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Design and Development of a Mini-Wind Turbine Car Battery Charger Intergrated to an Automobile Alternator

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Abstract
Wind energy is one of the sources of energy which is found everywhere on earth and is one of the clean energies being used all over the world Shinichi ODA (2015). Many studies have been done to improve the efficiency of wind turbines. In future, wind energy will be one of the most important sources of energy which human beings will be relaying on instead of fossil fuel. This project aims at designing a miniature wind turbine charger circuit to be installed on an automobile and be capable of charging a 12V or 24V battery. The project also involves the design of the wind turbine to be attached on an automobile to harvest wind energy from the wind speed due to velocity of an automobile. The purpose of the project is to be able to produce power from a wind source without compromising the current electromechanical system or efficiency of the automobile. The designed wind turbine will contain an alternator which will be integrated to the existing battery charging system and will only kick-in through an automatic change over gear when there is a fault in the existing alternator.
The project is anticipated to help drivers in times of alternator failure, the system will kick-in to continue charging the battery and keep the engine running.

Keywords: Wind-Turbine, Alternator, Battery, Electromechanical Energy

1. Introduction

The continuous trend to use renewable and non-contaminant energy supplies for electricity generation is well under way in industrialized countries, mainly in Europe, where it reaches significant levels in several countries (such as Denmark and Spain), but it is not so significant in developing countries, where a high percentage of the world population is concentrated. Since the amount of energy used per capital in those countries is rather low, any improvement in their habitant's quality of live, (a highly desirable goal), will necessarily result in a big growth in the demand for traditional contaminant energy supplies, unless a change to renewable and non-contaminant energy supplies is started from now on. Machielse and H. Snel (2010).

There have been many reasons why the developing countries have not started to use renewable and non-contaminant energy supplies for electricity generation, the most important being the cost and the lack of technology adaptation. For this reason, this work presents the first stage of a modular electricity generation system development based on the use of wind, solar and thermal (from gas produced by biomass) energies, with a low output power level, addressed to small users, dispersed in rural areas (either in isolated farms or in small villages). This system uses car alternators as generating components, Chung-Neng Huang, (2009) [1]. This choice can look peculiar given the wide range of electric generators present in the market, but it is made because, at least in Latin America, the widespread use of cars and trucks in all regions means the existence of spare parts supplies and skilled technicians in many localities, while car alternators are locally manufactured in several countries. All this can be used to develop a technological network that will cope with the installation maintenance of the wind generators. Without this network, the introduction of these renewable and no contaminant energy systems will not be successful, as it has happened till now.

Given the number of different electric generators already offered in the market, at first glance it is not evident why a non-standard solution will be best for a low power wind turbine set. Nevertheless, car alternators are very rugged and both they and their spare parts are widely available in third world countries where other electric equipment is hard to find, or in any case, hard to repair. Hence the use of a car alternator as the generator in a wind turbine set for use in isolated third world locations is interesting, providing the other alternator characteristics are adequate for the application.

1.1 Motivation and significance of study

One of the major issues in this fast-moving world is to meet the demand of energy in the most economical and environmentally friendly way. This research works on designing a Vertical-axis wind turbines (VAWT) that gives a solution which is comparatively a cheap alternative of renewable energy that will be integrated to a car alternator to charge the battery. The mini wind turbine rotates with sufficient wind, causing it to generate electricity owing to magnetic coupling between the rotating and stationary coil. The work demonstrates a vertical rotating prototype of a mini turbine. The wind turbine can charge up to 12V to 24V battery. Advantage of this design is that it works without any consumption of fossil fuel and works efficiently in appropriate weather conditions without being closely monitored and the battery charges automatically without any harmful emissions or drawbacks. The work presented in this paper is an example of how natural resources like wind energy can be used efficiently to produce electricity.

1.2 Scope of study

A prototype system consisting of a mini wind turbine, rectifier, changeover switch and regulator. The entire system will now be designed and mounted on the car which will be integrated to the alternator.

1.3 Problem Statement

The alternator is a generator whose purpose is to distribute electricity to the car and recharge the battery. About the size of a coconut, the alternator is generally mounted to the front of the engine and has a belt running around it. Before the battery can use the power coming from the alternator, it needs to be converted to a format that the battery can use E.M. Farahani, (2012). That's because electricity can flow in different currents, or directions. Car batteries operate one-way direct current (DC) electricity, while alternators output alternating current (AC) electricity, which occasionally flows in reverse. So, prior to going to the voltage regulator, power intended for the battery goes through a diode rectifier to turn into DC. After the conversion, the battery can use the power to recharge. The alternator is able to generate this power by converting the vehicle's mechanical energy into electrical energy. If the alternator malfunctions, then the vehicle's electrical components would need to depend on the battery for power. Unfortunately, the battery is not powerful enough to provide the proper amount of electricity that these components need. The car may run for a couple of minutes before the power dies and in other instances a battery dies. To prevent such, a wind turbine battery charger will be designed and developed and integrated in the charging system of a car to work automatically when the alternator malfunction Vijaya Krishna and Teja Bangi (2017) [9].

1.4 Main Objective

The main objective of this research is to design and develop a mini-wind turbine car battery charger integrated to an automobile alternator.

1.4.1 Specific Objective

1. To design a wind turbine circuit.
2. To design the battery charger circuit.
3. To assemble the wind turbine circuit and the battery charger circuit.

1.5 Research Questions

1. How to design a wind turbine circuit?
2. How to design a battery charger circuit?
3. How to integrate the wind turbine circuit and the battery charger circuit?

1.6 Organization of the thesis

This thesis has five chapters that include:

Chapter One: discusses introduction, Motivation and significance of study, scope of study, problem statement, objectives and Organization of the thesis.

Chapter Two: discusses introduction, review of literature and related works.

Chapter Three: discusses introduction, Methodology and system components and summary.

Chapter Four: discusses introduction, results, operation, and summary.

Chapter Five has the conclusions and recommendations, references and appendix.

1.7 Summary

This chapter highlights the motivation and significance, scope of the project, problem statement and also includes the main objectives.

2. Literature Review

2.1 Introduction

With the population explosion, exploitation of natural resources is heading towards its peak. Some projections indicate that the global energy demand will almost triple by 2050 and oil can only supply the world for up to 150 years (Eltamaly, 2005). Keeping these facts in mind, science has started emphasizing upon sustainable development and has come up with advanced methods of energy conservation. Development on different technologies for utilization of renewable resources of energy has been seen with great progress and these technologies are also being implemented in almost all sectors. Whether it is power generation by hydro projects or use of large-scale solar panels, these technologies are being used at an extensive scale. Today, with the advancement of technology in the automobile sector, a large range of automobiles are being produced which run on fuel and battery called hybrid automobiles. Additionally, electric car which runs on battery only has been developed and is on world market. Wind energy is one of the main sources of energy these days. It is a part of the clean and renewable energy that we use in our lives. In some areas in the world, there are huge wind activities that should be utilized to produce energy. Great research has been conducted to improve the efficiency of wind turbine. In future, wind energy will be one of the most important sources which human beings will be relaying on instead of fossil fuel energy. This project aims at designing a miniature wind turbine car battery charger to be installed in front of an automobile and will be capable of charging a battery (12 V). This project involves the design and development of the wind turbine to be attached in front of an automobile to benefit from the harvest power from the wind speed due to movements of an automobile and later sent to the battery in instances where the alternator malfunctions.

2.2 Review of literature

2.2.1 Wind Turbine

A wind turbine is a device that converts the wind's kinetic energy into electrical energy. This device taps the energy of the wind by means of sails mounted on a rotating shaft. The sails are mounted at an angle or are given a slight twist so that the force of wind against them is divided into two components, one of which, in the plane of the sails, imparts rotation. Like waterwheels, windmills were among the original prime movers that replaced human beings as a source of power.

The use of windmills was increasingly widespread in Europe from the 12th century until the early 19th century. Their slow decline, because of the development of steam power, lasted for a further 100 years. Their rapid demise began following World War I with the development of the internal-combustion engine and the spread of electric power; from that time on, however, electrical generation by wind power has served as the subject of more and more experiments.

2.2.2 History of Wind turbines

The windwheel of Hero of Alexandria (10 AD – 70 AD) marks one of the first recorded instances of wind powering a machine in history. However, the first known practical wind power plants were built in Sistan, an Eastern province of Persia (now Iran), from the 7th century. These "Panemone" were vertical axle windmills, which had long vertical drive shafts with rectangular blades. Made of six to twelve sails covered in reed matting or cloth material, these windmills were used to grind grain or draw up water and were used in the grist milling and sugarcane industries.

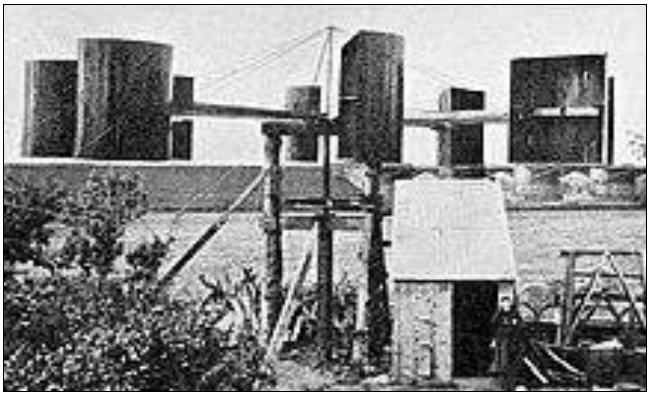

Fig 2.1.1: James Blyth's electricity-generating wind turbine

Wind power first appeared in Europe during the Middle Ages. The first historical records of their use in England date to the 11th or 12th centuries, there are reports of German crusaders taking their windmill-making skills to Syria around 1190. By the 14th century, Dutch windmills were in use to drain areas of the Rhine delta. Advanced wind turbines were described by Croatian inventor Fausto Veranzio. In his book Machine Novae (1595) he described vertical axis wind turbines with curved or V-shaped blades.

The first known wind turbine used to produce electricity was built in Scotland. The wind turbine is created by Prof James Blyth of Anderson's College, Glasgow (now known as Strathclyde University). "Blyth's 10 m high, cloth-sailed wind turbine was installed in the garden of his holiday cottage at Marykirk in Kincardineshire and was used to charge accumulators developed by the Frenchman Camille Alphonse Faure, to power the lighting in the cottage, thus making it the first house in the world to have its electricity supplied by wind power. Blyth offered the surplus electricity to the people of Marykirk for lighting the main street.

Some months later American inventor Charles F. Brush was able to build the first automatically operated wind turbine after consulting local University professors and colleagues Jacob S. Gibbs and Brinsley Coleberd and successfully getting the blueprints peer-reviewed for electricity production in Cleveland, Ohio. Although Blyth's turbine was considered uneconomical in the United Kingdom, electricity generation by wind turbines was more cost effective in countries with widely scattered populations, Sampath S, (2018).

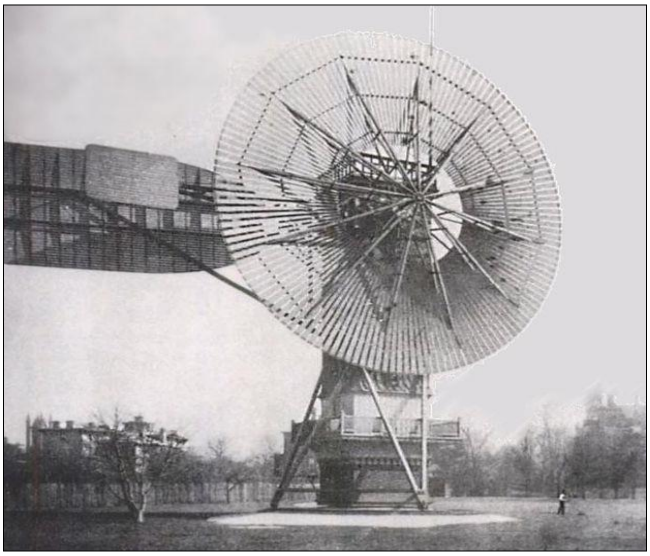

Fig 2.1.2: The first known US wind turbine.

In Denmark by 1900, there were about 2500 windmills for mechanical loads such as pumps and mills, producing an estimated combined peak power of about 30 MW. The largest machines were on 24-meter (79 ft) towers with four-bladed 23-meter (75 ft) diameter rotors. By 1908, there were 72 wind-driven electric generators operating in the United States from 5 kW to 25 kW. Around the time of World War I, American windmill makers were producing 100,000 farm windmills each year, mostly for water-pumping. By the 1930s, wind generators for electricity were common on farms, mostly in the United States where distribution systems had not yet been installed. In this period, high-tensile steel was cheap, and the generators were placed atop prefabricated open steel lattice towers, Sampath S, (2018).

A forerunner of modern horizontal-axis wind generators was in service at Yalta, USSR in 1931. This was a 100-kW generator on a 30-meter (98 ft) tower, connected to the local 6.3 kV distribution system. It was reported to have an annual capacity factor of 32 percent, not much different from current wind machines. In the autumn of 1941, the first megawatt-class wind turbine was synchronized to a utility grid in Vermont. The Smith– Putnam wind turbine only ran for 1,100 hours before suffering a critical failure. The unit was not repaired, because of a shortage of materials during the war. The first utility grid connected wind turbine to operate in the UK was built by John Brown & Company in 1951 in the Orkney Islands.

According to M. Zahir Hussain and R. Anbalagana, (2015), despite these diverse developments, developments in fossil fuel systems almost entirely eliminated any wind turbine systems larger than supermicro size. In the early 1970s, however, anti-nuclear protests in Denmark spurred artisan mechanics to develop microturbines of 22 kW. Organizing owners into associations and co-operatives led to the lobbying of the government and utilities and provided incentives for larger turbines throughout the 1980s and later. Local activists in Germany, nascent turbine manufacturers in Spain, and large investors in the United States in the early 1990s then lobbied for policies that stimulated the industry in those countries.

It has been argued that expanding use of wind power will lead to increasing geopolitical competition over critical materials for wind turbines such as rare earth elements neodymium, praseodymium, and dysprosium. But this perspective has been criticized for failing to recognize that most wind turbines do not use permanent magnets and for underestimating the power of economic incentives for expanded production of these minerals.

2.3 Basic Principles of Wind Energy Conversion

2.3.1 The Nature of the Wind

The circulation of air in the atmosphere is caused by the non-uniform heating of the earth's surface by the sun. The air immediately above a warm area expands; it is forced upwards by cool, denser air which flows in from surrounding areas causing a wind. The nature of the terrain, the degree of cloud cover and the angle of the sun in the sky are all factors which influence this process. In general, during the day the air above the land mass tends to heat up more rapidly than the air over water. In coastal regions this manifests itself in a strong onshore wind. At night the process is reversed because the air cools down more rapidly over the land and the breeze therefore blows offshore.

The main planetary winds are caused in much the same way: Cool surface air sweeps down from the poles forcing the warm air over the topics to rise. But the direction of these massive air movements is affected by the rotation of the earth and the net pressure areas in the countries-clockwise circulation of air around low-pressure areas in the northern hemisphere, and clockwise circulation in the southern hemisphere. The strength and direction of these planetary winds change with the seasons as the solar input varies.

Despite the wind's intermittent nature, wind patterns at any particular site remain remarkably constant year by year. Average wind speeds are greater in hilly and coastal areas than inland. The winds also tend to blow more consistently and with greater strength over the surface of the water where there is a less surface drag.

Wind speeds increase with height. They have traditionally been measured at a standard height of ten meters where they are found to be 20-25% greater than close to the surface. At a height of 60m they may be 30-60% higher because of the reduction in the drag effect of the earth's surface.

2.3.2 The Power in the Wind

Wind possesses energy by virtue of its motion. Any device capable of slowing down the mass of moving air, like a sail or propeller, can extract part of the energy and convert is into useful work. Three factors determine the output from a wind energy converter:

- The wind speed.
- The cross-section of wind swept by rotor; and
- The overall conversion efficiency of the rotor, transmission system and generator or pump.

No device, however well designed, can extract all of the wind's energy because the wind would have to be brought to a halt, and this would prevent the passage of more air through the rotor. The most that is possible is for the rotor to decelerate the whole horizontal column of intercepted air to about one-third of its free velocity. A 100% efficient aero generator would therefore only be able to convert up to a maximum of around 60% of the available energy in wind into mechanical energy. Well-designed blades will typically extract 70% of the theoretical maximum, but losses incurred in the gearbox, transmission system and generator or pump could decrease overall wind turbine efficiency to 35% or loss. The Power in the wind can be computed by using the concept of kinetics.

The wind mill works on the principle of converting kinetic energy of the wind to mechanical energy. We know that power is equal to energy per unit time. The energy available is the kinetic energy of the wind. The kinetic energy of any particle is equal to one half its mass times the square of its velocity, or $1/2m\ V^2$. The amount of air passing in unit time, through an area A, with velocity V, is AV, and its mass m is equal to its volume multiplied by its density ρ of air, or:

$$m=\rho AV$$

(m is the mass of air transverse the area A swept by the rotating blades of a windmill type generator).

Substituting this value of the mass in the expression for the kinetic energy, we obtain,

$$\text{kinetic energy} = 1/2\ \rho AV.V^2 \text{ watts.}$$

$$=1/2\ \rho AV^3 \text{ watts}$$

The equation tells us that the maximum wind available the actual amount will be somewhat less because all the available energy is not extractable-is proportional to the cube of the wind speed. It is thus evident that small increase in wind speed can have a marked effect on the power in the wind.

Equation also tells us that the power available is proportional to air density 1.225 kg/m^3 at sea level). It may vary 10-15 percent during the year because of pressure and temperature change. It changes negligibly with water content. Equation also tells us that the wind power is proportional to the intercept area. Thus, an aero turbine with a large swept area has higher power than a smaller area machine; but there are added implications. Since the area is normally circular of diameter D in horizontal axis aero turbines, then $A = \pi/4\ D^2$, (sq.m), which when put in equation gives,

$$\text{Available wind power } P\alpha = ½\ \rho\pi /4\ D^2V^3 \text{ watts}$$

$$= 1/8\ \rho\pi\ D^2V^3$$

The power extracted by the rotor is equal to the product of the wind speed as it passes through the rotor (i.e., V_r) and the pressure drop Δp in order to maximize the rotor power, it would therefore be desirable to have both wind speed and

pressure drop as large as possible. However, as V is increased for a given value of the free wind speed (and air density), increases at first, passes through a maximum, and then decreases. Hence for the specified free-wind speed, there is a maximum value of the rotor power.
The faction of the free-flow wind power that can be extracted by a rotor is called the power-coefficient; thus

Power coefficient = Power of wind rotor/Power available in the wind

Where power available is calculated from the air density, rotor diameter, and free wind speed as shown above. The maximum theoretical power coefficient is equal to 16/27 or 0.593. This value cannot be exceeded by a rotor in a free-flow wind-stream.

2.3.3 Maximum Power

The total power cannot be converted to mechanical power. Consider a horizontal-axis, propeller-type windmill, henceforth to be called a wind turbine, which is the most common type used today. Assume that the wheel of such a turbine has thickness αb. Let p_i and V_i are the wind pressure and velocity at the upstream of the turbine. V_e is less than V_i because the turbine extracts kinetic energy.
Considering the incoming air between I and a as a thermodynamic system, and assuming that the air density remains constant (since changes in pressure and temperature are very small compared to ambient), that the potential energy is zero, and no heat or work are added or removed between i and a, the general energy equation reduces to the kinetic and flow energy-terms only:

2.3.4 Wind Energy Conversion

Traditional windmills were used extensively in the Middle Ages to mill grain and lift water for land drainage and watering cattle. Wind energy converters are still used for these purposes today in some parts of the world, but the main focus of attention now lies with their use to generate electricity. There is also growing interest in generating heat from the wind for space and water heating and for glasshouses, but the potential market is much smaller than for electricity generation.
The term "windmill" is still widely used to describe wind energy conversion systems; however, it is hardly adopted. Description anymore. Modern wind energy conversion systems are more correctly referred to as 'WECS', aero generations', 'wind turbine generators', or simply "wind turbines". The fact that the wind is variable and intermittent source of energy is immaterial of some applications such as pumping water for land drainage – provided, of course, that there is a broad match between the energy supplied over any critical period and the energy required. If the wind blows, the job gets done; if it does not, the job waits.
However, for many of the uses to which electricity is put, the interruption of supply may be highly inconvenient. Operators or users of wind turbines must ensure that there is some form of back-up to cover periods when there is insufficient (or too much) wind available. For small producers, back-up can take the form of:

- Battery storage,
- Connection with the local electricity distribution system; or

For utilities responsible for public supply, the integration of medium – sized and large wind turbines into their distribution network could require some additional plant which is capable of responding quickly to meet fluctuating demand.

2.4 Recharging System Layout

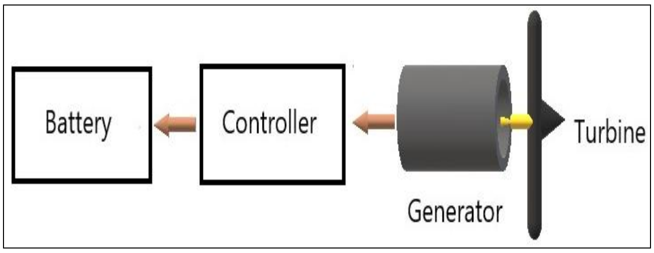

Fig 2.5.1: Layout of recharging system

Electric vehicles are gaining momentum, but one issue remains, range anxiety. This is where our proposed project comes in. With the help of a wind turbine, we plan on recharging the battery, and this therefore can add few additional kilometers to the range.
The Turbine is mounted on the front side of the vehicle. This is coupled to a generator. The generator does the work of converting wind energy into electrical energy. A 12v stepper motor will be used as the generator, controllers will be used to regulate the output from the motor. An Arduino UNO is used here to read the output voltage and helps in displaying the same. Hence, additional kilometers have been added by recharging the battery by the help of wind. The wind power can be determined by Aleksandar Hrnjak, (2014).

$$P_{Wind} = \frac{\rho \cdot A \cdot V_{WIND}^3}{2} \text{ - Wind power}$$

The wind speed is always less than vehicle speed and it is reduced by the system efficiency factor. The system efficiency factor is related to vehicle geometry, outside vehicle surfaces, turbine position relative to vehicle.

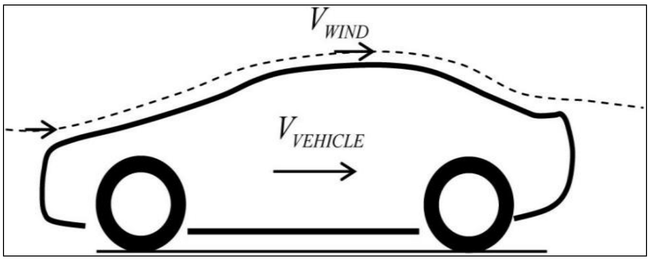

Fig 2.5.2: Air flow over the vehicle

$$V_{WIND} = V_{VEHICLE} \cdot \eta$$

η = 0.6-0.8 - System efficiency
Generated power can be determinate by'

$$P = \frac{\rho \cdot A \cdot (V_{VEHICLE} \cdot \eta)^3}{2}$$

3. Methodology

3.1 Introduction

Here we will have an overview of the components and methods used to achieve the implementation of the project. The success of the project is based on the integration of different hardware and other components such as batteries, power supplies, resistors, have been integrated to create a system. The project will be achieved in three stages that is

- Design and calculations.
- Fabrication
- And testing

3.2 Design Circuit

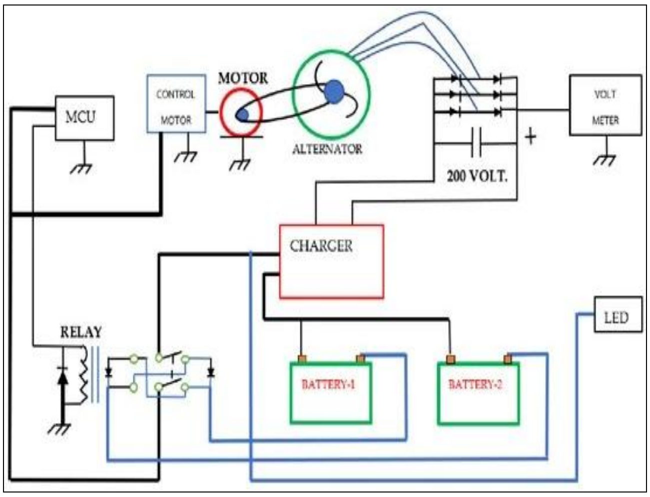

Fig 3.1: Show the main circuit system

3.3 Design and Calculations

3.3.1 Mathematical Modelling

$\rho - Air\ density$ (1.23 kg/m^3)
$A - Area\ of\ sweep$ (m^2)
$V - Wind\ speed$ (m/s)
$Cp - Coefficient\ of\ performance$ (max $value$ 0.59)

For PVC Blade which has a length of 0.205m:

$\rho - 1.23\ kg/m^3$

$A - \pi r^2$ *(r= 0.205m)*

$V - 12\ m/s$

$Cp - 0.4$

Calculations for PVC Blade

$$Pm = \frac{1}{2}\rho AV^3Cp$$

$$= \frac{1}{2} \times 1.23 \times \pi r^2 \times (12^3) \times 0.4$$

$$= \frac{1}{2} \times 1.23 \times 3.14(0.205^2) \times (12^3) \times 0.4$$

$$= \frac{1}{2} \times 1.23 \times 3.14(0.0420) \times (1728) \times 0.4$$

$$= \frac{1}{2} \times 1.23 \times 0.1319 \times (1728) \times 0.4$$

Pm =**56.7 W**

3.3.2 Fabrication of Controller

- The control unit was designed in such way that, when the generator starts to rotate the electricity generated from it should be able to recharge the battery.
- A display is kept to show the voltage produced at real time.
- Circuit diagram is given for proper understanding of connections.

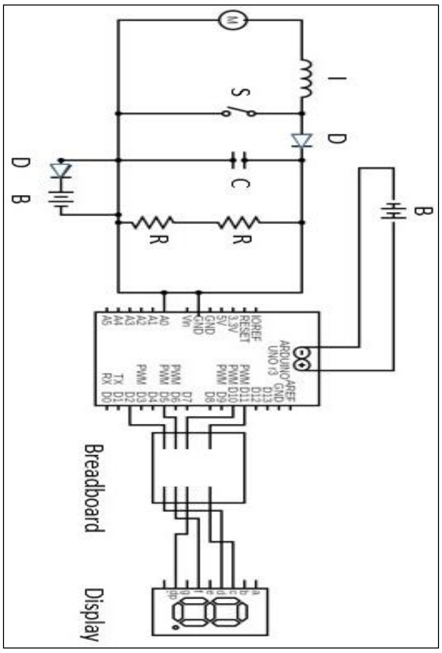

Fig 3.28: Circuit Diagram

- Arduino UNO is used here to process the voltage received and send the information to the display unit.

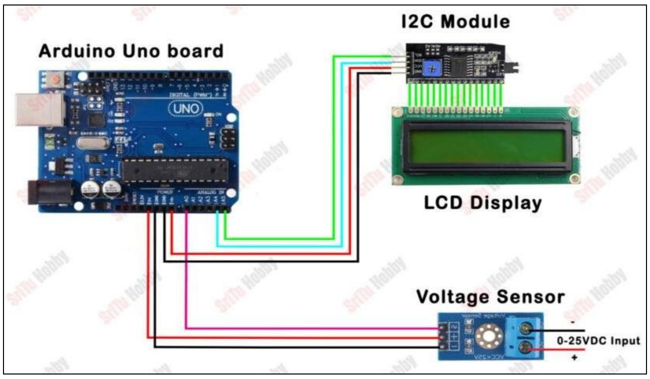

Fig 3.29: Arduino UNO connection

- First, connect the power source whose voltage you want to measure with the input pins of the voltage sensor module.
- This is done by connecting the ground pin of the voltage sensor to the negative terminal of the battery and the positive power supply pin i.e, VCC to the positive terminal of the battery.
- Screw the wires tightly.
- Connect the analog pin S to any of the input analog pins of the Arduino UNO.
- Similarly, connect the -(minus) pin to the ground pin of the Arduino.
- The Arduino code for Voltage Sensor module is provided below:

4. Results Analysis
4.1 Introduction
4.2 Testing Procedure
To test how much voltage each type of blade can produce, an external source of wind was needed. A table fan was kept in front of the project to depict this external wind source. With the help of a non-contact digital Tachometer, the rpm of blades was noted. At different rpm the voltage produced was also noted down.

4.2.1 PVC Blade

Fig 4.1.1: Testing of PVC Blade

4.2.2 Pedestal Fan Blade

Fig 4.1.2: Testing of Pedestal Fan blade

4.2.3 Hard PVC Blade

Fig 4.1.3: Testing of Hard PVC Blade

5. Conclussion and Recommendation
5.1 Introduction
This chapter discusses the conclusions and recommendations coming out of this project.

It also proposes future research on the integration of a mini wind turbine on an electric automobile.

5.2 Conclusion
Design of Battery recharging system using wind turbine for Automotive application has been fabricated. Using Autodesk Fusion 360 the 2D sketches and the 3D model of blades and the frame were made. Based on the sketches and 3D model the fabrication was done. Testing was done to find out the voltage given out by each blade. An external source of wind was provided for the testing and a non-contact digital tachometer is used to note down the speed in rpm.

Hard PVC blade design was found out to be effective by producing the highest voltage of 18.87v at 800rpm among the other two designs, but the Pedestal fan blade produced 16.02v at 602 rpm and PVC blade design produced 13.02v at 530rpm.

To conclude, with the help of this innovation the batteries of the vehicle can be recharged on the run and can provide a few extra kilometers which could prove to be useful, hence adding more range to the vehicle.

5.3 Recommendations
In the proposed project work a mobile battery charger has been investigated with a charging unit for automobile industry. The hardware realization as an external unit may bring a new technology to utilize renewable sources and can replace petrol / diesel driven automobile completely. Further integration of the system directly with the converter unit driving the wheel not only will save the cost but reduce the extra weight added to automobile and thus will be able to increase efficiency.

6. References

1. Chung-Neng Huang, Guohong Wu, Longyun Kang. Design of Auxiliary Generation System by Wind Power for Improving Vehicular Efficiency. IEEE, 2009.
2. Hassan Fathabadi. Possibility of Utilizing Wind Turbine to Recover a Portion of the Kinetic Energy Losses of a Car. IEEE Transactions on Vehicular Technology, 2010.
3. Bao YJ, Cheng KWE, Cheung NC, Ho SL. Experimental examination on a new switched reluctance wind power generator system for electric vehicles. International Engineering and Technology Journals, 2012.
4. Becker T. Electric Vehicles in the United States: A New Model with Forecaststo 2030 Center for Entrepreneurship & Technology, August 24, 2009. Retrieved from: hAp://cet.berkeley.edu/dl/CET_Technical%20Brief_EconomicModel203
5. Zhihao LI, Alireza Khaligh. An Integrated Parallel Synchronous Rectifier and Bi-directional Dc/Dc Converter System for Solar and Wind Powered Hybrid Electric Vehicle. IEEE, 2015.
6. Shinichi ODA, Yutaka HASEGAWA, Hiroki SUZUKI, Tatsuo USHIJIMA, Hideki OOYA. Research of electric power regeneration using automotive cooling fan (Influence of wind turbine on air resistance through vehicle cooling system. Transactions of the JSME (in Japanese), 2015.
7. Shinichi ODA, Yutaka HASEGAWA, Hiroki SUZUKI, Tatsuo USHIJIMA. Research of electric power regeneration using automotive cooling fan (Improvement of wind turbine efficiency by high solidity rotor, Transactions of the JSME (in Japanese), 2015.
8. Bhagyashree R Wadhai, Asmita S Nagrare, Manjushree D Kamble, Trupti J Durge, Vivek S Narnaware. Solar and Wind Powered Hybrid Vehicle Prototype. IJSDR, 2016.
9. Vijaya Krishna Teja Bangi, Yogendra Chaudhary, Ramesh K Guduru, Kendrick T Aung, Reddy GN. Preliminary Investigation on Generation of Electricity

Using Micro Wind Turbines Placed on a Car. Int. Journal of Renewable Energy Development (IJRED), 2017.
10. Bharathi1 S, Saravanan, Saravanan A, Sam Suresh. A Method for Generating Electricity by Fast Moving Vehicles A Renewable Energy Approach. Trans Tech Publications Journals, 2018.
11. Adil Hashim S, Mohammed Ansar KA, Mohammed Hafeez, Muhammed Jasim Saleem, Chithirai Pon Selvan. Design and Fabrication of Wind Powered Vehicle. Global Journal of Advanced Engineering Technologies, 2018.
12. Pudji Irasari. Experiment and Analysis of Car Alternator for Wind Turbine Application. Journal of Mechatronics, Electrical Power, and Vehicular Technology, 2011.
13. Feng-Tsai Weng, Yao-Xian Huang. An investigation of vehicle wind turbine system. International Journal of Energy Optimization and Engineering, 2018.
14. Md Rabiul Awal, Muzammil Jusoh, Md Nazmus Sakib, Fakir Sharif Hossain, Mohd Rashidi Che Beson, Syed Alwee Aljunid. Design and Implementation of Vehicle Mounted Wind Turbine. IOSR Journal of Mechanical and Civil Engineering, 2015.
15. Boorsma KL, Machielse AH, Snel H. Performance Analysis of a Shrouded Rotor for a Wind Powered Vehicle. Int. Journal of Renewable Energy Development (IJRED), 2010.
16. Ahmad Atieh, Samir Al Shariff. Hybrid Wind/Electric Powered Vehicle. International Journal of Energy Optimization and Engineering, 2015
17. Dare1 AA, Uguru-Okorie DC, Adegbola AA. Vehicular Wind Energy Converter (VWEC): A Solution to Sustainable Charging for Electric Vehicles. IOSR Journal of Mechanical and Civil Engineering, 2012.