PROJECT TITLE : LOW COST VERTICAL AXIS WIND TURBINE

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SUBMITTED TO : MR MULEI

DATE OF SUBMISSION: NOVEMBER 2011

DECLARATION

I hereby declare that this project is my original work and has not being submitted by anyone else in this university or any other institution for examination. All source of information have particularly being acknowledged by means of references.

Student: WILFRED GITHUKA GACHUGI

Signature______________________________ Date:___________________________________

Supervisor: MR. F.MULEI

Signature______________________________ Date:___________________________________

DEDICATION

I dedicate this project to my dear family, lecturer and my fellow students who shown concern by encouragement and supporting me morally and financially. God bless them all.

ABSTRACT

The vertical axis wind turbine project has been designed to meet the power needs of the rural communities where the power grid has not penetrated. Much of these areas rely heavily on fossil fuel for their lighting and cooking. With no basic understanding that they are the destroyers of forests and the environment, the VAWT project will offer a solution to their problems. It will provide a constant source of lighting and also a source of power for small loads like charging mobile phones and FM receivers, which are the common electronics in these areas. The wind turbines once blown by wind will rotate and during this rotation, a small current is being induced in each of the coils below. This current when added up will produce enough power for charging a 12V sealed Lead Acid Accumulator. Charging will be more efficient during the night since this is the best time for maximum wind power. High winds pick up at night and drop as daylight approaches.

ACKNOWLEDGEMENT

Thanks to almighty God for helping me come up with the idea and implement it to complete the project. And also to all my classmates, family and lecturer (Mr.Mulei) for educational support.

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LIST OF SYMBOLS AND DEFINITIONS

See the glossary in Appendix C for definitions of many of the following abbreviations and acronyms.

A: Amps

AC: Alternating current

AEO: Annual energy output

Ah: Amp-hours

BOS: Balance of systems

CFL: Compact fluorescent light

COE: Cost of energy

DC: Direct current

DMM: Digital multimeter

DOD: Depth of discharge

DOE: Department of Energy

R: Resistance (measured in ohms)

RE: Renewable energy

V: Volts

VAC: Volts alternating current

HAWT: Horizontal-axis wind turbine

Hz: Frequency

K: Ohms

kph: Kilometers per hour

kWh: Kilowatt-hours

LED: Light-emitting diode

mph: Miles per hour

m/s: Meters per second

PMA: Permanent magnet alternator

PV: Photovoltaic

VAWT: Vertical-axis wind turbine

VDC: Volts direct current

W: Watts

Wh: Watt-hours

1.0 CHAPTER 1

1.1.0 INTRODUCTION

With the ever increasing demand for electrical energy, non-renewable energy sources have proved either too expensive to operate and maintain as compared to their output and on the other hand are major contributors to Global warming.

Today's world is rapidly changing and has been forced to look into more renewable energy sources that will not destroy the earth's delicate energy balance and at the same time exploit the rich energy sources available. One of these sources is Wind Energy.

Wind is a renewable source of energy that roams the earth since the early years and does not impact the earth negatively. In fact the harnessing of this energy has a zero carbon foot print.

Wind energy is clearly on the rise and could become a major source of electricity in years to come because wind is widely available and often abundant in many parts of the world. Significant resources are found on every continent. Tapping into the world's windiest locations could theoretically provide 13 times more electricity than is currently produced worldwide, according to the World Watch Institute, a Washington, DC-based non-profit organization.

As the development of Wind energy has gone beyond borders, many concepts and designs have been proposed and tested on a massive scale. Countries and government funded projects have shown some fascinating designs. The Golding of 1955, Shepherd and Divone in Spera of 1994, record the 100 kW 30 m diameter Balaclava wind turbine in the then USSR in 1931 and the Andrea Enfield 100 kW 24 m diameter pneumatic design constructed in the UK in the early 1950s. In these turbines hollow blades, open at the tip, were used to draw air up through the tower where another turbine drove the generator. Horizontal and Vertical Axis Wind Turbines have emerged as the two major conceptual designs used commercially. Germany is currently leading with the invention followed by Sweden.

The VAWT (Vertical Axis Wind Turbine) is normally used for lower output in the range of 40 – 100W max. Anything above that will not be economic and hence a change to HAWT which can produce up to 1MW. One major advantage of the VAWT is the ability to change direction of rotation depending on the wind direction and can operate at low wind speeds of 4m/s. Most HAWTs will pick up at an average of 9-10m/s

1.2 STATEMENT OF THE PROBLEM

In rural areas, very few or no electrical distribution companies have been able to penetrate due to problems such as inaccessibility and vandalism of electrical equipment. The recently formed government corporation (REA) Rural Electrification Authority has been able to set up projects that seek to address this problem. Together with UNIDO – United Nations Industrial Development Organization, many rural homes have been able to be lit up. To a greater extent this projects have focused on areas rich in resources such as water, sun and livestock.

Deserted areas not mapped have been left to fend for themselves. Many have been left out in the dark. Initiatives such as solar have been implemented but the sun is not available at night despite having batteries to store the energy. Here we have a problem.

We need a renewable form of energy that is available on a 24/7 basis and its output can help reduce poverty.

1.3 JUSTIFICATION OF THE PROBLEM

The Low Cost Vertical Axis Wind Turbine (LCVAWT) will be in operational during day and night. During the day, low wind speeds are normally experienced and hence will be charging battery units for the night. When the night finally arrives, the stored energy can then be used for other purposes while the unit will produce power that can be used for lighting. Note that at night, higher wind speeds are normally experienced and hence more power can be achieved.

The unit is made up of locally available materials which are cheap and can be sourced from any electronics shop in the locality.

The wind turbines shall be made to rotate in any direction and are cut from unused water bottles. The charging and rectification circuits will be water proof for protection in case of precipitation. The base on which all these are mounted will be polished wood while it should be placed away from obstructions of any kind to get maximum wind power.

1.4 OBJECTIVES

1. To supply electrical energy at all times, day or night
2. To Charge batteries as a storage of energy
3. To help reduce poverty through production of alternative source of energy

1.5 BLOCK DIAGRAM

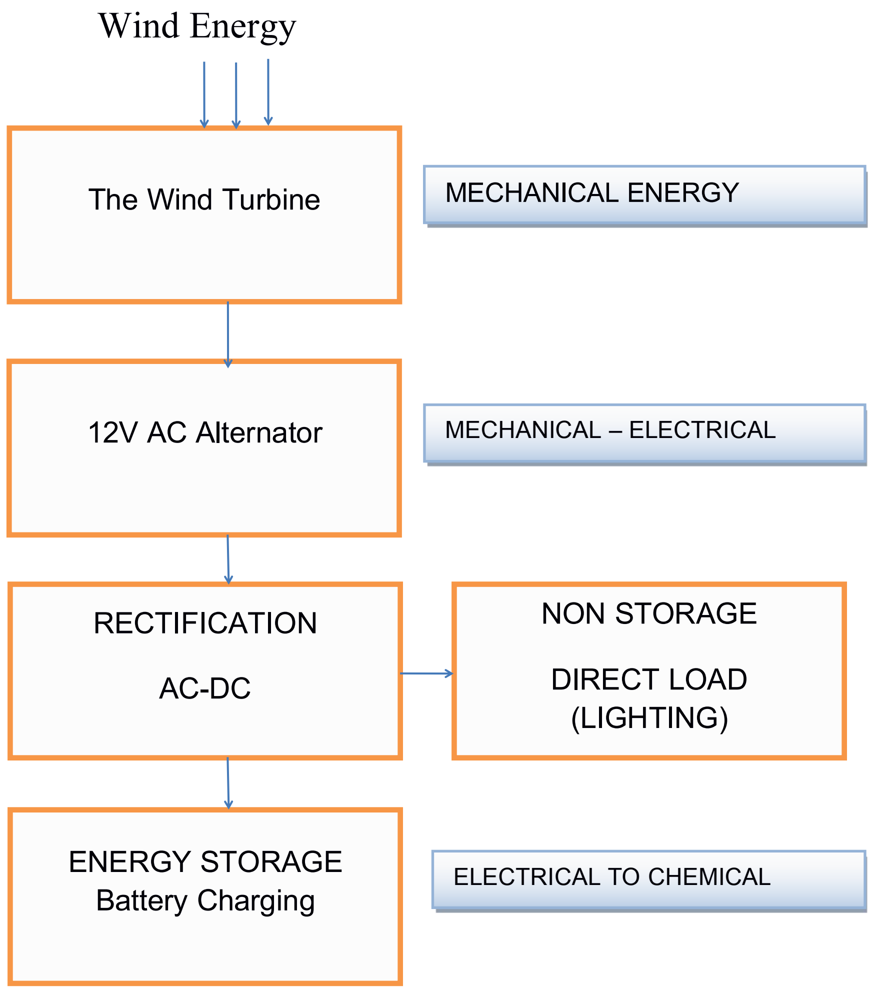


Figure 1.5: Block Diagram of Wind Energy conversion into electrical energy.

1.6 BLOCK DIAGRAM EXPLANATION

Wind Turbine – This is the most complex part of the project that involves the mechanical system which responds to wind movement and rotates in the direction of the wind. This is composed of 4 large half water bottles arranged in successful manner to capture the wind power.

Alternator – Made of 3 permanent magnet rotating on a common axis directly above the windings will produce the desired voltage.

Rectification Section – The AC from the alternator cannot be stored in its very nature and has to be converted to a more suitable form of DC. Also the AC from the alternator will not be a perfect sine wave AC, very varying in nature depending on the wind speed. It has to be stabilized for storage. Output of this section will be DC.

Battery Charging Section - As with any other renewable energy source like solar, there has to be a means of storing the electrical energy for future use. DC energy can be stored to a 12V DC Sealed Lead Acid Accumulator. A diode will be connected to stop reverse current should the battery be fully charged.

Direct Load – During heavy wind loads especially at night, and all batteries are fully charged, DC power can be tapped directly from the rectification section for direct loads such as lighting, mobile phone charging and FM receivers.

1.7 SPECIFICATIONS

Output Voltage (Alternator): 12V AC

Output Voltage (Rectification): 12V DC

Charging Voltage: 12V DC

Charging Current: ~0.9-1A

Best Wind Speed: 10-12m/s

2.0 CHAPTER TWO

2.1.0 LITRETURE REVIEW

Wind energy is without a doubt the most difficult renewable resource to capture. At the same time, it often ends up being the most attractive. The energy available in the wind varies as the cube of the wind speed, so an understanding of the characteristics of the wind resource is critical to all aspects of wind energy exploitation, from the identification of suitable sites and predictions of the economic viability of wind farm projects through to the design of wind turbines themselves, and understanding their effect on electricity distribution networks and consumers.

2.1.1 The Wind Turbine

As with any other generating plant equipment, there has to be a prime mover for it to be deemed as a generating unit. The wind turbine is of VAWT (Vertical Axis Wind Turbine) design. This technology is quite cheap to produce as compared to HAWT but nevertheless is hindered is amount of energy it can produce. This turbine is made up of locally available materials which comprise of:

1. Two 3Litre half-cut water bottles
2. Four 0.3cm thick wooded sticks
3. 1 Normal biro (pen)

These materials when put to together will form the turbine section. One major advantage of the VAWT over HAWT is the ability to rotate in any direction. In my wind turbine, should the wind dramatically change direction, the turbine will follow suit and generation will follow.

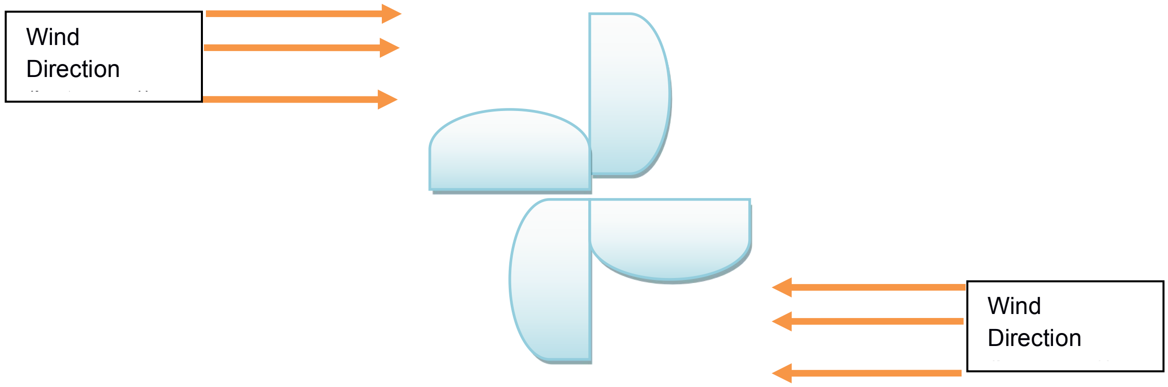


Figure 2.1.1: Illustration of a wind turbine working principle

Vertical-axis wind turbines (VAWTs) are a type of wind turbine where the main rotor shaft is set vertically and the main components are located at the base of the turbine. Among the advantages of this arrangement are that generators and gearboxes can be placed close to the ground, which makes these components easier to service and repair, and that VAWTs do not need to be pointed into the wind.[1] Major drawbacks for the early designs (Savionus, Darrieus and giromill) included the pulsatory torque that can be produced during each revolution and the huge bending moments on the blades. Later designs solved the torque issue by using the helical twist of the blades almost similar to Gorlov's water turbines. A VAWT tipped sideways, with the axis perpendicular to the wind streamlines, functions similarly. A more general term that includes this option is "transverse axis wind turbine".

Figure 2.1.1b: The Savionus Wind Turbine

Advantages of VAWTS

1. They can be packed closer together in wind farms, allowing more in a given space. This is not because they are smaller, but rather due to the slowing effect on the air that HAWTs have, forcing designers to separate them by ten times their width. VAWTs are rugged, quiet, Omni-directional, and they do not create as much stress on the support structure.
2. They do not require as much wind to generate power, thus allowing them to be closer to the ground. By being closer to the ground they are easily maintained and can be installed on chimneys and similar tall structures.

Disadvantages of VAWTS

1. Some disadvantages that the VAWTs possess are that they have a tendency to stall under gusty winds.
2. VAWTs have very low starting torque, as well as dynamic stability problems.
3. The VAWTs are sensitive to off-design conditions and have a low installation height limiting to operation to lower wind speed environments.
4. The blades of a VAWT are prone to fatigue as the blade spins around the central axis. The vertically oriented blades used in early models twisted and bent as they rotated in the wind. This caused the blades to flex and crack. Over time the blades broke apart and sometimes leading to catastrophic failure. Because of these problems, Vertical axis wind turbines have proven less reliable than horizontal-axis wind turbines (HAWTs).

Research programmes (in 2011) have sought to overcome the inefficiencies associated with VAWTs by reconfiguration of turbine placement within wind farms. It is thought that, despite the lower wind-speed environment at low elevations, "the scaling of the physical forces involved predicts that [VAWT] wind farms can be built using less expensive materials, manufacturing processes, and maintenance than is possible with current wind turbines" [10]

2.1.2 Types of Wind Turbines

In the Wind Power industry, there are 3 common types of wind turbine designs that are commercially viable and are used. The major difference between these types of wind turbines are the design of blades and as I said earlier, how much force each can take from a prevailing wind. The 3 major types include:

1. The HAWT (Horizontal Axis Wind Turbine)
2. The VAWT (Vertical Axis Wind Turbine)
3. The Savionus Rotor Wind Turbine.

2.1.1.1 The HAWT (Horizontal Axis Wind Turbine)

Most wind turbines in use today are horizontal axis units, or HAWTs, (explained shortly) with three blades attached to a central hub. Together, the blades and the hub form the rotor. In many wind turbines, the rotor is connected to a shaft that runs horizontal to the ground, hence the name.

It is connected to an electrical generator. When the winds blow, the rotor turns and the generator produce alternating current (AC) electricity. (See the accompanying box for an explanation of AC electricity.) One of the key components of a successful wind generator is the blades. They capture the wind's kinetic energy and convert it into mechanical energy (rotation). It is then converted into electrical energy by the generator. Horizontal-axis wind turbines (HAWT) have the main rotor shaft and electrical generator at the top of a tower, and must be pointed into the wind. Small turbines are pointed by a simple wind vane, while large turbines generally use a wind sensor coupled with a servo motor. Most have a gearbox, which turns the slow rotation of the blades into a quicker rotation that is more suitable to drive an electrical generator.[14] Since a tower produces turbulence behind it, the turbine is usually positioned upwind of its supporting tower. Turbine blades are made stiff to prevent the blades from being pushed into the tower by high winds. Additionally, the blades are placed a considerable distance in front of the tower and are sometimes tilted forward into the wind a small amount. Downwind machines have been built, despite the problem of turbulence (mast wake), because they don't need an additional mechanism for keeping them in line with the wind, and because in high winds the blades can be allowed to bend which reduces their swept area and thus their wind resistance. Since cyclical (that is repetitive) turbulence may lead to fatigue failures, most HAWTs are of upwind design.

2.1.1.2 The Savionus Rotor

Savionus wind turbines are a type of vertical-axis wind turbine (VAWT), used for converting the force of the wind into torque on a rotating shaft. The turbine consists of a number of aerofoils usually--but not always--vertically mounted on a rotating shaft or framework, either ground stationed or tethered in airborne systems. Savonius turbines are one of the simplest turbines. Aerodynamically they are drag-type devices, consisting of two or three scoops. Looking down on the rotor from

Figure 2.1.1.2: The Savionus Rotor

above, a two-scoop machine would look like an "S" shape in cross section. Because of the curvature, the scoops experience less drag when moving against the wind than when moving with the wind. The differential drag causes the Savonius turbine to spin. Because they are drag-type devices, Savonius turbines extract much less of the wind's power than other similarly-sized lift-type turbines. Much of the swept area of a Savonius rotor may be near the ground, if it has a small mount without an extended post, making the overall energy extraction less effective due to the lower wind speeds found at lower heights.

2.1.2 The Alternator

The Alternator is where a varying AC quantity is generated in the order of 0-12V. It works on the principle of a magnate rotating across a coil thereby inducing a small current in the coil. This current will be induced 4X since there are 4 magnets in NS NS NS orientation above the coils. The magnets will be placed directly above the coils as close as possible and when the turbine rotates, so does the magnets. This wind turbine model makes its electricity with a simple generator which produces pulses of current, or alternating current. It does so by passing strong magnets over coils of fine wire. Each time a magnet passes over a coil, the coil becomes energized with electricity. With 4 coils connected together in series, the result is a quadrupling of the voltage.

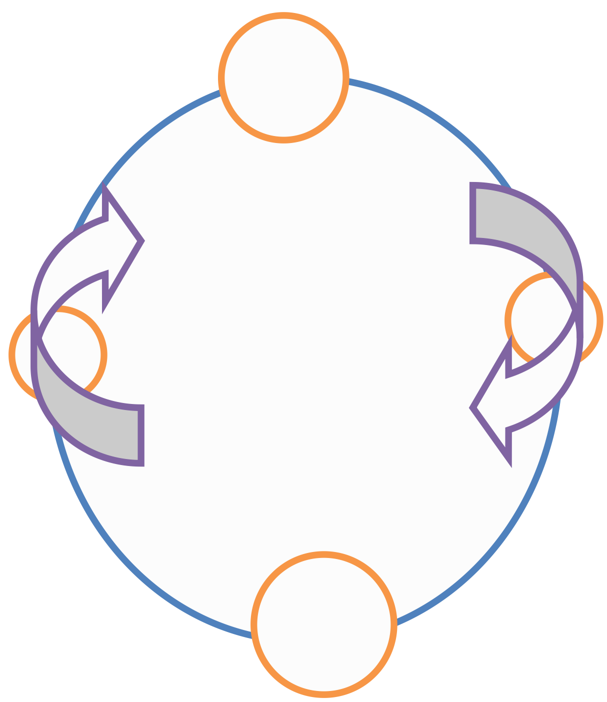


Figure 2.1.2: Principle of operation of the turbine magnets rotating above the windings

Rectification Section

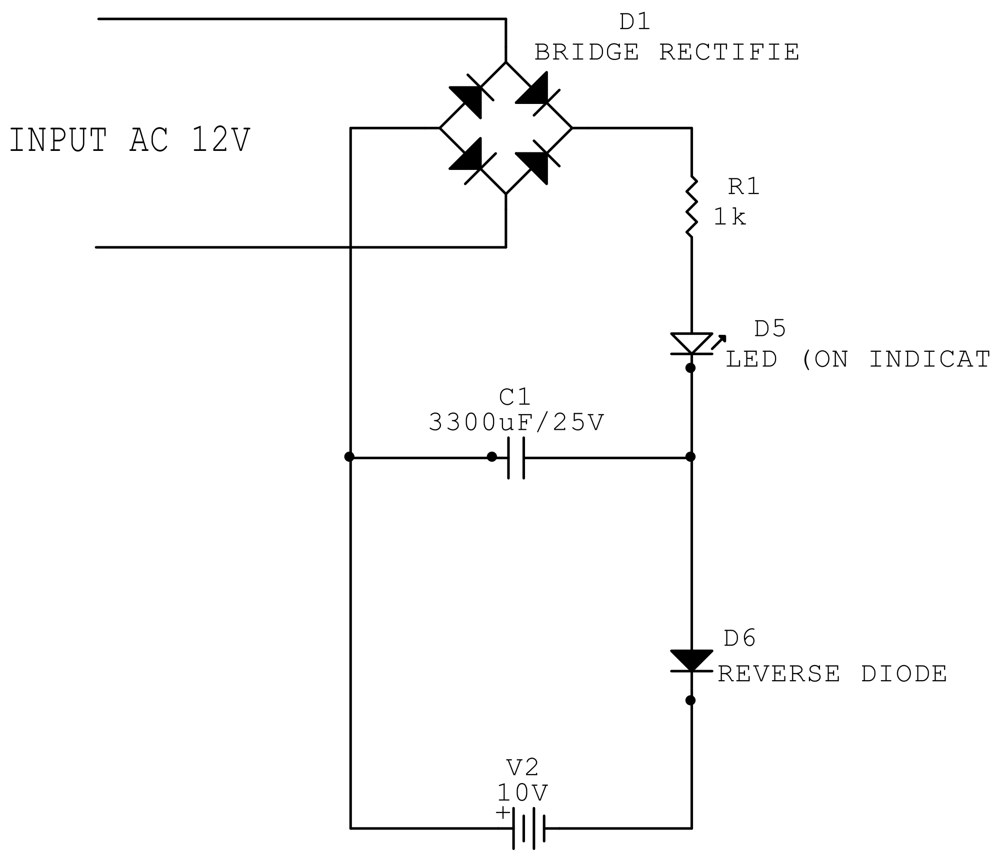


Figure 2.1.3 Rectification Circuit

The AC from the alternator cannot be stored in its very nature and has to be converted to a more suitable form of DC. Also the AC from the alternator will not be a perfect sine wave AC, very varying in nature depending on the wind speed. It has to be stabilized for storage. Output of this section will be DC.

From the main supply, current and voltage alternate sinusoidal. If this supply was to be used to charge battery, the positive pubes would charge and negative pubes would discharge the battery. There essence of rectification is to provide a unipolar voltage.

There are various methods of rectifications, these are:

i) Half wave rectification

ii) Centre tapped full wave rectifier

iii) Bridge rectification

2.1.4 Bridge Rectification

In order to overcome the disadvantages of half wave and center- tapped full wave rectifier a bridge rectifier circuits employed. It used four diodes as shown below

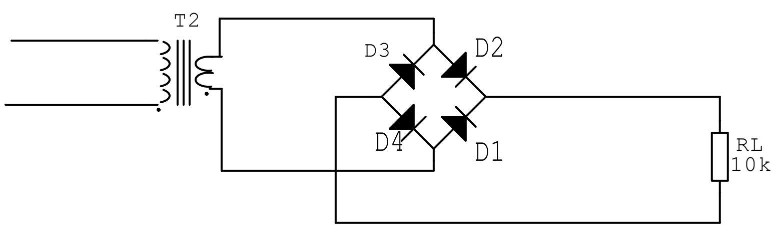


Figure 2.1.4: Circuit of a bridge rectifier

2.1.4.1 Operation of Bridge rectifier

Two diode conduct at the same time for any instant of the input voltage with the transformer voltage positive upward, diodes D_1 and D_2 conduct as shown on the figure above. In the following half cycle the transformer voltage is positive downwards and diode D_3 and D_4 conduct causing a second load current pulse in the same direction as pulse from the first cycle. A full wave current form is obtained in the load, with two diodes conducting in series in each half cycle.

2.1.4.2 Problems in Bridge rectifier

i. One diode in bridge rectifier open circuit

- The circuit behaves as half wave rectifier

i. One diode bridge rectifier short circuit.

- Fuse damaged

2.1.4.3 Smoothing circuit (filter)

There are several types of fitters:

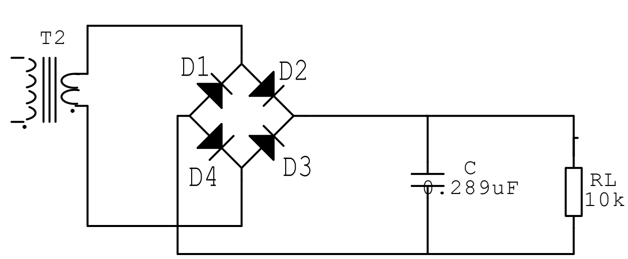
(a) Short Capacitor Filter

(b) Dc Filter

(c) LC Filter

(d) Choke input filter

The filters are used to smoothen the output voltage, the short capacitor filter is employed in this method in that it prevents the output voltage from failing to zero as the diode cuts off.



2.1.4.4 Operation

When the current through the load, the capacitor gets charged to its peak output voltages. The input voltages fail from its peak value towards cero at which the other set of diodes conduct. Since the voltage across the capacitors is now greater than the applied, the capacitor discharges through the load RL.

Battery Charging Section

As with any other renewable energy source like solar, there has to be a means of storing the electrical energy for future use. DC energy can be stored to a 12V DC Sealed Lead Acid Accumulator. A diode will be connected to stop reverse current should the battery be fully charged.

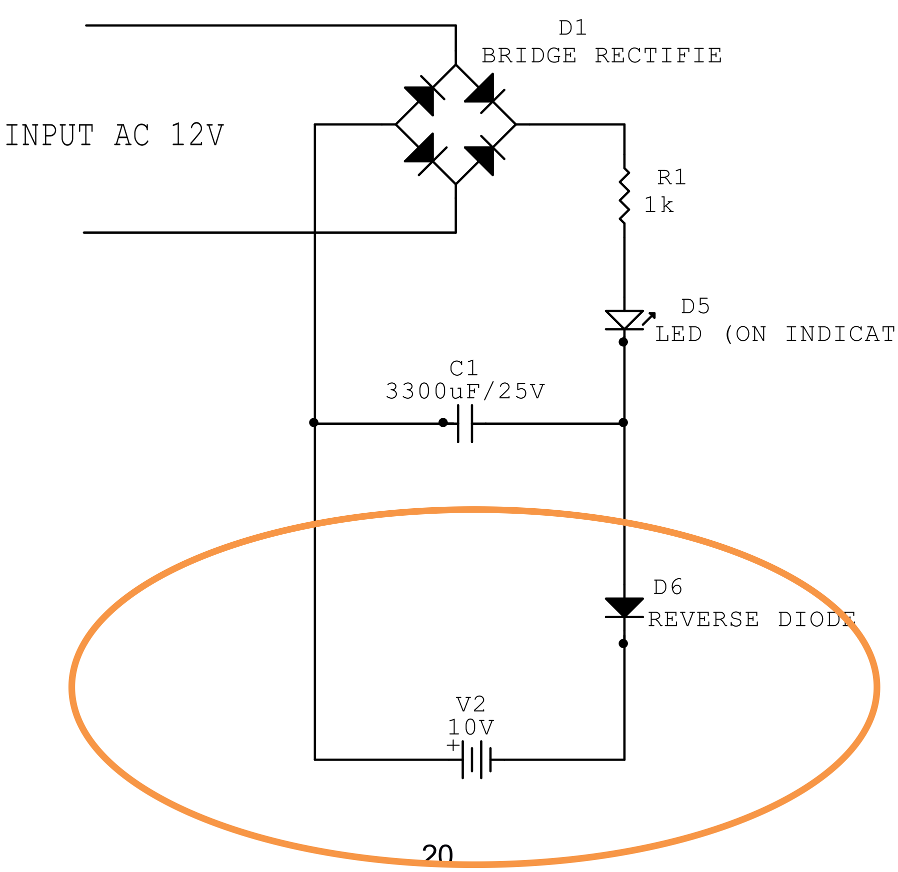


Figure 2.1.5: The battery charging

2.1.6 BATTERY

A battery is a device which is used to power. The storage of battery depends on the capacity of power it holds

2.1.6.1Types of Battery

(a) Iron oxide cells

(b) Lead acid cell

(c) Alkaline cells

(d) Zinc silver oxide cell

2.1.6.2Lead acid cell

The backup battery for power is from bank of 12v lead acid battery The electrolyte is dilute sulphuric acid (H_2 SO4)

Lead acid rating

Ampere-hour capacity

It is function of the total plate area multiplied by a number of plates. Thus ampere hour for battery in this project approximated to be 150 AH.

Operation

The electrolyte is the current carrier inside the battery between positive and negative plates through separators.

When the cell is discharging, the chemical energy in the electrolyte is converted in to electrical energy and otherwise is applicable when charging the battery.

2.3.5.0. RESISTORS

A resistor is a basic element in an electrical circuit .its role is to resist the flow of current through circuit. They are also used to create paths for direct current flow between circuit's nodes, typical uses for this include operational amplifier feedback or transistor biasing. The majority of resistor in a circuit has fixed resistance values.

However potentiometer may be used to allow adjustment of the resistance. Application potentiometer is volume control in audio players.

All resistors are basically just a piece of conducting material with a specific value of resistance. For that piece of conducting material to be made into a practical resistor, pair of electrodes and leads is attached so current can flow. The resistor is then coated with an insulating material to protect the conducting material from the surrounding environment and vice versa. There are several different resistor construction methods and body styles (or *packages*) that are designed for a certain range of applied voltage, power dissipation, or other considerations. The construction of the resistor can affect its performance at high frequencies where it may act like a small inductor or capacitor has been added, called *parasitic* inductance or capacitance.

2.3.5.1.0. Types of resistor

2.3.5.1.1. Carbon-composition resistors

These are also known as *carbon-comp* resistors. "Composition" means that the resistive material is a mix of carbon and stabilizing compounds. The amount of carbon in the mix determines the resistance of the material. A small cylinder, like a pencil lead, is held between the two electrodes and coated with resin or phenolic, making a *non-inductive* resistor (one with very low parasitic inductance) that is often used in RF circuits.

2.3.5.1.2. Film resistors

In a *film resistor,* the resistive material is a very thin coating of carbon or metal on an insulating substrate, such as ceramic or glass. The value of the resistance is determined by the thickness of the film and the amount of carbon or metal in it. These resistors are available with very accurate and stable values. A drawback of film resistors is that they are unable to handle large amounts of power because the film is so thin. Overloads can also damage the film by creating "hot spots" inside the resistor, changing its value permanently. The value of film resistors is sometimes adjusted before sealing by cutting away some of the film with a laser, a process called *trimming*. Surface-mount resistors are almost always film resistors; the film is deposited on a ceramic sheet. Because of their extremely small size, surface-mount resistors have very low power ratings from 1⁄10 to 1⁄4 watt.

2.3.5.1.3. Wire wound resistors

Common in power supplies and other equipment that dissipates lots of power, wire wound resistors are made just as you might expect: A high-resistance wire is wound around an insulating form usually a ceramic tube and attached to electrodes at each end. These are made to dissipate a lot of power in sizes from 1-watt to hundreds of watts! Wire wound resistors are usually intended to be air cooled, but some styles have a metal case that can be attached to a heat sink or metal chassis to get rid of undesired heat. Because the resistive material in these resistors is wound on a form, they also act like small inductors. For this reason, wire wound resistors are not used in audio and RF circuits. Be careful when using a resistor from your junk box or a grab bag in such a circuit! Small wire wound resistors look an awful lot like film or carbon-comp resistors. There is usually a wide color band on wire wound resistors, but not always. If you're in doubt, test the resistor at the frequencies you expect to encounter.

2.3.5.1.4. Ceramic and metal oxide resistor

If you need a high-power *non-inductive* resistor, you can use *cermet* (ceramic-metal mix) or metal oxide resistors. These are constructed much like carbon-comp resistors, substituting the cermet or metal oxide for the carbon-composition material.

2.3.5.1.5. Adjustable resistors

There are many different types of adjustable resistors. The simplest are wire wound resistors with some of the wire exposed so a movable electrode can be attached. The most common are adjusted with a rotary shaft. The *element* provides a fixed resistance between two terminals. The *wiper* moves to contact the element at different positions, changing the resistance between the end of the element and the wiper terminal. If an adjustable resistor has only two terminals — one end of the element and the wiper then it's called a *rheostat* and provides an adjustable value of resistance. Most rheostats are intended for use in high-power circuits with power ratings from several watts to several tens of watts. If the adjustable resistor has three terminals, it is called a *potentiometer* (or "pot" for short). Most pots are intended to act as voltage dividers; they can be made into rheostats by leaving one of the element terminals unconnected. Miniature versions called *trimmers,* mounted on a circuit board, are used to make small adjustments or calibrate a circuit. They are available in single-turn or multi-turn versions. Larger pots (with shafts 1⁄8" or 1⁄4" in diameter) are intended as user controls for example, the volume and tone pots on an electric guitar or a radio. Pots are available with resistance values from a few ohms to several megohms and with power ratings up to 5 watts. As with fixed-value resistors, the construction of the pot is important. Higher-power pots may have a wire wound element that has enough inductance to be unsuitable for audio or RF signals. Smaller pots, particularly trim pots, are not designed to be strong enough mechanically for use as a frequently adjusted control. Pots are also available with elements that have a non-linear *taper* or change of resistance with wiper position. For example, a *log taper* pot has a resistance that changes logarithmically with shaft rotation. This is useful in attenuator circuits. An *audio taper* pot is used to create a voltage divider that mimics the loudness response of the human ear so volume appears to change linearly with control rotation.

Power Dissipation and Voltage Ratings

After value, power dissipation is the next most important characteristic of a resistor. An overloaded resistor often changes in value over time and can often get hot enough to burn its self and surrounding components. Every circuit designer learns the smell of burnt resistor sooner or later!

Choosing Resistors

Here's a short list of special applications that require special types of resistors. These aren't hard and fast rules, but they can guide your initial selection. For most circuits, plain old carbon-film or carbon-comp resistors work just fine.

ESD and transient protection: Carbon composition and metal oxide (they withstand short pulse overloads and have low values of parasitic inductance).

Audio and instrumentation circuits: Metal film (low noise).

High voltage: Wire wound and metal oxide in high-voltage body styles.

RF: Carbon composition and metal oxide (low inductance).

Precision circuits: Carbon or metal film (fixed-value) and cermet (trimmers or controls).

Consider what's most important for your particular circuit value, power, voltage, stability, cost and then look for the resistor type that meets those requirements. Tolerance and temperature coefficient Resistors have a nominal value and a tolerance (the amount of acceptable variation above or below the nominal value). Most resistors have a 1%, 5%, or 10% tolerance, and you can find smaller (that is, tighter) tolerances. The tolerance series determines which values of resistors are available. For example, in the 5% series, values are selected so each is approximately twice the tolerance or 10% from the next highest or lowest value. Resistors also change value with temperature. The relative change of resistance with temperature is called the temperature coefficient specified as parts per million (ppm) or as percentage-change per degree-Celsius of temperature change. A positive temp coefficient means resistor value increases with temperature. When designing and constructing sensitive circuits that use precision (1% or tighter tolerance) resistors, it's important to keep them at an even temperature.

2.3.5.4. KEY PROPERTIES OF RESISTORS

When choosing resistor for a circuit, parameter such as power rating, tolerance and temperature drift should be considered.

Physical size of resistor component directly affects how much a heat generation. It can withstand before sustain damage. The resistor must be selected such that its max power rating is not exceeding. Resistor are specified with a nominal resistance value and tolerance often stated in percent . This tolerance states the max deviation of single resistor from its normal value.

The resistance of two resistor are rarely equal but their values are both with a certain guaranteed interval, defined by the tolerance as the ambient temperature of resistor fluctuates, so does the resistance of the resistor . The amount by which the resistance fluctuates is known as the temperature drifting and often stated in Celsius.

COMBINATION OF RESISTORS.

Resistor may be combining in either series or parallel.

RESISTOR IN SERIES

When connecting resistor in series the equivalent resistance becomes the sum of individual resistance

$$R=R_1+R_2$$

RESISTOR IN PARALLEL

When two or more resistor is connected in parallel the inverse of equivalent resistance is equal to the sum of the inverse of the individual resistance.

CAPACITORS

They are similar in a way to batteries but have different construction and characteristics. They store electric energy and release it when necessary, but unlike batteries, capacitors can be charged and discharge cycle during operation. However capacitors have one great disadvantage compared to batteries they cannot retain electrical energy to long period of time. Capacitor is the most simple basically they consist of two metallic brought in close approximating and isolated from one other with a dielectric substance such as air, paper, mica, Teflon, and other. The type of material used as dielectric depends on the application for example some dielectric material may behave well under high voltage and frequency but may fail to work out ultra-high frequency and low

HOW IT WORKS

When capacitors are connected in parallel with a battery, electrical charge from negative terminal of the battery travels to the negative terminal of the capacitor where it's accepted. On other hand positive loses electrons which travel to the battery. Although the charge is not stored instantaneously, the process is much faster than the charging process of a battery or of an accumulator.

The bigger the common surface area between the two metallic plates the higher the charge that can be stored inside a capacitor. The storing volume of capacitor is measured in units called farads. One farads represents the capacitance of this device

USES

Capacitor are used in

stabilizing DC voltages

making alternating current flow while DC current is being blocked

Types of capacitor

Ceramic capacitors

They are used in high frequency circuits such as RF. They are also the best choice for high frequency compensation in audio circuits. Now some may snub their noses when hearing this. Pretty much all amplifiers have some sort of high frequency compensation to prevent them from oscillating and instability. The frequency at which these ceramics were doing their work was at

240 KHz. They come in values from a few Pico farads to 1 microfarad. The voltage range is from a few volts up to many thousands of volts. Ceramics are inexpensive to manufacture and they come with several dielectric types. Types XR7 and Z5U are the least stable as far as temperature is concerned. They have a higher dielectric constant than the higher stability types like COG. The tolerance of ceramics is not great but for their intended role in life they work just fine.

Tantalum capacitors

They are made by depositing a film of oxide on tantalum. These are polarized types and are smaller than their aluminum counterparts. They are low voltage types only with a maximum rating of about 40 volts. We at zed do NOT use these as they are notoriously unreliable. They have a bad tendency to go leaky.

Aluminum Electrolytic capacitors

They are made by depositing a film of oxide on aluminum foil. The foil is formed for a specific voltage rating. These are polarized and of courser do not tolerate having reverse voltage applied to them .They are also not happy campers if the rated voltage is exceeded but higher quality types will tolerate about 5% over voltage. What happens in these capacitors that if one applies say 37 volts to a 35 volt capacitor it will actually reform its foil over time to the new applied voltage but its value will drop to keep CV a constant. Conversely if a lower voltage is applied it will reform to this new voltage and the capacitance will increase. Now do not get all excited and take your 10,000mfd 50v capacitor and use it at 25 volts and expect to get 20,000mfd out of it. There are limits to what these guys will do. It is also not a great idea to run electrolytic at voltages well below their rated voltage. A rule of thumb is about 25% lower voltage than rated is

OK. They are normally made by winding the foils around in each other in a cylindrical way. High capacitance is easily obtained. The ESR is the Equivalent Series Resistance and the higher the value and voltage the lower the ESR. The lower the ESR the less heat the capacitor will generate when current is drawn from it. Also closely related to the ESR is the available ripple current that a capacitor can tolerate. This is mainly of concern in power supplies. Most manufacturers offer many grades and sizes of electrolytic capacitors. There are of course both through hole and surface mount types. Within each category there are sub categories. Through hole types offer many more variations than surface mount. There are 85 deg C and 105 deg C versions leaded, snap in and screw type terminations. Electrolytic, especially those used in high current power supplies have a fixed lifespan and once an electrolytic decides it is tired of living, and then it is off to "the pie in the sky". Typically their life span is from 1,000 to 3,000 hours depending on the quality. Their tolerance is not good but then again a low tolerance component is not essential. Typically the value can vary from -50% to +100% of the nominal value. There are non-polar electrolytic and these are mainly used in passive speaker crossovers.

Silver Mica Capacitors

They are one of the best types of capacitors. They have excellent stability and are available in low tolerance values down to less than 0.1%. They are sensitive to heat and are now used mainly in RF and tuned circuits. I like them in RIAA preamplifiers as I think they do sound better in that application.

Film capacitors

Encompass polyester, polypropylene, polycarbonate and others. Each has its own strengths and weakness. These are normally used in audio for filters, equalizers and power supply bypass duty.

They are available in almost any value and voltages as high as 1,500 volts. They come in any tolerance from 10% to 0.01%.

DIODES

It's a semiconductor that allows current to flow in only one direction. It consists of cathode and Anode. The cathode is the electron emitting element of a tube. Cathode is usually composed of special material that are heated either directly or indirectly.

DIODE OPERTION

Depend upon current flow through the tube because the cathode is the only electron-emitting-element in the tube. Current can only flow in one direction from the cathode to the plate, which is the Anode. For current to flow anode must be positive with respects to the cathode

Types of diodes

Laser diode

This type of diode is not the same as the ordinary light emitting diode because it produces coherent light. Laser diodes are widely used in many applications from DVD and CD drives to laser light pointers for presentations. Although laser diodes are much cheaper than other forms of laser generator, they are considerably more expensive than LEDs. They also have a limited life

Light emitting diodes

The light emitting diode or LED is one of the most popular types of diode. When forward biased with current flowing through the junction, light is produced. The diodes use component semiconductors, and can produce a variety of colours, although the original colour was red. There are also very many new LED developments that are changing the way displays can be used and manufactured. High output LEDs and OLEDs are two examples.

Photodiode

The photo-diode is used for detecting light. It is found that when light strikes a PN junction it can create electrons and holes. Typically photo-diodes are operated under reverse bias conditions where even small amounts of current flow resulting from the light can be easily detected. Photo-diodes can also be used to generate electricity. For some applications, PIN diodes work very well as photo detectors.

PIN diode

This type of diode is typified by its construction. It has the standard P type and N-type areas, but between them there is an area of intrinsic semiconductor which has no doping. The area of the intrinsic semiconductor has the effect of increasing the area of the depletion region which can be useful for switching applications as well as for use in photodiodes, etc.

PN Junction

The standard PN junction may be thought of as the normal or standard type of diode in use today. These diodes can come as small signal types for use in radio frequency, or other low current applications which may be termed as signal diodes. Other types may be intended for high current and high voltage applications and are normally termed rectifier diodes.

Schotty diodes

This type of diode has a lower forward voltage drop than ordinary silicon PN junction diodes. At low currents the drop may be somewhere between 0.15 and 0.4 volts as opposed to 0.6 volts for a silicon diode. To achieve this performance they are constructed in a different way to normal diodes having a metal to semiconductor contact. They are widely used as clamping diodes, in RF applications, and also for rectifier applications

Step recovery diode

A form of microwave diode used for generating and shaping pulses at very high frequencies. These diodes rely on a very fast turn off characteristic of the diode for their operation.

Tunnel diode

Although not widely used today, the tunnel diode was used for microwave applications where its performance exceeded that of other devices of the day.

Varactor diode or varicap diode

This type of diode is used in many radio frequency (RF) applications. The diode has a reverse bias placed upon it and this varies the width of the depletion layer according to the voltage placed across the diode. In this configuration the varactor or varicap diode acts like a capacitor with the depletion region being the insulating dielectric and the capacitor plates formed by the extent of the conduction regions. The capacitance can be varied by changing the bias on the diode as this will vary the width of the depletion region which will accordingly change the capacitance.

Zener diode

The Zener diode is a very useful type of diode as it provides a stable reference voltage. As a result it is used in vast quantities. It is run under reverse bias conditions and it is found that when a certain voltage is reached it breaks down. If the current is limited through a resistor, it enables a stable voltage to be produced. This type of diode is therefore widely used to provide a reference voltage in power supplies. Two types of reverse breakdown are apparent in these diodes: Zener breakdown and Impact Ionization. However the name Zener diode is used for the reference diodes regardless of the form of breakdown that is employed.

Summary

Semiconductor diodes are widely used throughout all areas of the electronics industry from electronics design through to production and repair. The semiconductor diode is very versatile, and there are very many variants and different types of diode that enable all the variety of different applications to be met. The different diode types of types of diodes include those for small signal applications, high current and voltage as well as different types of diodes for light emission and detection as well as types for low forward voltage drops, and types to give variable capacitance. In addition to this there are a number of diode types that are used for microwave applications. From this it can be seen that the semiconductor diode is a particularly versatile form of electronics component that can be used in many areas of electronics.

3.0. CHAPTER THREE

3.1. METHODOLOGY

3.1.1 The Wind Turbine

The construction of the wind turbine project started with the assembly of the vertical turbine. Composed of 4 turbines mounted vertically close to one another, they rotate in a 360 degrees angle around a common axis, hence the name, vertical axis wind turbine.

Figure 3.1.1: The wind turbine

The blades are made of a locally available plastic material which is both durable and also able to withstand the elements.

The turbines are held into position by 4 wooden sticks 30cm in length which bore through all the 4 turbines to ensure maximum structural strength and stability.

The wooden sticks mentioned above are covered with insulating tape to ensure a long lasting unit which will mostly be left unattended. These sticks form a 90 degree joint at the axis of the turbine.

3.1.2 The Alternator

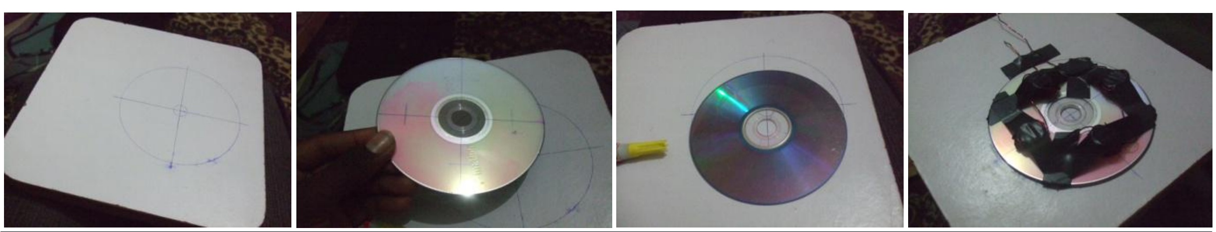


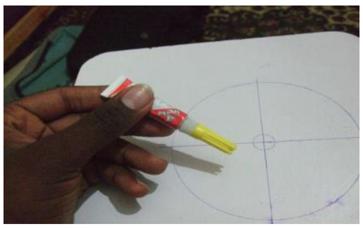
Figure 3.1.2: Various steps in the development of the permanent magnet alternator.

The permanent magnet alternator is composed of 3 magnets rotating directly above a set of 4 coils where a small current will be induced at every crossing of the rotating magnets. The magnets are mounted on the turbines so every move the turbine makes is the same movement of the turbines.

The coils are held into position by an insulation tape work which ensures they do not move. The arrangement of the coils are such that, they form a clock wise motion of current flow through each and every turbine.

3.1.3 The Armature Stand

To hold the entire structure in place during heavy wind loads. Guy cables/wires are for holding it to the place of application so that it remains stable during operation. A base of water resistant wood has been used which provides the basic support to the structure. The coils above are mounted on this board with super glue since they are to remain stationery.



3.1.4 The Rectification Unit

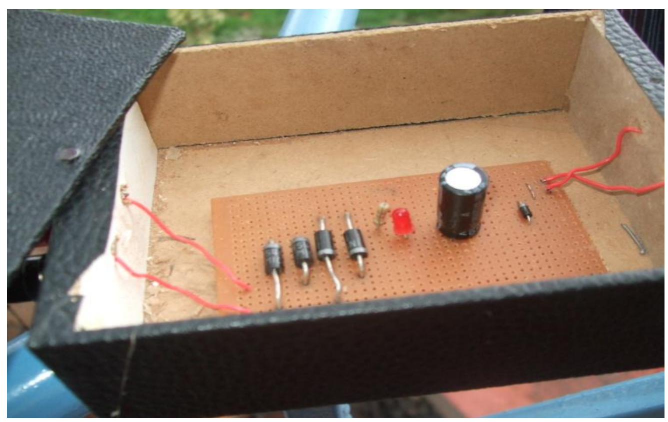


Figure 3.1.4: Images showing the various parts of the power rectification unit

The AC from the alternator cannot be stored in its very nature and has to be converted to a more suitable form of DC. Also the AC from the alternator will not be a perfect sine wave AC, very varying in nature depending on the wind speed. It has to be stabilized for storage. Output of this section will be DC.As with any other renewable energy source like solar, there has to be a means of storing the electrical energy for future use. DC energy can be stored to a 12V DC Sealed Lead Acid Accumulator. A diode will be connected to stop reverse current should the battery be fully charged. During heavy wind loads especially at night, and all batteries are fully charged, DC power can be tapped directly from the rectification section for direct loads such as lighting, mobile phone charging and FM receivers

Calculation of the Battery

When a battery is being charged, the emf of the cell act in apposition to the applied voltage. If V is the supply voltage which sends a charging current of I Against the back emf E_b then input is V_1 but the power spent in overcoming the opposition is E_b I

This power E_bI is converted into the chemical energy which stored in cell.

Thus

Input power = V_1

Power spent in overcoming the opposition of the back emf = E_bI

The charging current is given by

$$I = \frac{V-E_b}{R}$$

4.0. CHAPTER FOUR

4.1. TESTINGS AND RESULTS

ITEM	EXPECTED VALUES	ACTUAL VALUES
SEALED LEAD ACID ACC. (VOLTAGES)	**12V**	**12V**
WINDING RESISTANCE	**20 OHMS**	**28 OHMS**

OUTPUT VOLTAGE	**12V**	**<1V [NEGLIGIBLE]**
WIND SPEED	**12m/s**	**8m/s**
EFFICIENCY		

Reason for deviation

The output voltage at from the alternator deviated from the anticipated voltage due to the following reasons:

1. Lack of proper disc magnets, but a regular magnet was used and the output is as above.
2. Regular wind speed, wind speed during the day varies and the result is an insignificant current.

BUDGET

QTY	ITEM	**COST (KSH)**
1	23 Gauge Enameled Copper Wire(Spool)	Ksh. 1,500.00
4	Diodes	Ksh. 80.00
1	Capacitor	Ksh. 20.00
1	L.E.D (Light emitting diode)	Ksh. 15.00

4 Meters	Solder wire	Ksh. 80.00
1	Circuit board	Ksh. 35.00
N/A	Transport	Ksh. 1000.00
N/A	Report writing	Ksh. 1000.00
N/A	Research	Ksh. 2000.00
TOTAL		Ksh. 5,730.00

WORK PLAN/GANNT CHART

ACTIVITIES	IN YEAR 2011

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
Research		///////	///////		/////////	///////				
Proposal							//////	///		
Further research							///////	///////	///////	
Design							///////	///////		
Mounting and testing								////////	///////	
Presentation										///////

5.1. RECOMMEDATIONS

1. In the project I used a 28 Gauge copper wire; a 12 Gauge will produce a greater output as compared with the 28 Gauge.
2. The VAWT will produce more power if mounted at the top most position of the homestead in the rural communities which experience a lot of wind.

3. Maintenance of the unit should be done periodically i.e. monthly to check on joints and the copper windings.
4. Though I managed to get this far with the project, I would have done much more if I had more time to undertake it.

5.2. CONCLUSIONS

With the VAWT Project complete, I think that the rural communities have been given a chance to help reduce global carbon emissions and at the same time have a renewable source of energy for their domestic use. Mass production of the VAWT Project will enable communities to develop and hence reduce poverty in the long run.

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APPENDICES

Appendix A: Wind Speed Classification of the Beaufort Wind Scale

BF	v in m/s	Description	Effect
0	0-0.2	Calm	Smoke rises vertically
1	0.3-1.5	Light Air	Smoke moves slightly and shows direction of wind
2	1.6-3.3	Light Breeze	Wind can be felt. Leaves start to rustle
3	3.4-5.4	Gentle Breeze	Small branches start to sway. Wind extends light flags
4	5.5-7.9	Moderate Breeze	Larger branches sway. Loose dust on ground moves
5	8.0-10.7	Fresh Breeze	Small trees sway
6	10.8-13.8	Strong Breeze	Trees begin to bend, whistling in wires
7	13.9-17.1	Moderate Gale	Large trees sway
8	17.2-20.7	Fresh Gale	Twigs break from trees
9	20.8-24.4	Strong Gale	Branches break from trees, minor damage to buildings
10	24.5-28.4	Full Gale/Storm	Trees are uprooted
11	28.5-32.6	Violent Storm	Widespread damage
12	+32.7	Hurricane	Structural damage

Legend: BF Beaufort Fort; v: wind speed in m/s, 1m/s=3.6km/h

Figure A: Wind Speed Classification of the Beaufort Wind Scale

Appendix B: Conversions

Size Conversions

1 inch = 2.54 cm

1 cm = 0.39 inches

1 foot = 0.305 meters

1 meter = 3.28 feet

1 square foot = 0.093 square meters

1 square meter = 10.8 square feet

Speed Conversions

1 mph = 0.446 m/s = 1.61 kph

1 m/s = 2.24 mph = 3.60 kph

1 kph = 0.62 mph = 0.28 m/s

Appendix C: Glossary of Terms

Air Density: Mass per unit volume of air; air is less dense by roughly 3 percent for every 1,000 feet of elevation above sea level

Airfoil: A blade shaped to optimize the lift/drag ratio and to maximize the wind generator's energy production

Alternating Current (AC): Charge (electron) flow in two directions

Alternator: A rotating device that generates AC electricity by passing magnetism past coils of wire

Ammeter: A device that measures amperage

Ampacity: The maximum safe amperage-carrying capacity of wire or an electrical device

Amperage: The rate of charge flow in electrical circuits, measured in amperes, or amps (A); popularly called current

Amp-Hour (Ah): Unit of charge; used for specifying battery capacity

Anemometer: A device that measures wind speed

Annual Energy Output (AEO): The amount of energy in kilowatt-hours that a specific wind generator will produce at a specific average wind speed over a year average wind speed: The average of available wind in a set period, typically one year

Balance Of Systems (BOS): Wind-electric system components besides the wind generator and tower, typically including the charge controller, voltage clamp, batteries, inverter, disconnects, over current protection, grounding, and so on base: The concrete foundation that supports the steel structure of a wind generator tower

Battery: A group of electrochemical cells that store electrical energy via chemical reactions

Battery less Grid-Tied System: A wind-electric system that connects to the utility grid without batteries, providing no backup for utility outages

Betz Limit: The maximum percentage of wind energy (about 60 percent) that a perfect wind generator could capture

Blade: An airfoil designed for capturing wind energy

Blade Pitch Control: A method of governing that twists the orientation of the blades to degrade the airfoil and spill energy in high-wind conditions brake switch: A switch that allows the owner to electrically brake (stop the machine through short-circuiting the three phases) a wind generator

Breaker: A device to allow the disconnection of electrical devices; it also provides over current protection.

Conduit: Metal or plastic pipe to carry electrical wires

Cost of Energy (COE): Cost in cents per kilowatt-hour of electrical energy

Cube Law: Wind power is proportional to the cube of the wind speed (V × V × V, or V3)

Current: A common-language term for the rate of charge (electron) flow; also known as amperage

Cut-In: The wind speed at which a wind generator starts to generate, typically 5 to 9 mph, below which there is very little energy

Cut-Out: The wind speed at which a wind generator stops producing, typically not applicable with home-scale turbines, which may or may not continue generating in high winds (see also governing) depth of discharge (DOD): Level of battery discharge expressed in the percentage of charge removed; it's the inverse of state of charge digital multimeter (DMM): A device that measures voltage, amperage, resistance, and possibly other electrical qualities

Direct Current (DC): Flow of charge in one direction

Direct Drive: A type of wind turbine with blades connected directly to the generator, with no gears, pulleys, or belts

Disconnects: Mechanical means for disconnecting electrical devices from each other, such as loads on circuits from energy sources

Downwind: Describes a wind turbine with rotor (blades) on the lee or downwind side of the tower

D-Ring: A D-shaped attachment point on a climbing harness; typically there are two at the hip, two at the waist, one at the chest center, and one at the back center

Dump Load: An air or water heater that dissipates excess energy from a wind turbine, usually controlled by the charge controller

Efficiency: The ratio of energy out to energy in, expressed as a percentage

Energy: Work done over time; power (watts) × time (hours) = energy (watt-hours)

Energy Curve: A graphic presentation of the energy (watt-hours) produced by a wind generator in a range of specific average wind speeds.

Transmission: Wires used to transmit electricity from the wind generator to batteries, loads, and/or the grid

Upwind: Describes a wind turbine with rotor (blades) on the windward side of the tower utility interconnection equipment: Disconnects, meters, and wiring that connect the inverter to the utility grid, for the purpose of "selling" wind energy to the utility vertical-axis wind turbine (VAWT): A wind generator that spins on a vertical shaft, unlike most machines available today

Volt (V): The unit of electrical pressure

Watt (W): A unit of power (wattage), the rate of energy generation, transmission, or use

Watt-Hour (Wh): The unit of electrical energy

Wind Generator: A device for generating electricity using wind as the motive force; also called a wind turbine

Wind Rose: A graphic presentation of which directions a specific site's wind comes from

Wind Shear: The rate of increase in wind speed as you move away from the ground

Wound Field Alternator: An alternator that uses wound coils as electromagnets to produce the field magnetism

Yaw: The motion of a wind generator around the tower to face the wind

Yaw Bearing: The bearing (typically a ball bearing) that allows a wind generator to turn and face the wind