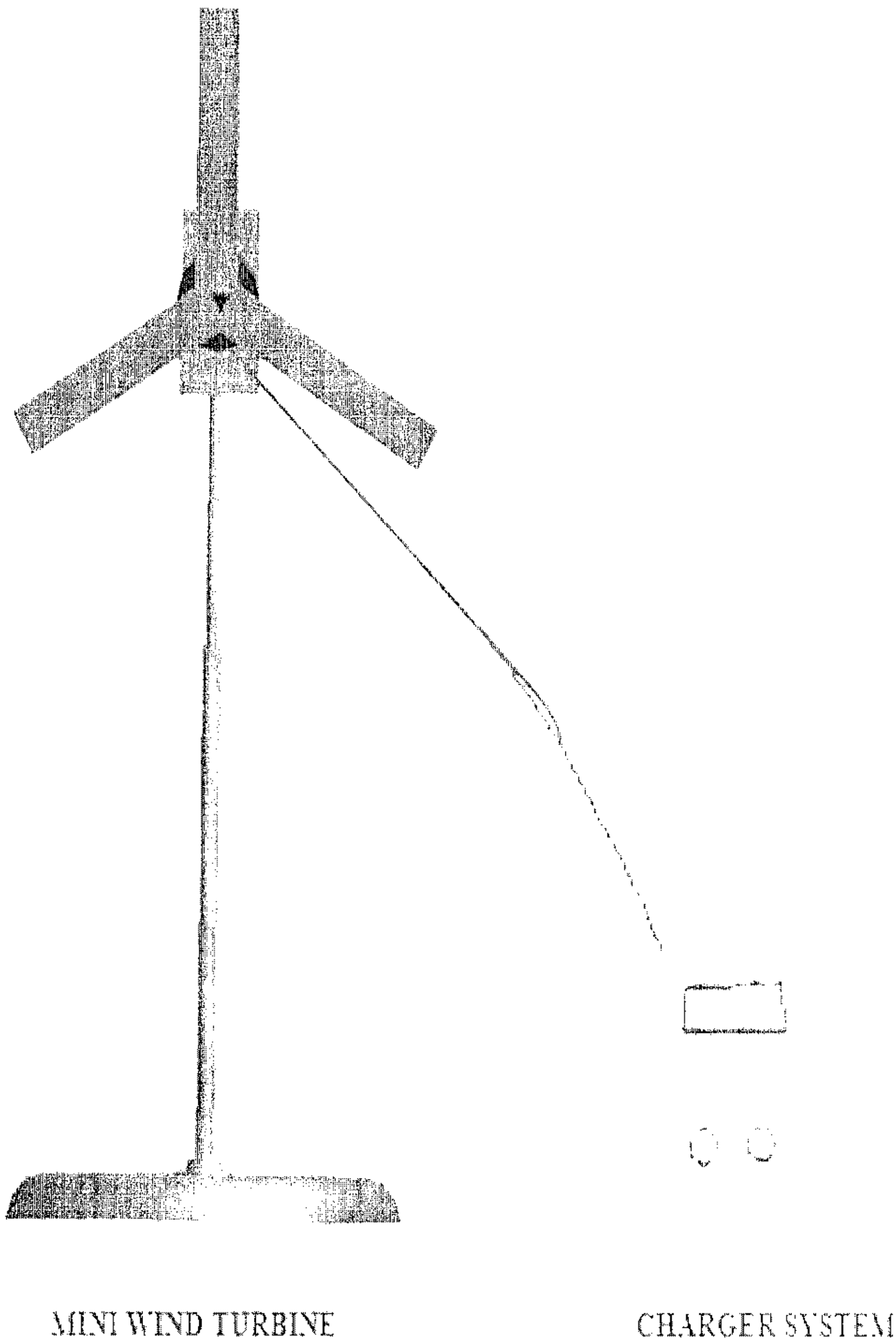


Figure: 1.1 A schematic diagram of the project.

1.2 STATEMENT OF THE PROBLEM

Nowadays, many types of the electrical equipment are often used at home and people have been suffering due to electricity crisis for a long time in terms of monthly increment in electricity bills and power failures. Also, most gasoline generator that an average person can afford, which could serves as an alternative means of power supply requires manpower to start their operation which could be difficult for some people to handle. In addition, manual gasoline generator requires raw materials like fossil fuel to operate which is one of the environmental challenges we are facing with the ozone layer because of the greenhouse gas emission from the gasoline engines, likewise the sound pollution. To reduce this problem, an alternative means of generating electricity would be adopted which is wind generator.

With a simple method, wind generator can move without the need for manpower and automatically works, also environmental pollution including greenhouse gas emission and sound pollution can be reduced. Compare with the manual gasoline generator causes the harmful pollution to the environment.

1.3 PROJECT MOTIVATION

The oil shortages of the year 2016 which disrupted the energy picture of the country motivated my interest in alternative energy sources, paving the way for the entry of the wind turbine to generate electricity, because it has no greenhouse gas emissions. The most important is that, it does not require fossil fuel. It does not need any substance like cooling water that is use in fuel engine and nuclear reactor. They are free from causing pollution such as water pollution that is produced by human activities. The system is thus readily available.

1.4 AIM AND OBJECTIVES

The aim of this project is to design a prototype of mini wind turbine that generates electricity and stores generated electricity in batteries. To achieve this aim, the following are the objectives of the project.

I. To design and implementation of a mini wind turbine prototype.

II. To design and implementation of a charger system.

1.5 SIGNIFICANCE OF THE PROJECT

The significance of this project is to generate electricity and the generated electricity will be store on the battery through charger system then the stored power will be used to charge phone and a 6volt gadgets, this project can also serves as an alternative means of charging gadgets, without depending on electricity from the national grid or standby generator.

1.6 SCOPE OF THE PROJECT

The scope of this project work took into consideration the hardware design of a mini wind turbine and an oscillator circuit using 555 timer to generate the waveform. This oscillator circuit is the charger system which charges the battery when the turbine blade is spinning.

1.7 HYPOTHESIS

If a three-blade rotor on a horizontal axis windmill generates a given amount of electrical energy, it will increase the amount of electrical energy output.

I predict that the orientation of the rotors (i.e. blades off set or in line) will affect the amount of electrical energy produced.

I predict that the size of the rotors will affect the amount of electrical energy produced.

I predict that the wind speed will affect the amount of electrical energy produced.

1.8 PROJECT ORGANISATION

This project is organized into five chapters:

1. Chapter one introduced the project background which provides a description of the basic facts and importance of the research area, it also talked about the problem statement, significance of the project, motivation, aim and objectives, scope of the project and the hypothesis.
2. Chapter two presents the literature review which provides a summary of previous related research on the research problem and their strength and weakness and a justification of the research, also it presents the fundamental concept which talks on the components.
3. Chapter three presents the methodology and design of the project work.
4. Chapter four presents the results and analysis of the project, in addition it presents the implementation, testing of the hardware and the project management.
5. Chapter five is the conclusion part of the report that presents the limitation, future works, contribution to knowledge, problem encountered and the critical appraisal of the work.

The organization chart is shown in figure 1.2

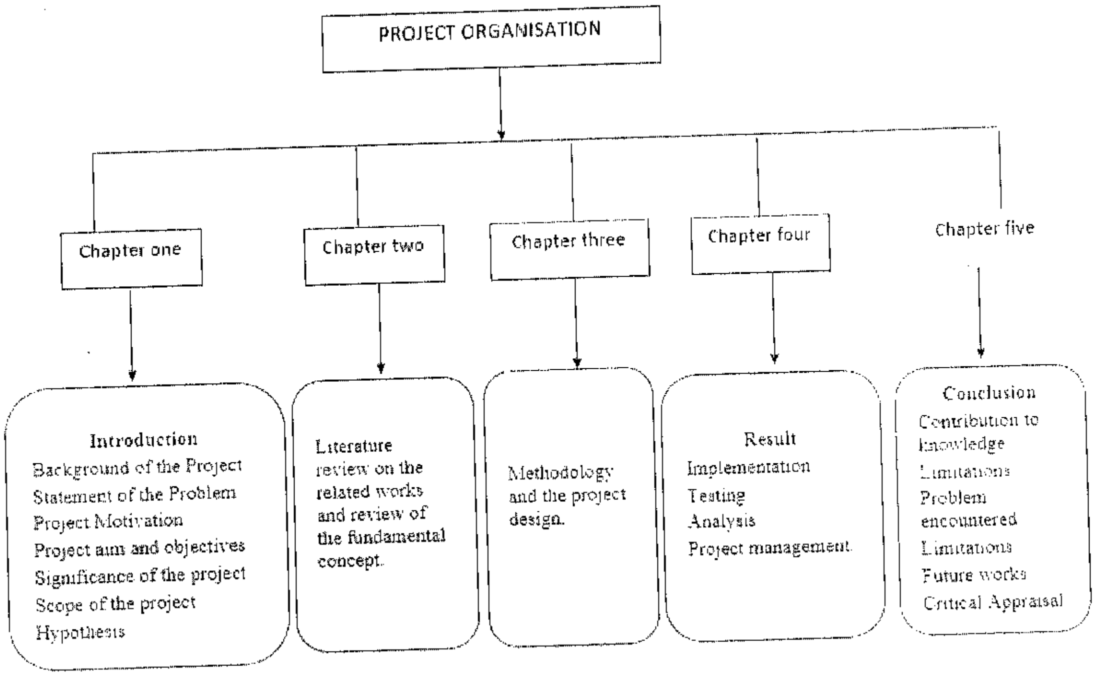


Figure 1.2: Project organization chart.

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

Literature review and research on theories related to the project involves the theories of numerous of wind turbine by obtaining most of the information from the internet and reference books. This section is divided into two sections which is review of related works that have to do with the research that have been done by some scholars, their challenges, limitations and how it can be improved, the second section is the review of the fundamental concept which talked about the wind energy, wind turbine itself and the components/equipment needed for the charger system were thoroughly discussed in this project work.

2.2 REVIEW OF RELATED LITERATURE

Roy, (1998) studied on optimal planning of wind energy conversion systems over an energy scenario. The wind power system design must optimize the annual energy capture at a given site. The only operating mode for extracting the maximum energy is to vary the turbine speed with varying wind speed such that at all times the TSR is continuously equal to that required for the maximum power coefficient. The theory and field experience indicate that the variable-speed operation yields 20 to 30% more power than with the fixed-speed operation. In the system design, this trade-off between energy increase and cost increase has to be optimized. In the past, the added costs of designing the variable pitch rotor, or the speed control with power electronics, outweighed the benefit of the increased energy capture. However, the falling prices of power electronics for speed control and the availability of high-strength fiber composites for constructing high-speed rotors have made it economical to capture more energy when the speed is high.

Wang, Bai, Fletcher, Whiteford, & Cullen, (2007) studied on a small domestic HAWT with scoop. The aim of their study is to investigate the possibility of improving wind energy capture.

under low wind speed conditions, in a built-up area, and the design of a small wind generator for domestic use in such areas. The activities reported in their report are optimization of a scoop design and validation of the computational fluid dynamics CFD model. The final design of scoop boosts the air flow speed by a factor of 1.5 times equivalent to an increase in power output of 2.2 times with the same swept area. Wind tunnel tests show that the scoop increases the output power of the wind turbine. The results also indicate that, by using a scoop, energy capture can be improved at lower wind speeds. The power generation of such a new wind turbine is expected to be increased, particularly at locations where average wind speed is lower and more turbulent.

In this case, scoop is too expensive and it needs an additional expert technician or engineer to design this type of turbine. Mini HAWT would be used because its required small wind speeds to operate in the range of 1.5 to 3 m/s.

Wright & Wood, (2008) analyzed that the magnitude of gyroscopic rotor shaft and blade bending moments on a free yaw wind turbine rotor are proportional to the product of rotor speed and yaw rate. An analysis is presented of the relationship between two variables and wind speed, based on field test data from a 2m diameter wind turbine with a tail-fin furling system, and in reference to the recent revision of the International Electro technical Commission standard for small wind turbine design. Examples are given of fast yaw rates caused by furling, and by large wind direction changes at relatively small wind and rotor speeds. Analyses of data showed that reducing turbine yaw moment of inertia increases the magnitude of maximum yaw rate for a given rotor speed, and that yaw rate is highly influenced by tail fin aerodynamics.

However, buck-boost converter requires input filter to reduce current ripple and to meet electromagnetic interference (EMI) requirements as input current is pulsating due to switching of power switch. Also output current is discontinuous and hence large output capacitor is required to reduce ripple voltage. Moreover, presence of right half zero in continuous conduction mode makes feedback loop compensation difficult. In this case, 555timer would be used.

Mercyline & Mokaya, (2013) designed a small wind turbine for pumping water by using a horizontal axis wind turbine with 24 blades. Each blade has a radius of 2m giving a total surface area of 0.5585 m^2 and this gives a solidity of 0.8, the minimum theoretical optimum value for wind turbine. The torque output of the wind turbine is 106.4572 Nm and this is sufficient to sustain the desired flow rate of (0.1736 X 10^{-3}) m^3per second with a maximum head of 30m, and also overcome other barriers to motion such as friction. But the limitation of this project is that horizontal axis wind turbine of 24 blades was used in the design. if the wind speed is not high enough, the turbine will not spin the blades to deliver the maximum output power. In this case horizontal axis wind turbine with 3 blades will be considered to minimize cost and maintenance of the turbine, also to have the desired output power with little wind speed.

McCosker, (2012) the design process includes the selection of the wind turbine type and the determination of the blade airfoil, pitch angle distribution along the radius, and chord length distribution along the radius. The pitch angle and chord length distributions are optimized based on conservation of angular momentum and theory of aerodynamic forces on an airfoil. Blade Element Momentum (BEM) theory is first derived then used to conduct a parametric study that will determine if the optimized values of blade pitch and chord length create the most efficient blade geometry. Finally, two different airfoils are analyzed to determine which one creates the most efficient wind turbine blade.

Ali, et al., (2016) published an Indian Journal of Science and Technology on design and implementation of portable mobile phone charger using multi directional wind turbine extracted which a prototype of battery charger was developed for application with mobile phones as an example to address the design considerations, plus demonstrates the performance of the charger adapted to a practical application system findings. This mobile charger is better than normal mobile charging as it uses wind power as a renewable energy source. Applications/ Improvement of the Direct Current (DC) motor is attached to the blade toque which produced an output voltage of 3v in order to ensure the output that will produce constant in DC voltage; full wave Rectifier Bridge was used. After that, DC to DC boost circuit was also used to boost the output voltage to 5v and constant the voltage output.

Munarriz, (2013) constructed a wind turbine and a charge controller, the converter that deals in the project was controlled converter; which constitute the switches that can be controlled in their power (Thyristor), on and off. (MOSFET, Isolated Gate Bipolar Transistor IGBT) was used as an oscillator to generate the waveform. In this case, 555timer would be used in replace of the MOSFET.

Allen, Smit, Ocorr, & VanDeLinde., (2014) presented a portable charging solution for a single cell lithium ion battery using wind power as a renewable energy source. A single cell battery was chosen to minimize both power consumption from the Wireless Open-source Command and Control System (WOCCS) and minimize overall volume. The LT3650 chip, specifically (Allen, Smit, Ocorr, & VanDeLinde., 2014). Presented a portable charging solution for a single cell lithium ion battery designed for the charging of a single cell lithium ion battery, was chosen to distribute the generated power to the battery. The efficiency of the power transferred from the wind through the generator was determined to be about 11%. The efficiency of the power electronics charging the battery was determined to be about 92%. The overall operating time of the WOCCS family transceiver systems given a charged battery was successful in meeting the four 2-hr mission target. Charge time for the battery using the charging system was determined to be about 8 hours. In this case, lead acid battery would be charged by using wind power as a renewable energy source.

2.3 REVIEW OF FUNDERMANTAL CONCEPT

2.3.1 WIND ENERGY

The term wind power or energy describes the process, by which the wind is used to generate mechanical power or electrical power by the use of wind turbine; it is the energy that is extracted from air (SJ.Dijkstra & Ir.OH. 2010).

Fundamental Equation of Wind Power

Wind Power depends on the amount of air (volume), speed of air (velocity) and the mass of air (density) flowing through the area of interest (flux).

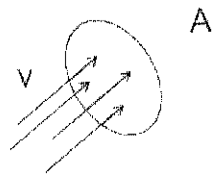


Figure 2.1 Wind Power Fundamentals (Kalmikov & Dyke, 2010)

Kinetic Energy definition

$$KE = \frac{1}{2} \times m \times v^2 \quad (2.1)$$

Where v *is the velocity* and m *is the mass of air density*

Power is KE per unit time:

$$P = \frac{1}{2} \times m \times v^2 \quad (2.2)$$

where , P is Power, v *is velocity and the* m *is mass of air density*

Fluid mechanics gives mass flow rate:

(density × volume flux):

Thus:

$$P = \frac{1}{2} \times \rho \times A \times v^3 \quad (2.3)$$

where, P is Power, ρ is air density, v is velocity and A is rotor swept area A is πr^2

Advantages of Wind energy

I. It is the cheapest source of energy. This is because it does not require importation and it is readily available.

II. It is environmental friendly i.e. it is a major source of green energy as no greenhouse emissions are released to the atmosphere during its production.

III. Require less labour expenses as maintenance is very minimal and few personnel are required at the site.

Disadvantages of Wind energy

I. Varying wind speeds and directions make it difficult to use wind as a consistent source of power.

II. They produce so much noise and are therefore limited to areas away from homesteads and also away from wildlife reserves.

Variability and predictability of Wind Power

The variability of wind energy needs to be examined in the wider context of the power system in wind turbine level. The wind does not blow continuously at any particular site, but there is little overall impact if the wind stops blowing in a certain area, as it is always blowing elsewhere. Wind can be harnessed to provide stable output regardless of the fact that wind is not available all the time at any particular site. So in terms of overall power supply, it is largely irrelevant to consider the case when a wind power plant produces zero power for a time, due to local wind conditions (Europe programme of the Executive Agency for Competitiveness and Innovation , November 2007 to October 2009.). Moreover, until wind becomes a significant producer (supplying around 10 per cent of electricity demand), there is a negligible impact on net load variability.

Wind power varies over time (Europe programme of the Executive Agency for Competitiveness and Innovation , November 2007 to October 2009.), mainly under the influence of meteorological fluctuations. The variations occur on all time scales: seconds, minutes, hours, days, months, seasons and years. Understanding these variations and their predictability is of key importance for the integration and optimal utilization of wind in the power system. Electric power systems are inherently variable in terms of both demand and supply, but they are designed to cope effectively with these variations through their configuration, control systems and interconnection.

2.2.2 Wind turbine

Wind turbines are machines that generate electricity from the kinetic energy of the wind. The giant blades one sometimes sees (mostly in the countryside) are wind turbines. Although they look like fans, spinning around in place, functionally, they're the opposite of fans. Instead of using electricity to generate wind, as fans do, wind turbines uses wind to generate electricity. Wind turbines operate on a simple principle. The wind turns the blades around a rotor connected to the main shaft. The shaft spins and is connected to a generator which generates electricity.

Performance of wind turbine

The major problem of wind power is that the power output is highly variable and depends on the uncontrollable condition of the weather. The output power cannot be predicted for a particular period of time. Nevertheless, it is possible to estimate the proportion of time that the turbine produces different levels of power.

Classes of wind turbine

Based on the wind speed, wind resources are categorized into seven classes. A wind-class refers to a range of wind power density and speed that describes the energy contained in the wind. The wind power classes are shown in the Table below.

Table 2.1 Classes of wind turbine (Ghosh & Prelas, 2014)

Wind power Class	10m (33 ft.) Wind power density (W/m^2)	10m (33 ft.) Speed m/s (mph)	50m (164 ft.) Wind power density (W/m^2)	50m (164 ft.) Speed m/s (mph)
1	<100	<4.4 (9.8)	<200	<5.6(12.5)
2	100 < 150	4.4 (9.8) < 5.1(11.5)	200 < 300	5.6(12.5) < 6.4(14.3)
3	150 < 200	5.1 (11.5) < 5.6(12.5)	300 < 400	6.4(14.3) < 7.0(15.7)
4	200 < 250	5.6(12.5) < 6.0(13.4)	400 < 500	7.0(15.7) < 7.51(16.8)
5	250 < 300	6.0(13.4) < 6.4(14.3)	500 < 600	7.5(16.8) < 8.0(17.9)
6	300 < 400	6.4(14.3) < 7.0(15.7)	600<800	8.0(17.9) < 8.8(19.7)
7	>400	>7.0(15.7)	>800	>8.8(19.7)

Coefficient of Performance

As mentioned in equation 2.3 that the power available in wind can be expressed as:

$$P_W = \frac{1}{2}\rho AV^3 \quad (2.4)$$

The turbine coefficient is given by this relation:

$$C_p = \frac{P_T}{P_W} \quad (2.5)$$

Therefore it is derived that the output power of the wind turbine rotor can be calculated as:

$$P_T = C_p \times P_W \quad (2.6)$$

Also,
$$P_T = C_p \frac{1}{2}\rho AV^3 \quad (2.7)$$

Where:

P is the density of the air measure in kg/m^3

A is the area swept by the turbine,

V is the wind speed in meters per second,

Cp is turbine power coefficient,

P_W is wind power,

P_T is turbine power.

The power actually captured by the wind turbine rotor, P_T, is some fraction of the available wind power, defined by the coefficient of performance, C_p, which is essentially a type of power conversion efficiency. The maximum theoretical value of the coefficient of performance is 0.593, a value determined by a fluid mechanics constraint known as the Betz limit. Actual coefficients of performance are less than this limit due to various aerodynamic and mechanical losses. The Cp of the turbine design is a function of the ratio between the rotational speed of the tip of the blades and the actual speed of the wind known as tip speed ratio (TSR) (Tavner & Spinato, 2013) .

$$TSR(\lambda) = \frac{Rotororbladetipspeed}{Windspeed} = \frac{rpm \times \pi D}{60 \times V} \quad (2.8)$$

Where rpm is the rotor speed, D is the rotor diameter (m); and v is the wind speed (m/s) upwind of the turbine.

There are basically two types of wind turbine being based on the orientation of the axis of the rotor, the horizontal axis wind turbine (HAWT) and the vertical axis wind turbine (VAWT).

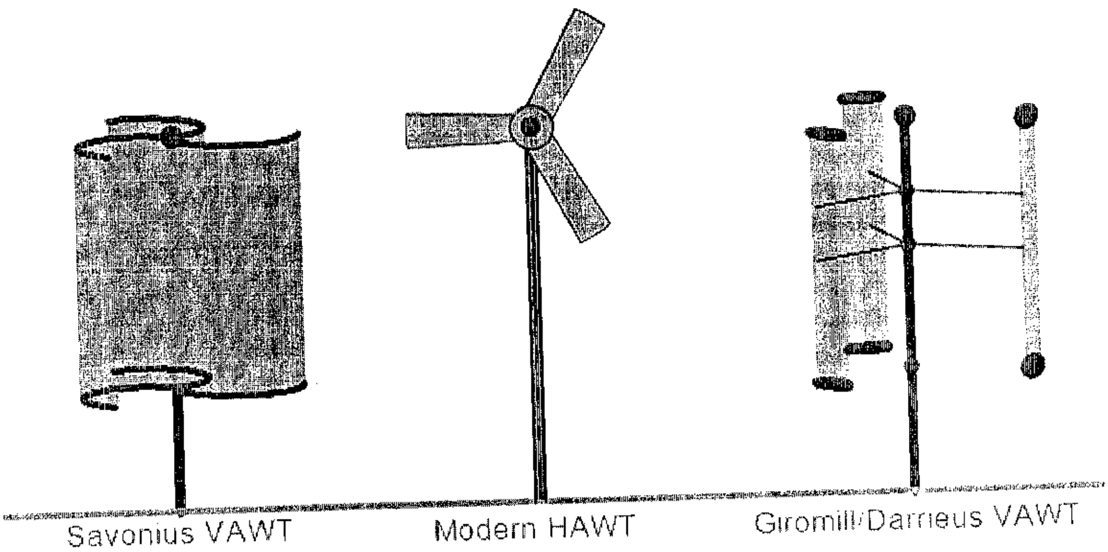


Figure 2.2 Types of wind turbine being based on the orientation of the axis of the rotor.

Vertical Axis Wind Turbine (VAWT)

This has blades which are arranged on the vertical axis and are rotated by wind and therefore it doesn't require a yaw mechanism since it can harness wind from any direction. It does not rely on the direction of the wind to generate power as in the case of the horizontal axis. They usually operate closer to the ground which has an advantage of allowing for placement or replacement of heavy equipment. However this is a disadvantage as winds are lower near ground level hence less power output.

There are two main types of the VAWT namely:

Savonius

It operates like a water wheel which uses drag forces. It has a simple design and is therefore relatively simple and cheaper to build. It is mostly used in situations that do not require large amounts of power. However, it is less powerful than most HAWT because it uses drag to rotate itself and has a higher power to weight ratio. The total amount of turning torque of the mechanism relies on the drag force on each blade (Hemami, 2009).

Darrieus

It uses blades similar to those used in the horizontal axis wind turbine (HAWT). It has two or more curved blades that depend on wind in order to revolve around a central column. It functions by generating a lift using the rotating motion of the blades. The wind acting on the blade creates a rearward momentum change which propels the blade in the direction of rotation. This cannot occur unless the blades are already rotating and therefore they require a separate means of starting i.e. they are not self-starting (Hemami, 2009).

Horizontal Axis Wind Turbine (HAWT)

It has blades that are similar in design to aircraft propellers where air flow over the airfoil shaped blades produces a lifting force that turns the rotor. They should be placed on towers to ensure maximum use of the winds at higher levels. For large scale types, they have an active yaw mechanism with wind direction sensors and motors that will rotate the nacelle. In both upwind and downwind the rotors should be perpendicular to the direction of wind and if the rotor is held in a fixed position. For upwind type, the rotor rotation is accomplished by using a vane to measure the direction of the wind and then the information is communicated to the yaw drive. The yaw drive then drives the rotor so that the turbine is facing the direction of wind for maximum harness. They don't suffer from wind shade phenomenon as the wind is tapped early enough before obstruction by the tower.

The capture area must face directly into the wind to maximize the power generation. For this reason, the HAWT requires a means of alignment (Yawing mechanism) so that the entire nacelle can rotate into the wind. On smaller wind turbines, a tail vane provides passive yaw control while in large turbines; yaw control is active with wind direction sensors and motors that rotate the nacelle.

Advantages of (HAWT) (Atta, 2010).

I. Most HAWT are self-starting.

II. Tall towers which allow the blade to face much higher velocity wind.

III. Have high efficiency.

Disadvantages of (HAWT) (Atta, 2010).

I. The construction and installation cost is expensive.

II. It cannot carry large generators.

III. When placed offshore, it can cause navigation problem.

Comparison between HAWT and VAWT

Both the HAWT and VAWT have the same theory of operation and suffer from fatigue load. However there are some basic differences between the two which are in table 2.2

Table 2.2: Comparison between HAWT and VAWT (Tavner & Spinato, 2013).

Performance	**Horizontal**	**Vertical**
Wind range	5-7 m/s	1.5-2 m/s
Power generation efficiency	High efficiency	Less efficiency
Wind resistance capability	Weak	Strong(it can resist typhoon up to 12-14 class
Rotating speed	High	Low
Gear box	Yes (for power above10kw)	No
Failure rate	High	Low
Effects on birds	Great	Small
Maintenance	High maintenance cost is required	Low maintenance
Noise	5-60 Db	0-10Db
Electromagnetic interference	Yes	No

The wind turbine chosen for this project is a lift-type HAWT because lift-type wind turbines have the potential to produce more power. Another benefit of choosing a horizontal axis, lift-type wind turbine is that they are the most popular type of wind turbine which results in the most data supporting its design.

2.3.3 DC GENERATOR

Generators are machines that convert mechanical energy into electrical energy. the moving rotor of the wind turbines resulted from the blades rotation due to the wind speed drives the shaft of the generators and hence electricity is generated. Henceforth Suitable generators should be considered while dealing with the wind power system in order to generate effective power from the resulting wind speed.

Function of Each Part of D.C Generator

A D.C Generator consists of the following parts:

1) Yoke or magnetic frame
2) Pole cores and pole shoes
3) Field windings
4) Brushes and brush holders
5) End covers
6) Armature core
7) Armature winding
8) Commutator
9) Shaft

1. **Yoke or magnetic frame**: The outer most frame is known as Yoke. It is made of high permeability material possessing sufficient mechanical strength. Cast iron is used in small machines and cast steel or rolled steel is employed in large machines.

The Yoke serves two fold as:

(a) It protects the entire machine from dust and dirt and also provides mechanical support for the magnetic poles.

(b) It acts as the return path for the magnetic flux.

2. Pole cores and Pole shoes: the field magnet consists of pole core and pole shoe. In modern design, the complete pole cores and pole shoes are made of thin (about 0.5 mm thick) laminations of annealed steel which are pressed together and riveted and are secured to the yoke by means of screws bolted in to steel rod.

The main function of the pole core is to establish the required magnetic flux. The field winding is placed on the pole core. When (field) current passes through this field winding the core becomes an electromagnet and establishes the magnetic flux. The flux can be varied by varying the current through field winding.

The pole shoe serves two fold as:

(a) It distributes the magnet flux uniformly in the air gap and reduces the reluctance of the magnetic path due to its larger cross-section.

(b) It supports the field winding (also called as exciting coils)

3. Field winding: The field winding consists of enamel coated copper/aluminum wire and are former-wound to fit over the pole core.

When current is passed through winding coils, they electro-magnetise the pole core which produce the necessary magnetic flux. All the field coils are connected in such a way that the adjacent poles are made of opposite polarities.

4. Brushes and Brush Holders: The function of the brush is to collect current from rotating commutator and deliver it to the external stationary load circuit. They are usually made of high grade carbon and are housed in brush holders. The brush holders are secured to the front tend housing with clamps. The brushes are held under pressure over the commutator, the pressure being provided by a tension adjusting spring. A flexible copper pigtail mounted at the top of the brush conveys current from the brushes.

Advantages:

1) Facilitates the collection of current from rotating commutator to stationary terminals.
2) Carbon brushes minimizes the sparking.
3) Carbon brushes are cheap.

Disadvantages:

1) Wear and tear takes place and necessitates replacement of new one.
2) Requires maintenance.
3) Terminal voltage reduces due to brush contact drop.

5. End covers: The end covers are usually made of cast iron or cast steel. Its main function is to protect the inner parts i.e. armature, commutator etc. from dust and other foreign particle also provides the protection to the workers. One end cover hold the brush assembly.

6. Armature core: Armature core is cylindrical in shape and built up of high permeability silicon steel stampings or lamination of 0.5 mm thick. Each stamping being separated from the neighbouring one by varnish. The purpose of using laminations is to reduce eddy current loss whereas the high permeability silicon steel is used to minimize the hysteresis loss.

Slots are provided on the outer periphery of the core to house the winding in proper position and the key way is provided on the inner diameter to fix it on the shaft. Air holes or ventilating ducts are provided, which permits the axial flow of air for cooling purpose. All the laminations are immersed in varnish and after drying up they are pressed together by means of hydraulic press or by other means to form and armature. Insulating paper is placed in the slots to form a closed loop and may be either in lap or wave fashion. When the shaft is driven the armature and armature winding also rotates in between the magnetic poles.

The armature core serves the following purposes:

1) It houses the armature conductors in slots.
2) It provides a path low reluctance to the magnetic flux.

The armature is mounted on the shaft so that when it is rotated, the conductor housed in it cut the magnetic flux.

7. **Armature winding**: The armature windings are usually former-wound. These are first wound in the form of rectangular coils and are then pulled into the proper shape. The coils are insulated from each other. The conductors are placed in the armature slots which are lined with insulating material (like paper). This slot insulation is folded over above the armature conductors placed in the slots (or a fresh insulating paper will be placed over the conductors) and is secured in place by wooden or fibre wedges.

EMF can be induced in a stationary conductor (statically induced emf) or moving conductor i.e. in the armature winding (dynamically induced emf) according to faraday's laws of EMI. A.C generator works on former principle and D.C generator works on later principle.

Usually copper wires coated with enamel is used for winding purpose. Aluminium is the next best material for winding of course the use of aluminium reduces the cost of the machine.

8. Commutator: the commutator is of cylindrical in shape and is made up of wedge-shaped high conductivity hard drawn copper segments. These segments are insulated from each other by a thin layer of mica. Each commutator segment is connected to armature coils.

The commutator is an important part of a D.C generator and it serves the following purposes.

(A) It facilitates the collecting of current from armature conductors.

(B) It converts the alternating current induced in the armature conductors into unidirectional current in the external load circuit.

It is fixed on the main shaft on one of the sides of armature and rotates with armature winding. The armature winding terminal are connected to the commutator risers.

9. Shaft: It is usually made of cast iron or cast steel and is supported between to bearings. The armature and commutator are housed on the shaft. It provided with a key to hold the armature firmly (not to slip) in proper position. Its main function is to rotate.

2.3.4 BATTERY FOR WIND ENERGY

Battery is a device that stores electrical energy in form of chemical energy. Batteries are used in wind turbine systems to provide continuity of power supply to the loads due to the inconsistency of the wind at a particular time. When there is available wind in the day, electricity is generated and batteries are charge through the charge controller (dc-dc boost converter) and power is supply to the load as well. When there is low or unavailability of the wind to drive the generator, the batteries being charge previously will be used to supply the load and off course it requires the use of inverter circuit to convert the power to alternating current (ac) form since batteries stored electricity in dc form. However, after more than a few days of low wind, batteries are likely to discharge and finally run flat. Obviously these sorts of conditions could occur several times a year. That is why choosing the best batteries are so important to minimized these effects, else users will be out of the supply for long period of time after completely discharged and should wait for the wind availability to recharge the batteries again. Since a prototype mini wind turbine would be design, 6V battery will be considered in this project.

Table 2.3: Battery Specification

Battery Specification	
Parameter	Value
nominal voltage	6V
Charging Nominal current	O.7A

2.3.5 BATTERY CHARGER

This battery charger would be design by using 555 timer to perform the basic operation of the charging through the mini wind turbine. The component of the battery charger would be explain in details.

RESISTOR

The resistor is an electronic component that has electrical friction. This friction opposes the flow of electrons and thus reduces the voltage (pressure) placed on other electronic components by restricting the amount of current that can pass through it. There are many different types of resistors used in electronics. Each type is made from different materials. Resistors are also made to handle different amounts of electrical power. Some resistors may change their value when voltages are placed across them. These are called voltage dependent resistors or nonlinear resistors. Most resistors are designed to change their value when the temperature of the resistor changes. Some resistors are also made with a control attached that allows the user to mechanically change the resistance. These are called variable resistors or potentiometers (Boylestad & Louis, 1999).

CAPACITOR

Capacitors are components that can store electrical pressure (Voltage) for long periods of time. When a capacitor has a difference in voltage (Electrical Pressure) between its two leads it is said to be charged. A capacitor is charged by forcing a one way (DC) current to flow through it for a short period of time. It can be discharged by letting an opposite direction current flow out of the capacitor. Also it can pass alternating current (AC), but blocks direct current (DC) except for a very short charging current, called transient current. There are many different types of capacitors used in electronics. Each type is made from different materials and with different methods. Capacitors are also made to handle different amounts of electrical pressure or voltage. Each capacitor is marked to show the maximum voltage that it can withstand without breaking down. All capacitors contain the same fundamental parts, which consist of two or more conductive plates separated by a nonconductive material. The insulating material between the plates is called the dielectric.

INDUCTOR

The electronic component known as the inductor is best described as electrical momentum. Since Inductors are made by coiling a wire, they are often called Coils. In practice the names Inductor and Coil are used interchangeably. A coil of wire will pass DC and block AC. Recall that the nature of a Capacitor blocked DC and passed AC, the exact opposite of a coil. Because of this, the Capacitor and Inductor are often called Dual Components.

TRANSISTOR

Transistors are active components used basically as amplifiers and switches. The two main types of transistors are:

The bipolar transistors whose operation depends on the flow of both minority and majority carriers, and the unipolar or field effect transistors (called FETs) in which current is due to majority carriers only (either electrons or holes). The transistor as a switch operates in class A mode. In this mode of bias the circuit is designed such that current flows without any signal present. The value of bias current is either increased or decreased about its mean value by the input signal (if operated as an amplifier) or ON and OFF by the input signal if operated as a switch.

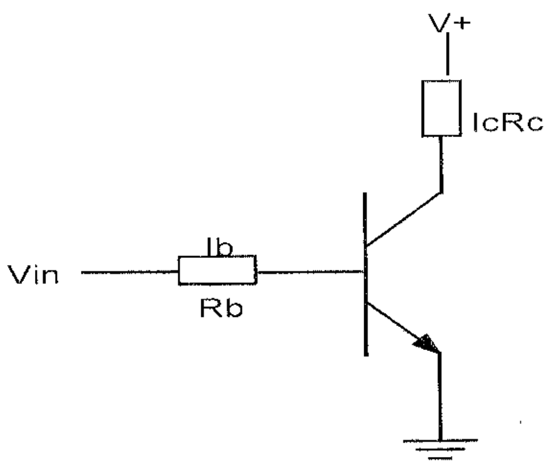


Figure 2.3 Circuit diagram of a transistor

LIGHT-EMITTING DIODE (LED)

A LED consists of a junction diode made from the semi-conducting compound gallium arsenide phosphide. It emits light when forward biased the colour depending on the composition and impurity content of the compound. At present red, yellow and green LEDs are available. When a p-n junction diode is forward biased, electrons move across the junction from the n-type side to the p-type side where they recombine with holes near the junction. The same occurs with holes going across the junction from p-type side. Every recombination results in the release of certain amount of energy, causing, in most semiconductors, a temperature rise. In gallium arsenide phosphide some of the energy is emitted as light which gets out of the LED because the junction is formed very close to the surface of the material.

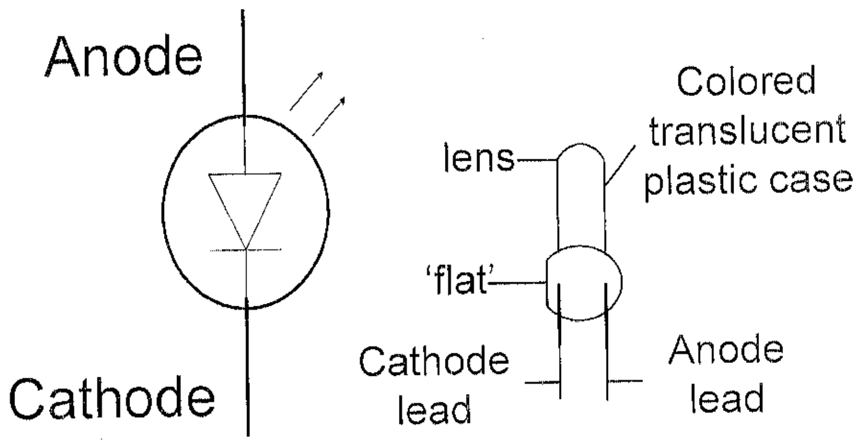


Figure 2.4 light emitting diode

IC TIMERS

The emanation of IC timers eliminated a wide range of mechanical and electromechanical timing devices. It also helped in the generation of clock and oscillator circuits. Timing circuits are those, which will provide an output change after a predetermined time interval. This is, of course, the action of the monostable multivibrator, which will give time delay after a fraction of a second to several minutes quite accurately. The most popular of the present IC, which is available in an eight, pin dual in line package in both bipolar and CMOS form. The 555 timer is a relatively stable IC capable of being operated as an accurate bistable, monostable or astable multivibrators. The timer comprises of 23 transistors, 2diodes and 16 resistors in its internal circuitry.

The operation of the 555 timer is further defining the functions of all the pins. The details regarding connection to be made to pins are as follows.

Pin 1: This is the ground pin and should be connected to the negative side of the supply voltage.

Pin 2: This is the trigger input. A negative going voltage pulse applied to this pin when falling below 1/3Vcc causes the comparator output to change state. The output level then switches from LOW to HIGH. The trigger pulse must be of shorter duration than the time interval set by the external CR network otherwise the output remains high until trigger input is driven high again.

Pin 3: This is the output pin and is capable of sinking or sourcing a load requiring up to 200mV and can drive TTL circuits. The output voltage available is approximately −1.7V.

Pin 4: This is the reset pin and is used to reset the flip-flop that controls the state of output pin 3. Reset is activated with a voltage level of between 0V and 0.4V and forces the output low regardless of the state of the other flip-flop inputs. If reset is not required, then pin 4 should be connected to same point as pin 8 to prevent accidental resetting.

Pin 5: This is the control voltage input. A voltage applied to this pin allows the timing variations independently of the external timing network. Control voltage may be varied from between 45 to 90 of the Vcc value in monostable mode. In astable mode the variation is from 1.7 to the full value of supply voltage. This pin is connected to the internal voltage divider so that the voltage measurement from here to ground should read 2/3 of the voltage applied to pin 8. If this pin is not used it should be bypassed to ground, typically use a 10nF capacitor. This helps to maintain immunity from noise. The CMOS Ics for most applications will not require the controlled voltage to be decoupled and it should be left unconnected.

Pin 6: This is the threshold input. It resets the flip-flop and hence drives the output low if the applied voltage rises above two-third of the voltage applied to pin 8. Additionally, a current of minimum value 0.1 A must be supplied to this pin since this determines the maximum value of resistance that can be connected between the positive side of the supply and this pin. For a 15V supply the maximum value of resistance is 20M.

Pin 7: This is the discharge pin. It is connected to the collector of an NPN transistor while the emitter is grounded. Thus when the transistor is turned on, pin 7 is effectively grounded.

Usually the external timing capacitor is connected between pin 7 and ground and is thus discharged when the transistor goes on.

Pin 8: This is the power supply pin and is connected to the positive of the supply. The voltage applied may vary from 4.5V to 16V although devices, which operate up to 18V, are available.

Its functional diagram is shown below:

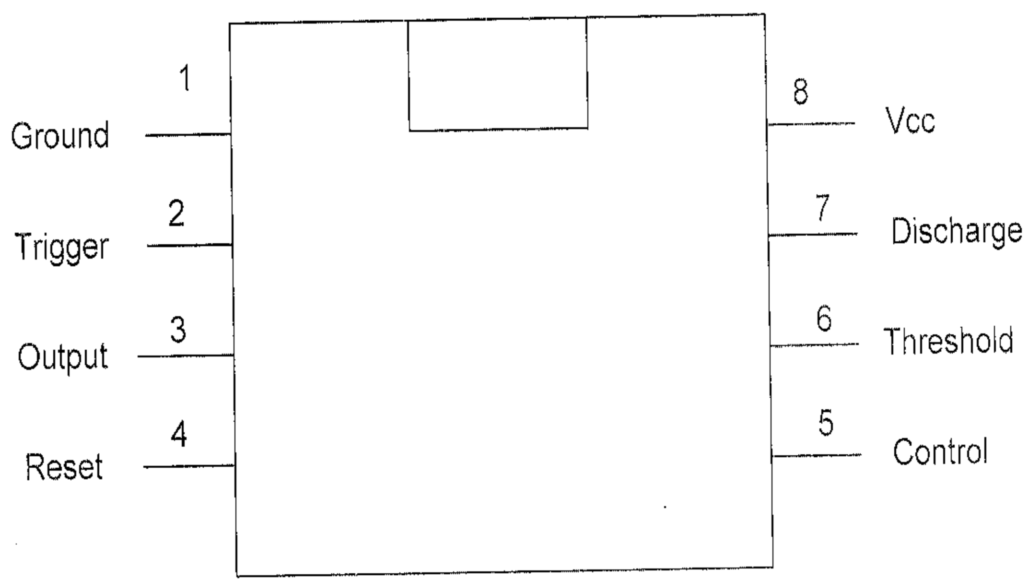


Figure 2.5: Timer pin configuration

CHAPTER THREE

METHODOLOGY AND HARDWARE DESIGN

3.1 INTRODUCTION

This chapter will explain about the methods used to complete the project. In addition, it will consider the hardware structure of the entire project.

Initial approach to project designing and execution is to gather enough information in order to help speed up the operation once the actual work commences. In order to achieve this, Proteus was used. This is because; Proteus is an internationally accepted software engineering model mainly used in most circuit analysis.

3.2 FUNDAMENTAL BLOCK DIAGRAM

The block diagram of the circuit is a block of drawings that expresses different segments of the stages involved for the circuit to be functional. The various segments involved in this circuit includes: the source, generator, the battery charger, battery and the load.

The DC source generated through the DC generator as the wind blows. The oscillator is the 555 timer which produces a frequency at about 1kHz with a voltage which is half the supply voltage. The driver drives the output voltage via the transistor stage, while the multiplier multiplies the output voltage and this is the final soldered stage of the circuit which goes to the battery before reaching the load, the circuit does not over charge the battery rather it maintain the supply voltage to the battery. The diagram is shown in figure.3.1

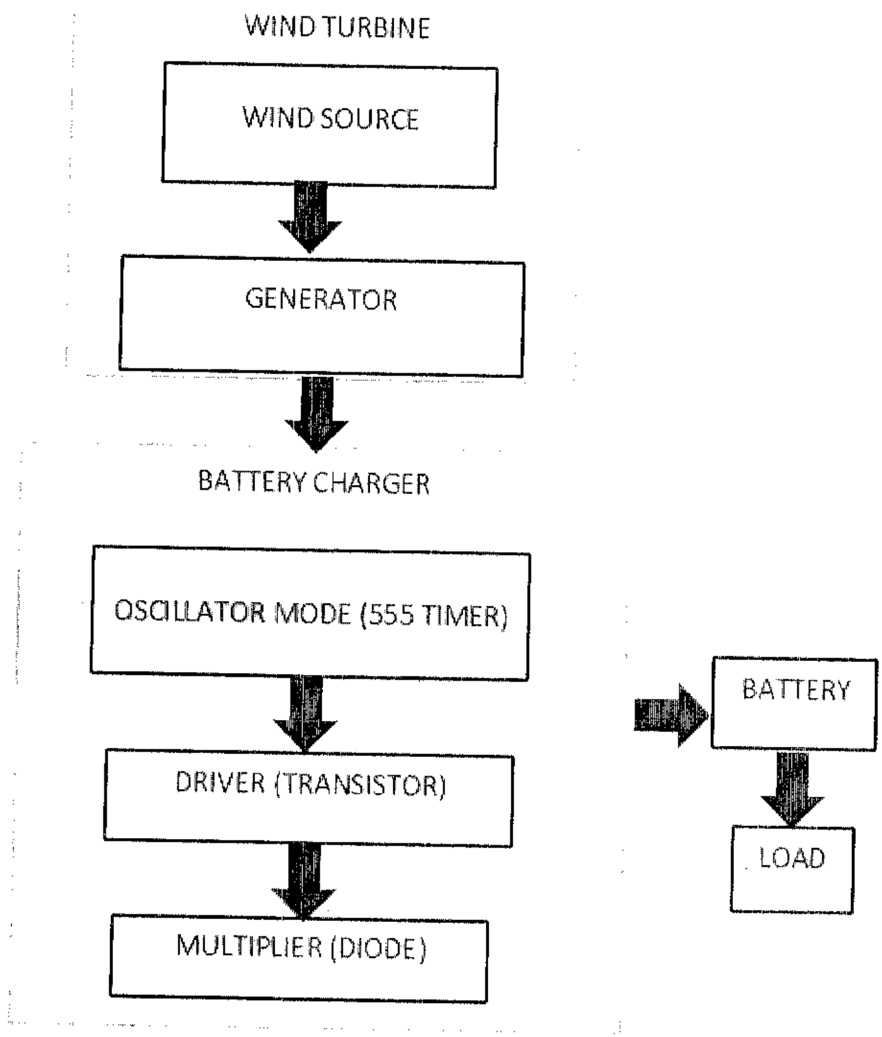


Figure 3.1: Block diagram

WIND SOURCE: Wind is a natural resources that spin the turbine blades. It is caused by irregularities of the earth surface, rotational of the earth and the uneven heating of the atmosphere by the sun. Wind flow patterns are modified by the earth's terrain, vegetation and bodies of water.

GENERATOR: this convert the kinetic mechanical energy from the wind source to electrical energy, with the principle of electromagnetic induction.

OSCILLATOR: The oscillator is the 555 timer which produces a frequency at 1kHz - 2kHz with a voltage which is half the supply voltage from the generator.

DRIVER: The driver drives the output voltage via the transistor stage.

MULTIPLIER: These are the diodes, they multiplies the output voltage flowing from the transistor and finally stores it on the battery.

BATTERY: This is the storage device, it charges during the rotation of the turbine and discharges when load is connected to it.

LOAD: This is an external device that consumes electrical energy in the form of the current and transforms it into other forms via USB like phone.

3.3 HARDWARE DEVELOPMENT

The development of the hardware is the main part of the project. The basic components use for the project are generator, battery and charger system.

3.3.1 BLADE DESIGN CONSIDERATION

Betz' Theorem Revisited "Power Coefficient, C_p, is the ratio of power extracted by the turbine to the total contained in the wind resource".

Power is extracted from the wind by decelerating it (Betz' Theorem). There's however a limit as to how much power can be extracted from the wind. According to Betz' Theorem, this deceleration is as much as a third of the upstream velocity. This translates to 59.3%. Any further deceleration of the wind will divert the wind away from the rotor.

According to Newton's third law of motion; for every action, there is equal and opposite reaction. Therefore, the decelerating force on the wind is equal to the thrust force which the wind applies to the rotor. In designing the rotor, the main goal is to make sure that the thrust produced is able to produce Betz' optimum deceleration (Mercyline & Okero, 2014).

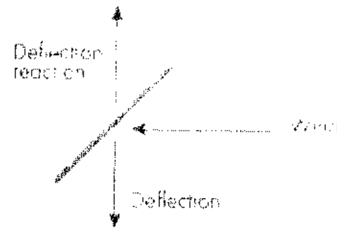


Figure 3.2: Illustration of the reaction force that causes thrust.

The other source of the thrust that enables the rotors rotate is the Bernoulli Effect. According to the Bernoulli Effect theorem, faster moving air has lower pressure. The blades of the wind turbine are shaped such that the air molecules moving around the blade travel faster downwind side of the blade than those moving across the upwind side of the blade. This shape is known as an aerofoil. The curve in the downwind side of the blade is much larger whereas the one on the upwind side is relatively flat. Given that the air moves at a faster velocity on the curved downwind side of the blade, the pressure on this side of the blade is less. This difference in pressure on the opposite sides of the blade causes the blade to get a 'lift' towards the curve of the aerofoil.

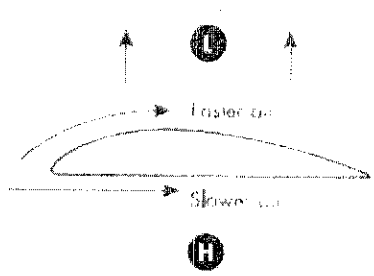


Figure 3.3: Illustration of the Bernoulli Effect causing lift (blade cross-section)

The Aerofoil

In the design of the cross-section (aerofoil) of the blades, there are some key considerations and specifications that should also be taken into account to ensure maximum thrust and lift. The following figure shows these important specifications.

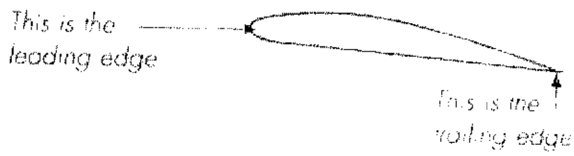


Figure 3.4: Illustration of the leading and trailing edges

The other important specification is the Angle of attack (α). This is the angle between the chord line and the relative air (or wind) movement. It is illustrated in the figure below.

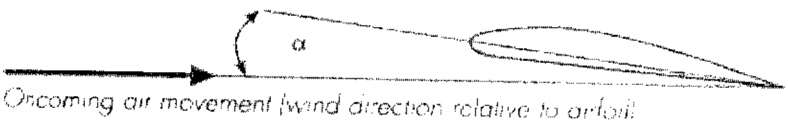
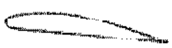


Figure 3.5: Illustration of the angle of attack.

The angle of attack has a direct impact on the lift experienced and thus the lift coefficient as well.

Wind tunnel studies have proved that the drag to lift ratio is not a constant factor. The best ratio is usually at an angle of attack of around 40°.The Lift Coefficient (C_L) is approximately equal to radians. The typical range of the Lift Coefficient is 0.8 to 1.25.The following table shows data for the different shapes.

Table 3.1: Data for some common blade cross-sections.

Section	Sketch	Drag/Lift Ratio	Optimum angle of attack	Lift Coefficient (C_L)
Flat plate		0.1	5^0	0.8
Curved Plate (10% curvature)		0.02	40^0	1.25
Curved plate with tube on concave side		0.003	4^0	1.1
Curved plate with tube on convex side		0.2	14^0	1.25
Aerofoil		0.01	4^0	0.8

BLADE DESIGN

In the design of a blade, it's convenient to divide the blade into sections. This is particularly due to the fact most blade designs taper towards the blade tip. This is to reduce the drag force to the end of the blade. For convenience, these sections could be referred to as stations.

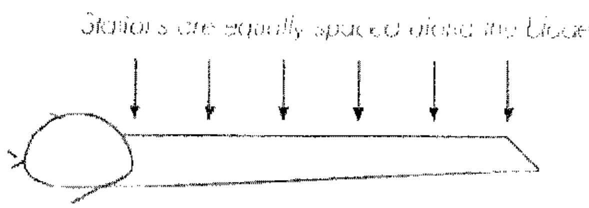


Figure 3.6: An Illustration of the stations

At each of these stations, the following parameters have to be noted or taken into account:

i. Radius
ii. Setting Angle (Pitch)
iii. Chord
iv. Thickness

Radius

This is the distance from the center of the rotor to the rotor station.

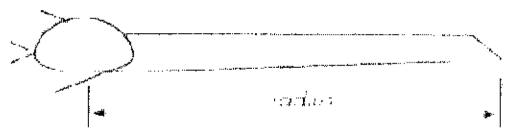


Figure 3.7: An Illustration of the radius.

Setting Angle (Pitch)

The Setting angle or pitch (β) is the angle between the chord line and the plane of rotation of the wind turbine rotor.

Both the setting angle and flow angle depend on how far from the root of the blade you go.At the root of the blade, the wind comes in at almost a right angle towards the blade. Therefore, the pitch/setting angle will have to be much larger at the base. Towards the tip, it should be smaller since the headwind is much larger meaning that the relative wind is rotated.

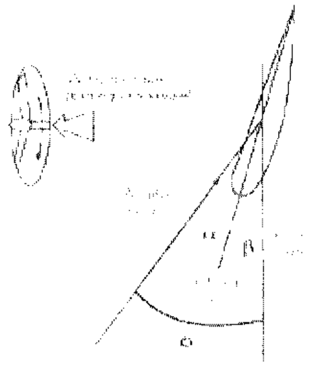


Figure 3.8.: Illustration of the angle of attack (α), setting angle (β) and flow angle (Φ)

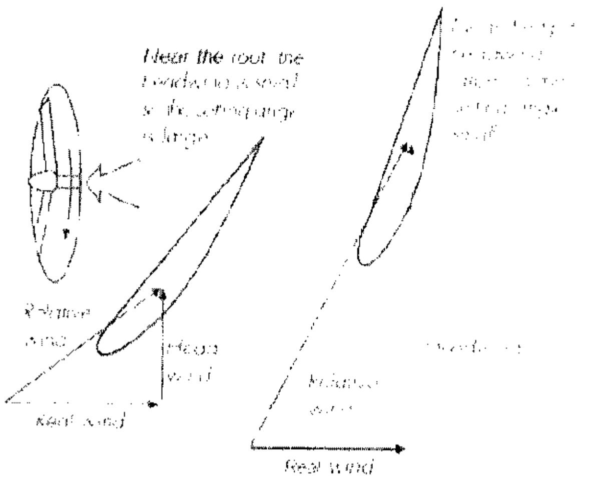


Figure 3.9: The variation of the setting angle at the root and at the tip.

Chord

This is the width of the blade at that particular station. Theoretically, the chord can be calculated by equating the aerodynamic thrust with the Force required for the Betz' change of momentum. The thrust is got from the lift calculations and the change of momentum is from Newton's third law of motion. As shown in Equation (1.1), the power extracted from the air is the result of a torque and angular velocity in the wind turbine. According to the conservation of angular momentum, the torque in the wind turbine shaft can only be created if there is a rotation in the downstream wake opposite the direction of the rotor's rotation.

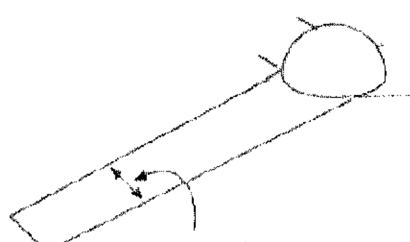


Figure 3.10: Illustration of the Chord

Twisted and Tapered Blades

Most of the commercial wind turbines are made of twisted and tapered blades. The following are the reasons as to why this is mainly so:

I. Both the tapered and twisted blades have a slight improvement on the efficiency.

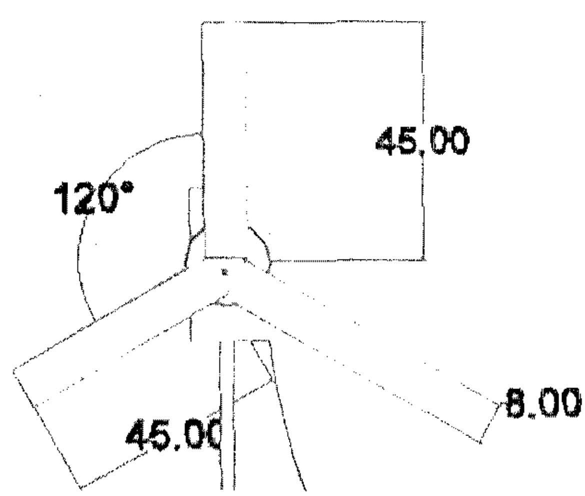
II. A tapered blade is much stronger compared to that with an equal chord all-through. Given that the maximum bending stresses are experienced at the root of the blade, a tapered blade means that the blade will be less vulnerable to yielding due to fatigue as compared to a 'straight blade'.

III. Starting of tapered blades is better since the wider root gives a slightly better torque.

In the design of wind turbines, the most important parameter is torque. This means that the taper is not necessary.

Final Blade Design

The blade was designed using 2D such that the base and the top are of the same dimension. The projected dimension of the blade is shown in figure 3.11.



All dimensions in cm

Figure 3.11: Projected Area of the blade

To achieve the optimum interaction of the blade with the wind. The dimensions measured on the blade are **109.163^0** top end curvature, 7.**8 mm** radius **109.163^0** bottom end curvature as well as 60.2 **mm** radius. The blade is made of Gauge 16 sheet metal which has a thickness of 0.754. **mm.** Using Gauge 16 Mild Steel sheet metal ensure that the rotors are rigid and can therefore withstand the various wind conditions that it may be exposed to during operation. The rotor assembly is made up of 3 blades because of the fast speed and the low torque.

3.3.2 DESIGN OF CHARGER SYSTEM

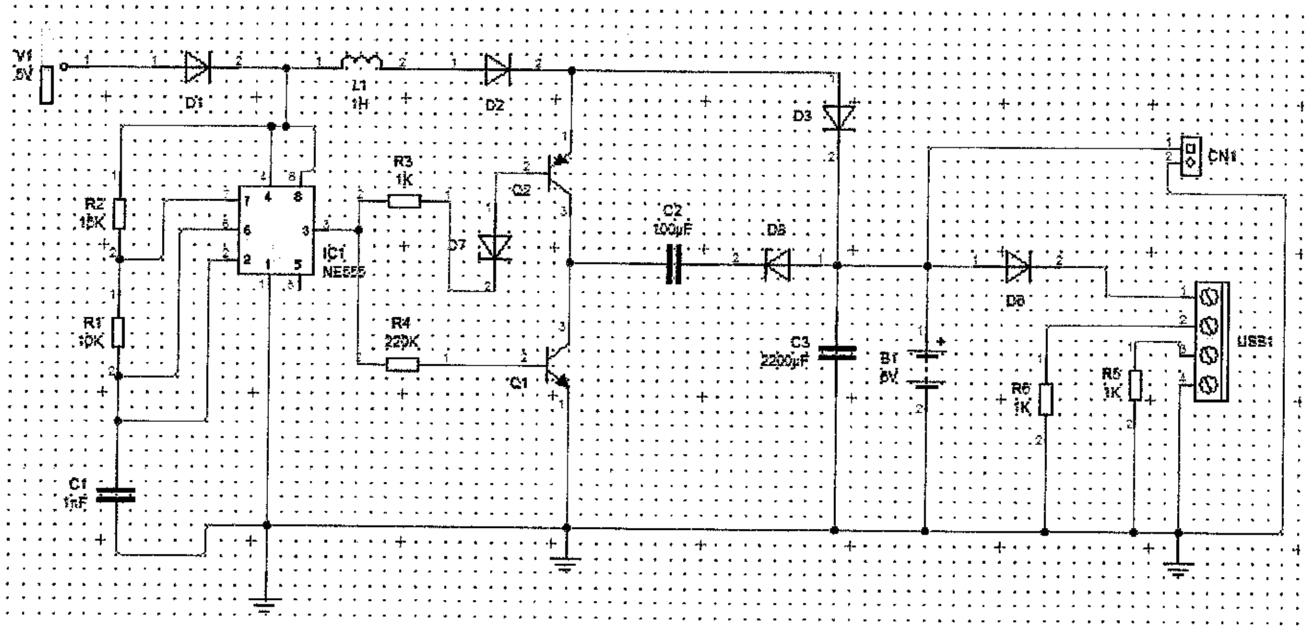


Figure 3.12: Circuit diagram.

An Astable Multivibrator is an oscillator circuit that continuously produces rectangular wave without the aid of external triggering. So Astable Multivibrator is also known as Free Running Multivibrator. Astable Multivibrator using 555 Timer is very simple, easy to design, very stable and low cost. It can be used for timing from microseconds to hours. Due to these reasons 555 has a large number of applications and it is a popular IC among electronics hobbyists.

Since the Control Voltage (pin 5) is not used the comparator reference voltages will be 2/3 Vcc and 1/3 Vcc respectively. So the output of the 555 will set (goes high) when the capacitor voltage goes below 1/3 Vcc and output will reset (goes low) when the capacitor voltage goes above 2/3 Vcc.

3.4 DESIGN CALCULATIONS

This is the calculation of how the values of some of the components used were reached.

Calculation

555 timer astable mode equations

Following equations were used for 555 timer calculation in astable mode in the design.

$$T_1 = 0.693 \times C_1 \times (R_1 + R_2)$$

$$T_2 = 0.693 \times C_1 \times R_2$$

$$C_1 = 1 \times 10^{-9} f$$

$$R_1 = 10 \times 10^3 \Omega$$

$$R_2 = 15 \times 10^3 \Omega$$

$$T_1 = 0.693 \times 1 \times 10^{-9} \times (10 \times 10^3 + 15 \times 10^3) = 1.7325 \times 10^{-5} sec$$

$$T_2 = 0.693 \times 1 \times 10^{-9} \times 15 \times 10^3 = 1.0395 \times 10^{-5} sec$$

Pulse Frequency $= \frac{1}{(T_1 + T_2)}$

$$= \frac{1}{(1.7325 \times 10^{-5} + 1.0395 \times 10^{-5}} = 36.075 kHz$$

Pulse Period

$$\frac{1}{Pulse\ Frequency}$$

$$\frac{1}{36075} = 2.772 \times 10^{-5} sec$$

$$\text{Duty Cycle} = \frac{R_1+R_2}{(R_1+2\times R_2)}$$

$$= \frac{(10 \times 10^3 + 15 \times 10^3)}{(10 \times 10^3 + 2 \times 15 \times 10^3)} = 0.88$$

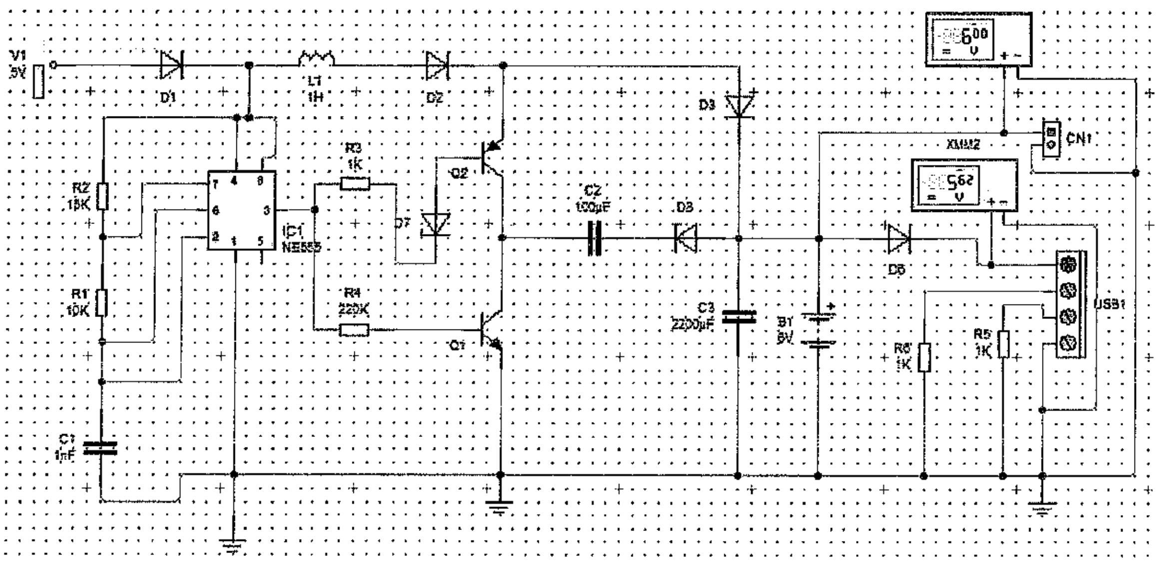


Figure 3.13: Design output voltage using the simulation software (Proteus)

CHAPTER FOUR

4.0 SYSTEM IMPLEMENTATION AND TESTING

4.1 IMPLEMENTATION

In implementing any electronics circuit, a circuit diagram is first obtained after which all components and materials needed for the circuit project are made available. The components are then connected on a breadboard which provides a temporary platform to construct a circuit and make sure that the circuit is operational as desired before it is transferred and soldered on the permanent platform for the construction which is a Vero board.

The Vero board:

The construction of this project was done on a vero board and the procedure methods used are:

The vero board was inspected of wrong linkages of its line which may be mistake from the producers. The holes of the board were made sure to be through for passing the terminals of the components for soldering. An abrasive paper was used on the soldering section of the board for easy binding of the terminals on the board.

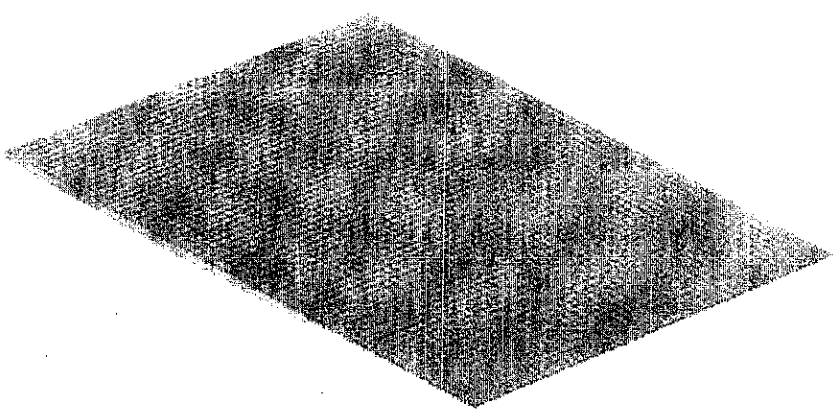


Figure: 4.1. Vero board used in the project

Components are usually placed on the plain side of the vero board, with their leads protruding through the holes. The leads are then soldered to the copper tracks on the other side of the board to make the desired connections, and any excess wire is cut off. The continuous tracks may be easily and neatly cut as desired to form breaks between conductors using a 5mm twist drill, a hand cutter made for the purpose, or a knife. Tracks may be linked up on either side of the board using wire. With practice, very neat and reliable assemblies can be created, though such a method is labor-intensive and therefore unsuitable for production.

The system layout that makes up this charge controller is therefore shown in figure 4.2

4.1.1 IMPLEMENTATION STAGES AND PROCEDURES OF THE CHARGER SYSTEM

In achieving such a project as this, it is recommended to take into consideration some steps and procedures to be followed. The steps taken for this project are explained further below;

Stage one

The circuit is thought out and designed using a simulator software, it is then tested for errors and corrections are made.

Stage two

The components are then soldered on a Vero board (the power components, the oscillator components, the driver components and the battery) following the circuit diagram simulated. At this stage the LED are then added as well as the USB port connected to the main circuit. They are joined with a lot of care to avoid breaks or errors. Then, testing is carried out.

Stage three

Finally, the main circuit then housed in a cubic containment as required tapping out the LED. The final testing is done at this stage to ascertain the work done. After this the project is ready. At this stage, also an external load can be added to check the output description.

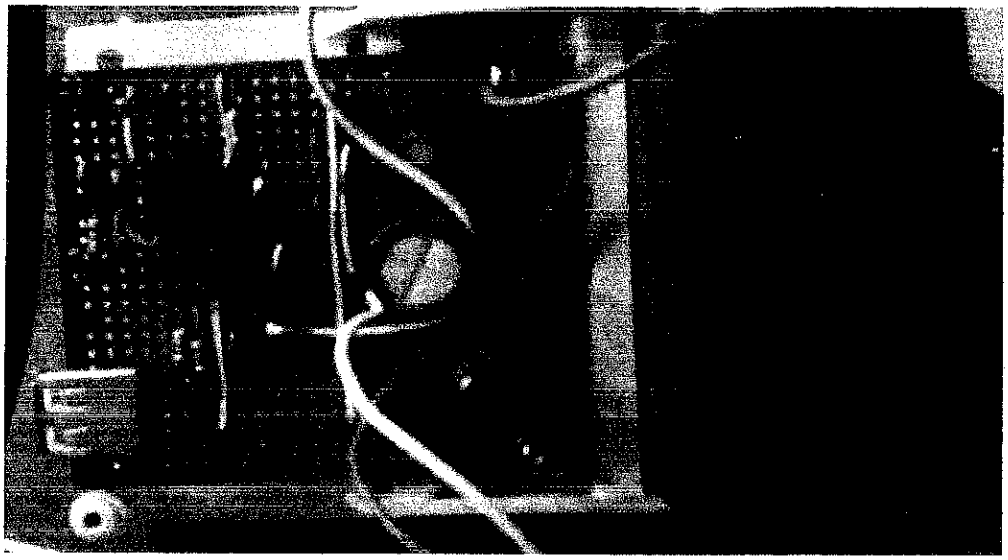


Figure 4.2 System layout of the charger system and the battery.

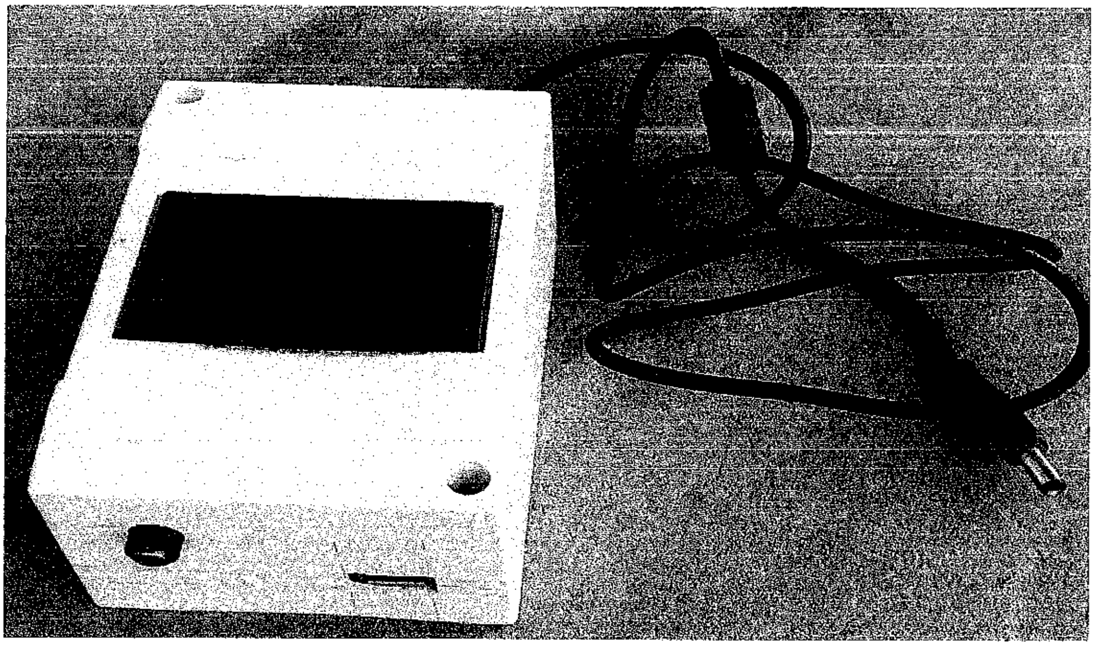


Figure 4.3: The charger system housed in a cubic containment

4.1.2 IMPLEMENTATION STAGES AND PROCEDURES OF THE MINI TURBINE

Stage one

The first step to be considered in this stage is to acquire the specific motor needed for the design, it is then tested for errors and corrections were made. The error that was in the motor was the rotation of the blade in clockwise direction that gives a negative output which was corrected to be rotate in anticlockwise direction giving a positive output after changing the polarity of the wires.

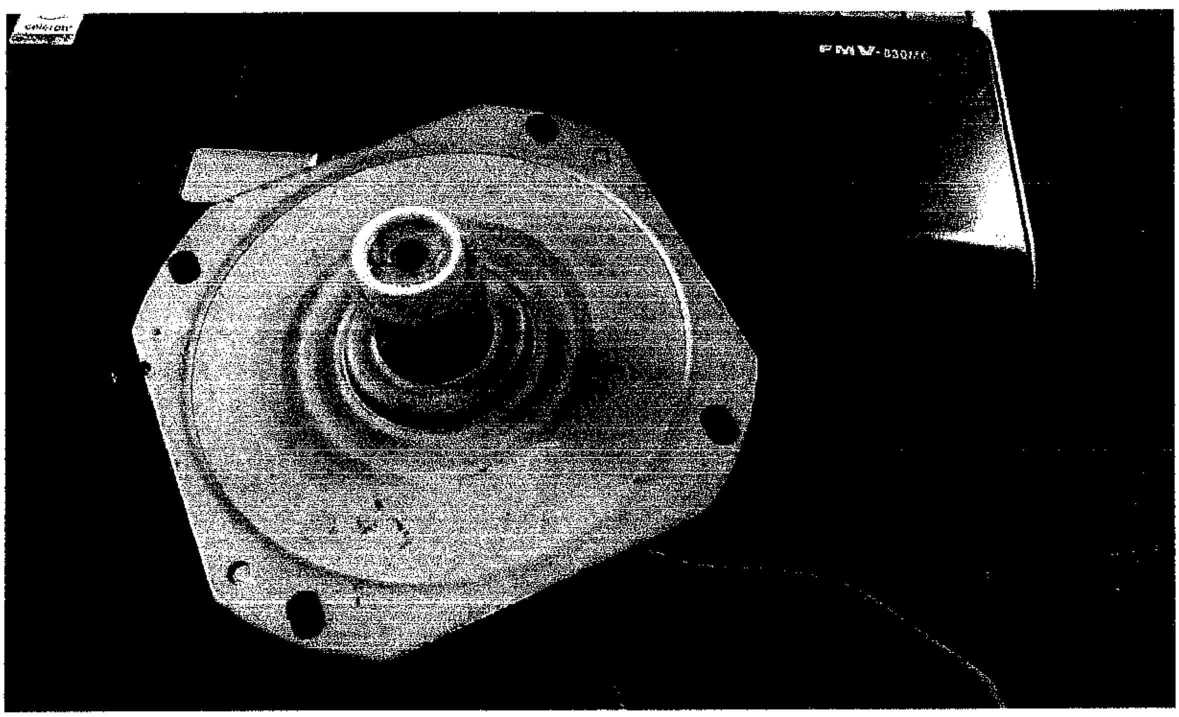


Figure 4.4: wind turbine generator

Stage two

The next stage is to design and construct the rotor blade which would be connected to the motor to make it a wind turbine. The measurements of the blade sheets were taken and cut from a plate with length 45cm, breathe 8cm and curved at the curvature length is 2cm.

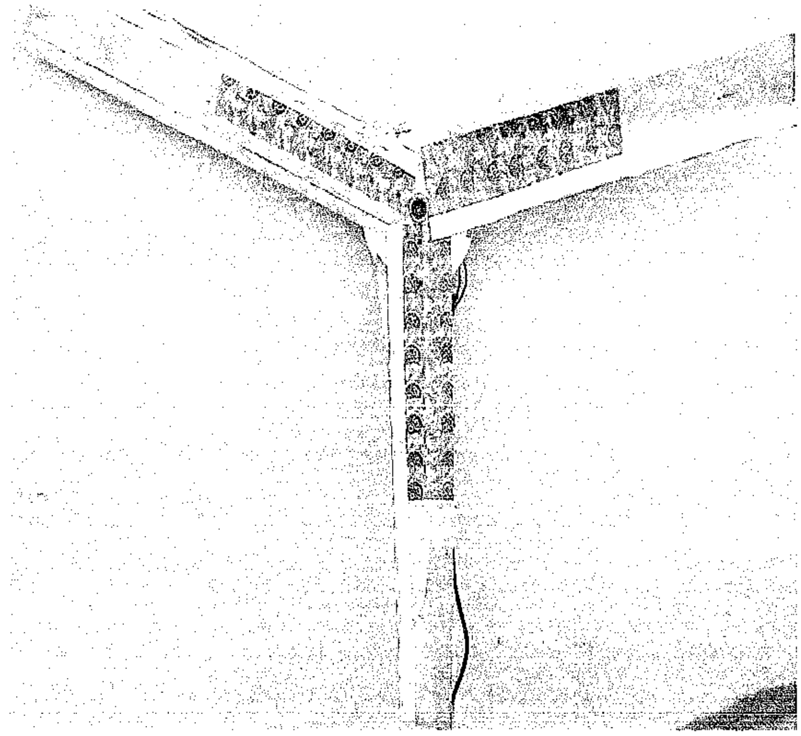


Figure 4.5: Turbine blades.

Stage three

Finally, the motor was attached on the tower and mounted in the direction of the wind. The final testing is done at this stage to ascertain the work done. After this the project is ready. At this stage, the output of the motor would be connected to the charger.

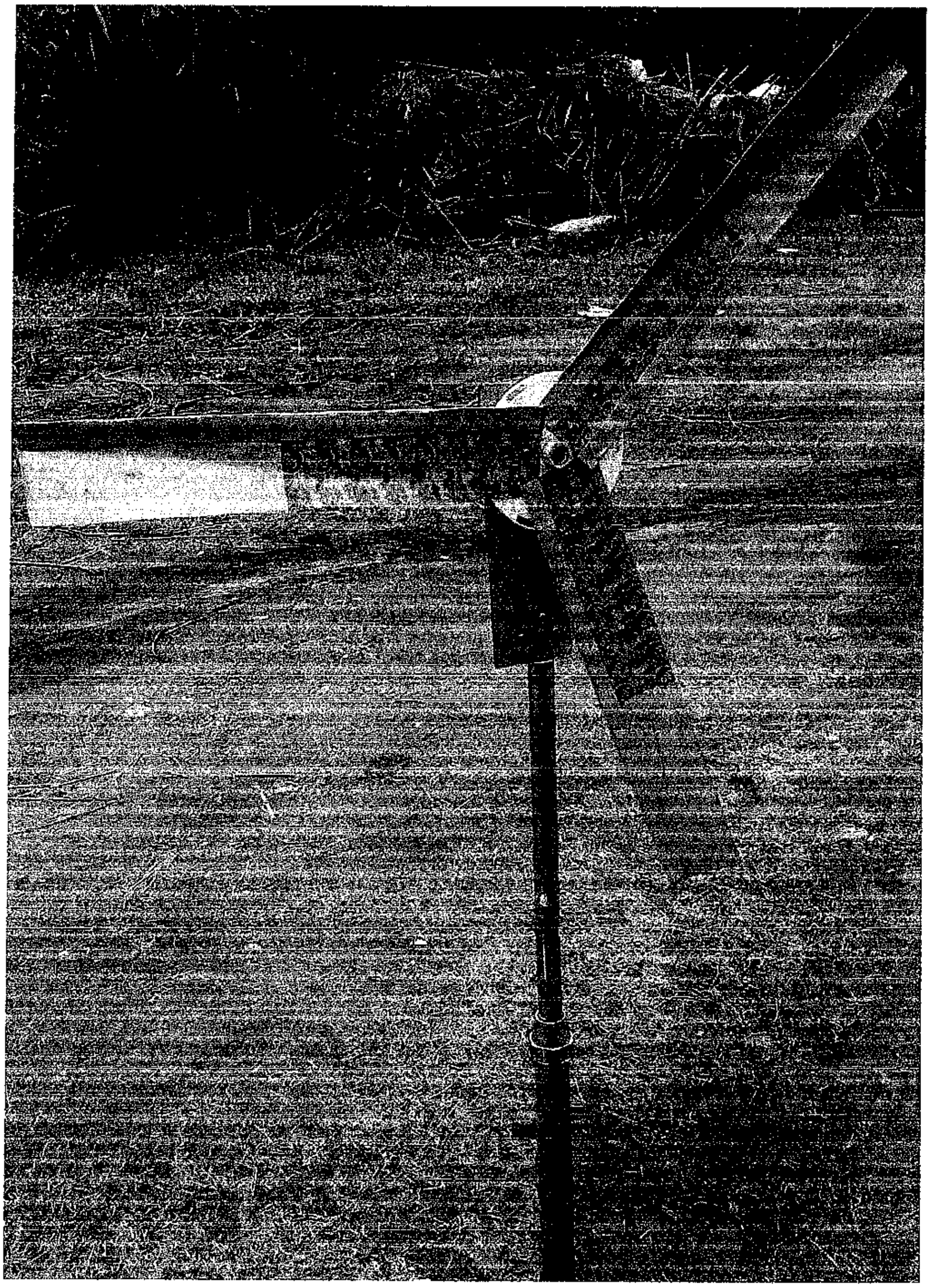


Figure 4.6: Wind Turbine

4.2 TESTING

The testing of the project was first done on a bread board whereby all the components used for the project were affixed into the breadboard as it is on the circuit diagram. Also, another testing was done when the components have all been soldered on the permanent casing, at this point the working principle of the project can be fully tested and further corrections can be made if need be.

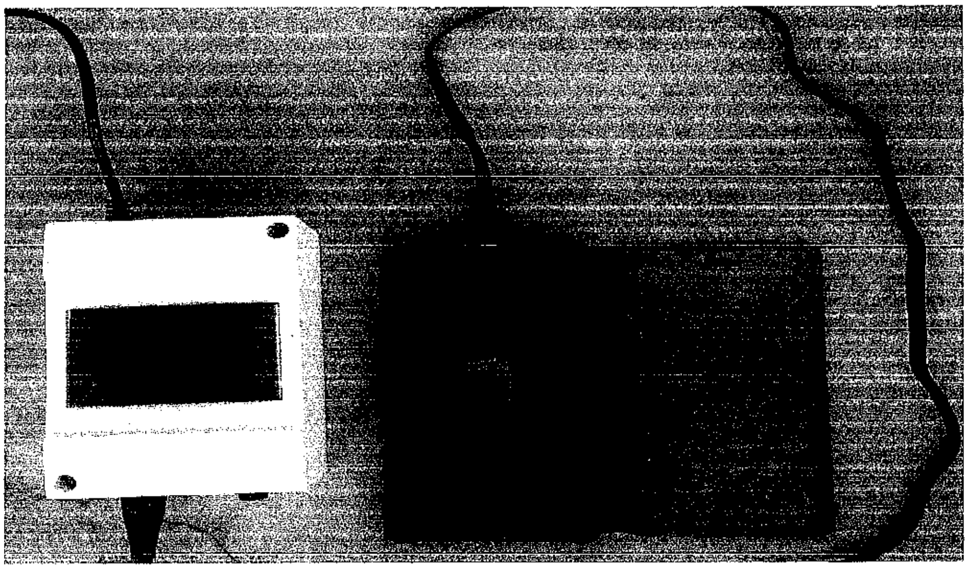


Figure 4.7: Testing of the project with phone.

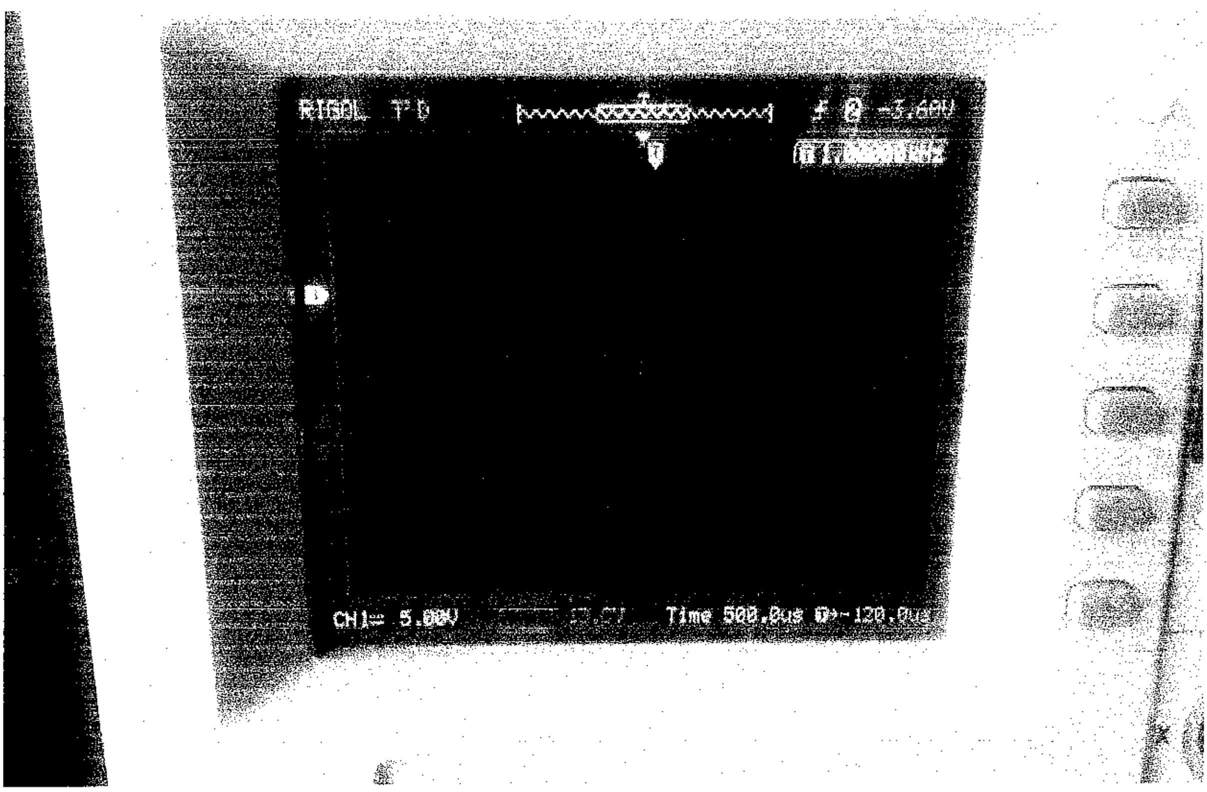


Figure 4.8: 555 timer output waveform from the oscilloscope.

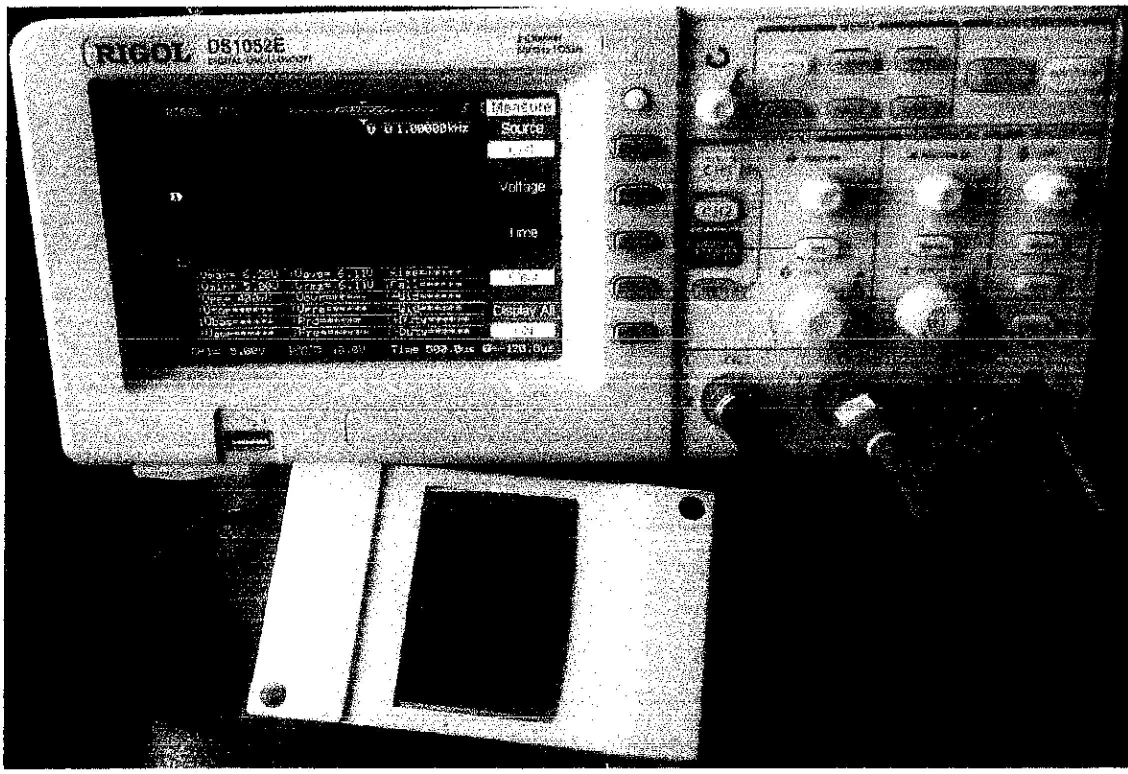


Figure 4.9: Output waveform of the charger at the battery point.

Figure 4.10 Output voltage of the charger at the jack cord.

4.3 PROJECT MANAGEMENT

4.3.1 PROJECT WORK BREAKDOWN STRUCTURE

The design and implementation of a mini wind turbine and the battery charger in not an easy task for an undergraduate student to work-on in a session due to lectures and other curriculum activities. To accomplish the aim and objectives of this project, this work was structured into sub-sections, which are stated below;

Software design of the charger system.

Blade design and implementation.

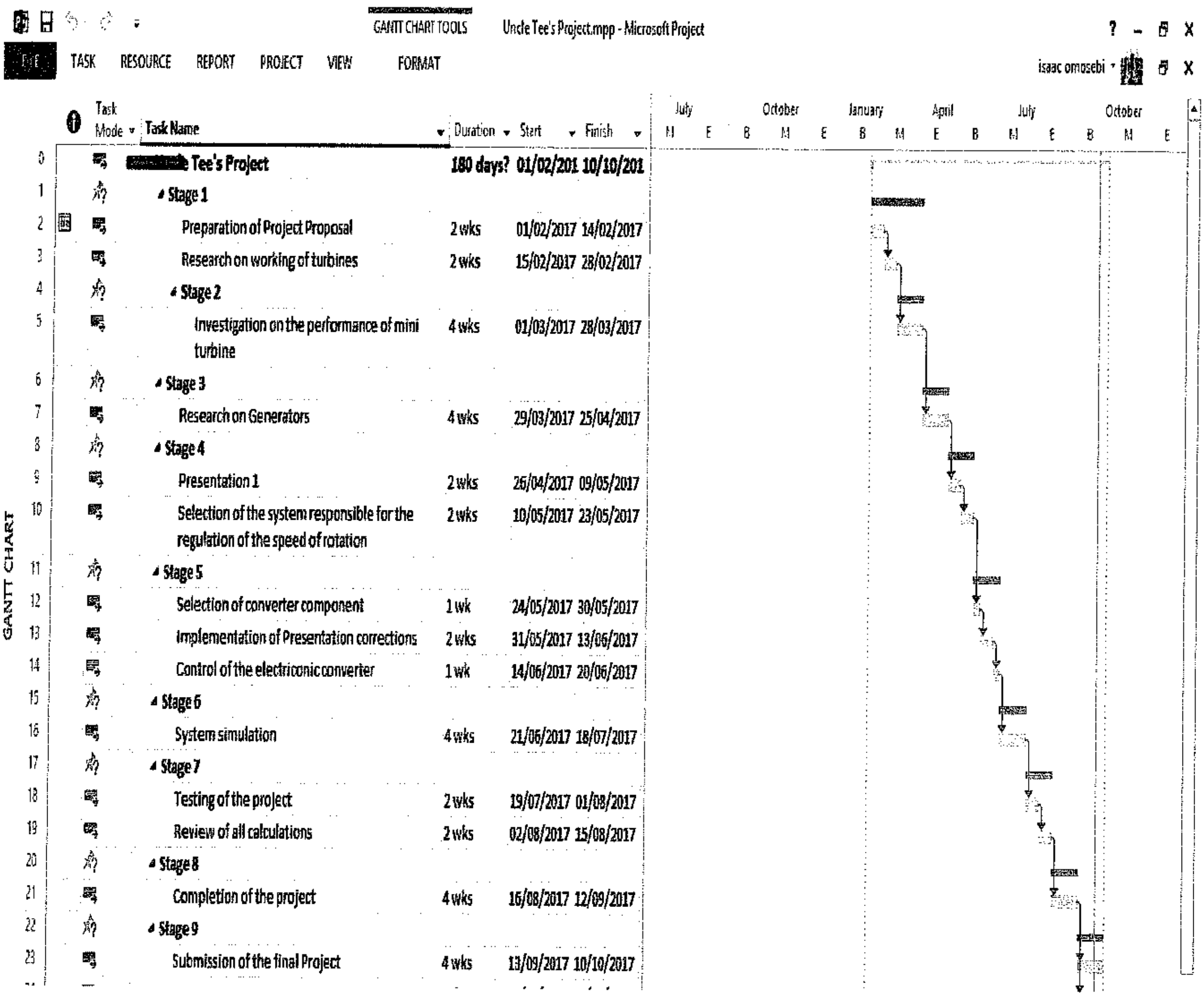
Implementation of the mini turbine.

Implementation of the battery charger.

Casing of the battery charger.

4.3.2 GANTT CHART

This section of the project explained the project schedule on how the project was accomplished within the period of February to October, as illustrated by using the Gantt chart in figure 4.11.



	Task Mode	Task Name	Duration	Start	Finish
0		[redacted] Tee's Project	180 days?	01/02/201	10/10/201
1		Stage 1			
2		Preparation of Project Proposal	2 wks	01/02/2017	14/02/2017
3		Research on working of turbines	2 wks	15/02/2017	28/02/2017
4		Stage 2			
5		Investigation on the performance of mini turbine	4 wks	01/03/2017	28/03/2017
6		Stage 3			
7		Research on Generators	4 wks	29/03/2017	25/04/2017
8		Stage 4			
9		Presentation 1	2 wks	26/04/2017	09/05/2017
10		Selection of the system responsible for the regulation of the speed of rotation	2 wks	10/05/2017	23/05/2017
11		Stage 5			
12		Selection of converter component	1 wk	24/05/2017	30/05/2017
13		Implementation of Presentation corrections	2 wks	31/05/2017	13/06/2017
14		Control of the electriconic converter	1 wk	14/06/2017	20/06/2017
15		Stage 6			
16		System simulation	4 wks	21/06/2017	18/07/2017
17		Stage 7			
18		Testing of the project	2 wks	19/07/2017	01/08/2017
19		Review of all calculations	2 wks	02/08/2017	15/08/2017
20		Stage 8			
21		Completion of the project	4 wks	16/08/2017	12/09/2017
22		Stage 9			
23		Submission of the final Project	4 wks	13/09/2017	10/10/2017

Figure 4.11: Gantt chart

4.4 APPLICATION

Charging of USB device gadgets like phone.

CHAPTER FIVE

5.0 CONCLUSION

The Mini wind turbine was finally achieved, also the charger system was designed and implemented. The system was to regulate the charging of a 6 volts battery from the output voltage of the wind generator which was then regulated to charge a 5 volts 2Amperes USB gadget and a 6volts 2Amperes jack cord. The charging rate of the battery also depends on the wind speed, if the wind speed is low, the charging rate would be slow but if the wind speed is high, the charging rate would be faster.

5.1 CONTRIBUTION TO KNOWLEDGE

This study could be used to address the issues of Nigeria energy situation vis-à-vis the assessment of utilization of wind energy in the country. It is found that Nigeria is blessed with abundant supply of wind energy resources for power generation, she is still engrossed with high level of energy poverty which have invariably affected development and impinged negatively on economic growth with some parts of the country especially the rural areas lacking access to modern resources which come with availability of electric power.

5.2 LIMITATIONS

The limitation of this project is that, there is no cut in speed and cut out speed that will be regulating the charging of the battery, also there is no yaw mechanism that will automatically direct the position of the turbine to the wind direction if there is no or low wind speed at the initial position.

5.3 PROBLEM ENCOUNTERED

Along the course of project completion, various problems and obstacles was encountered. Not everything that was planned went smoothly during the project development span. Due to the scarcity of the generator and its late arrival, I had a limited amount of time for its completion so it was under a certain amount of pressure as well. I had to start from the research phase at the beginning and needed to gain knowledge on all the devices and components that I had intended to use for the project. Other phases of the project included simulation, implementation, documentation and testing and it needed certain time for completion so I really had to manage the limited time available and work accordingly to finish the project within the schedule.

5.4 FUTURE WORKS

There is always improvement in every project work because of the advancement of technology. The only thing that need to be worked on this work later in future is using of Microcontroller that would be displaying the input voltage from the wind generator and the output voltage that flows through the battery to the USB port likewise the charging system cycle.

5.5 CRITICAL APPRAISAL

The design and implementation of a prototype mini wind turbine and charger system can be adopted in a real and large type by the government to reduce the rate of power failure in the country, also an individual can adopt it for their personal use without connecting to the grid. Lots of knowledge have be achieved during the course of this project which made me known that I can be running on wind turbine without connecting to the grid or using gasoline generators, but one of the shortcoming that this project can encounter is when the wind speed is low, what I need to do is just to install the wind turbine on top of a building to capture enough wind to spin the blade.

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