Wind Powered Cars

Submitted in partial fulfillment of the requirements for the degree of

Bachelor of Technology

in

Electrical and Electronics Engineering

by

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April,2023

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We here by declare that the thesis entitled "**Wind Powered Cars"** submitted by us, for the award of the degree of *Bachelor of Technology in Electrical and Electronics Engineering* to VIT University is a record of bonafide work carried out by us under the supervision of **Dr. KOWSALYA M**, Professor Higher Academic Grade, SELECT, VIT University, Vellore.

We further declare that the work reported in this thesis has not been submitted and will not be submitted, either in part or in full, for the award of any other degree or diploma in this institute or any other institute or university.

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This is to certify that the thesis entitled “**Wind Powered Cars”** submitted by **Aditya Aspat(19BEE0002), Hamraaz Singh Khurana(19BEE0311), Sushant Pal(19BEE0317)**, SELECT , VIT, Vellore, for the award of the degree of *Bachelor of Technology in Electrical and Electronics Engineering* , is a record of bonafide work carried out by them under my supervision during the period, xx.xx.2022 to xx.xx.2023,, as per the VIT code of academic and research ethics.

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(Dr. Guide Name)

Internal Examiner

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Programme

Acknowledgement

With immense pleasure and deep sense of gratitude, We wish to express our sincere thanks to our supervisor **Dr. KOWSALYA M** , Professor Higher Academic Grade, SELECT, VIT University, without her motivation and continuous encouragement, this project work would not have been successfully completed.

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Executive Summary

This project answers the problem of wind powered cars and details about the power and energy generated by the turbines as a whole. The aerodynamic drag experienced by the car is used to rotate the blade of the turbines and thus generate electricity.

The placement of turbine and wind profile was measured and accordingly fed to the simulation.The turbines and motors are added in such a way that they are able to charge the battery of an electric vehicle with the help of various converters and inverters.

It tells us about the practicality and real world simulation done by us on MATLAB Simscape where the outputs and devices are studied and tested for practical applications. The results of the simulations helped us compare with the existing renewable energy sourced EVs and how practical wind power is as compared to solar power.

To back this software simulation we have implemented the hardware ourselves using smaller equipment to check the results of our simulations.

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CHAPTER 1

INTRODUCTION

1.1 Objective

Our project, wind-powered cars, aims to develop a car that relies on wind energy as its main source of propulsion rather than conventional fuels like petrol or diesel. Reducing reliance on fossil fuels and developing more ecologically friendly and sustainable transportation options are the objectives.

Wind energy is used to produce electricity that can run an electric motor or recharge a battery in wind-powered vehicles. While some wind-powered automobile designs employ turbines to produce electricity from the wind, others use big sails that collect the wind and use it to move the vehicle forward. The practicality, feasibility and value of this project is then studied using software and hardware simulation.

1.2 Motivation

Numerous studies are made to extend the range of an EV by renewable sources like Solar Power. There have been commercial EVs released by various companies which harness solar energy with the help of panels located on the body. The previous models of wind powered cars have been a little bizarre and impractical in modern day scenario and the study on the everflowing wind dynamics has been very limited, and thus this motivated us on how we could be the pioneers to study the wind characteristics and help in reducing the range anxiety in modern EVs.

1.3 Background

The transportation sector is a significant contributor to global greenhouse gas emissions, and reducing these emissions is crucial to mitigate the impact of climate change. One potential solution to this problem is the use of renewable energy sources to power vehicles. Among the renewable energy sources, wind power is a promising option due to its abundance and widespread availability.

Wind-powered cars, which use wind energy to propel the vehicle instead of relying on fossil fuels, have been proposed as a sustainable alternative to traditional cars. The concept of wind-powered cars is not new, and several attempts have been made in the past to develop these vehicles. However, the main challenge in designing wind-powered cars is to harness the wind's energy effectively and convert it into electrical energy to charge its battery.

In recent years, advances in technology have made it possible to design more efficient wind turbines and lightweight materials, making wind-powered cars more feasible. Several studies have explored the potential of wind-powered cars, and many have shown promising results. For instance, adding wind turbines to cars could improve their fuel efficiency by up to 10

Despite the encouraging findings, several academics are dubious about the viability of wind-powered vehicles. They contend it would be difficult to develop an automobile that could successfully capture wind power since it is unpredictable and fluctuating. Therefore, further study is required to examine the potential of wind-powered vehicles and create workable ways to efficiently harvest wind energy.

In this research paper, we will investigate the feasibility of wind-powered cars as an alternative to traditional EVs. We will review the current research on wind-powered cars, including their design, performance, and challenges. Additionally, we will explore the type of design which will prove to be useful for maximum efficiency. Overall, this research paper aims to contribute to the ongoing discussion on wind powered cars.

CHAPTER 2

PROJECT DESCRIPTION AND GOALS

2.1 Review of Literature

The transportation sector is a significant contributor to global greenhouse gas emissions, and reducing these emissions is crucial to mitigate the impact of climate change. One potential solution to this problem is the use of wind-powered cars, which can use the wind's energy to move instead of relying on fossil fuels. In this literature review, we will explore the current research on wind-powered cars and their feasibility as an alternative to traditional cars.

The concept of wind-powered cars is not new, and several attempts have been made in the past to develop these vehicles. However, the main challenge in designing wind-powered cars is to harness the wind's energy effectively and convert it into mechanical energy to propel the car. In recent years, advances in technology have made it possible to design more efficient wind turbines and lightweight materials, making wind-powered cars more feasible.

[1]One of the earliest studies on wind-powered cars was conducted by Botez et al. (2013), who developed a small-scale wind-powered car using a 3-bladed wind turbine. They found that the car was capable of achieving a maximum speed of 30 km/h with a wind speed of 8 m/s.

[2]Another study by Adhikari and Prasad (2016) investigated the feasibility of using wind energy to power a small electric car. They developed a simulation model to analyze the energy requirements and estimated that a wind turbine with a diameter of 1.5 m could provide enough energy to power the car at speeds up to 60 km/h.

[3]In a more recent study, Singh and Singh (2020) developed a wind-assisted hybrid electric car that combined the use of wind energy with a conventional electric motor. They found that the car was able to travel up to 10 percent further on the same amount of energy when the wind was blowing at speeds of 15-20 km/h.

[4]Another approach to wind-powered cars has been to use the wind to generate electricity to power an electric vehicle. In a study by Arsalis and Bakirtzis (2015), a small-scale wind turbine was used to charge the batteries of an electric car. They found that the wind turbine was capable of providing up to 2 kW of power, which was

sufficient to charge the car's batteries in a reasonable amount of time.

[5]Similarly, Gupta and Verma (2017) investigated the use of a vertical-axis wind turbine to generate electricity for a small electric car. They found that the wind turbine was capable of generating enough power to charge the car's batteries, and that the car was able to travel up to 20 km on a single charge.

[6]Finally, a study by Amini et al. (2018) investigated the feasibility of using a large-scale wind turbine to power an electric car. They found that a 3 MW wind turbine could generate enough power to charge the batteries of an electric car, and that the car would be capable of traveling up to 450 km on a single charge.

[7]Another study by Bell et al. (2018) explored the use of vertical-axis wind turbines (VAWTs) to power cars. The researchers designed a VAWT that could be mounted on the roof of a car and tested it in a wind tunnel. They found that the VAWT was able to generate enough power to supplement the car's power needs and improve its efficiency.

[8]However, some researchers have expressed skepticism about the feasibility of wind-powered cars. A study by Kreider and Curtiss (2018) argued that wind-powered cars would be impractical due to the limitations of wind power. The researchers argued that wind power is unreliable and variable, and it would be challenging to design a car that could effectively harness its energy.

Overall, the research on wind-powered cars is mixed, with some studies showing promising results and others expressing skepticism. While there are challenges to designing efficient wind-powered cars, advances in technology have made them more feasible than ever before. Further research is needed to explore the potential of wind-powered cars and develop practical solutions to harness the wind's energy effectively. However, it is clear that wind-powered cars have the potential to be a sustainable alternative to traditional cars and reduce greenhouse gas emissions in the transportation sector.

2.2 Project Description

This project consists of a software simulation of 3 turbines placed in the effect of wind profile which are used to generate electricity and thus help us to recharge the battery of an EV.

The software simulation tells us about the voltage and current characteristics of the output. The simulation is done in such a way that all devices used are accurate in practicality with real and calculated values for all resistors,inductors and capacitors. The wind turbine outputs are fed to a DC-DC converter which boosts up the voltage to be fed to the battery of an EV, the battery output which is DC is then converted into 3 phase AC voltage by the help of an inverter and fed into a BLDC motor and the RPM is generated.

The output of the simulation is compared to the hardware that we have made on a smaller scale which consists of 5 smaller turbines placed on the roof of a car and the voltage and current was measured. Thus, the feasibility and practicality of wind powered cars was researched and studied with the help of the outputs of both software and hardware simulation.

2.3 Block Diagram

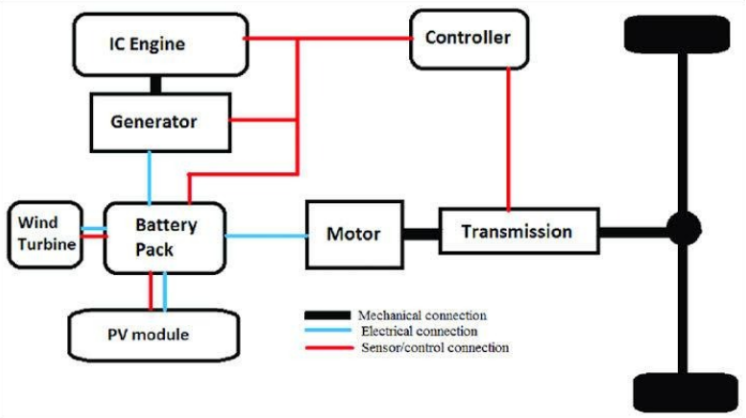


Fig. 2.1 Block Diagram

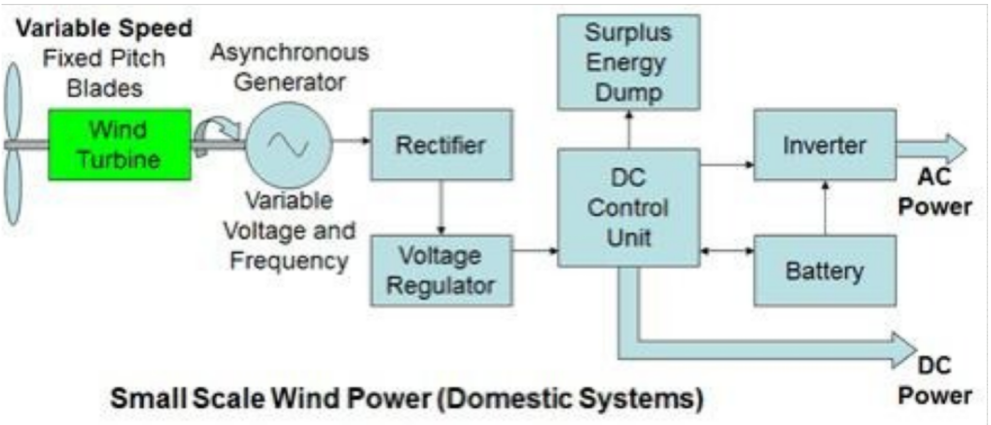


Fig. 2.2 Small scale wind power(Domestic Systems)

2.3.1 Software

Simulations done on MATLAB Simulink 2022(b) Matlab Simulink is an effective tool for modeling and simulating dynamic systems. The use of block diagrams, it enables engineers and scientists to create models of physical systems and simulate their behavior under various circumstances. Simulink's ability to embed Simulink models in a

Simulink environment, which enables modeling of system interactions between diverse components, is one of the software's important characteristics.

Simscape is a Simulink toolkit that gives Simulink an extensive library of preset blocks that let engineers simulate and examine the behavior of physical systems including mechanical, electrical, hydraulic, and thermal systems. The Simulink blocks in the Simscape collection depict parts that are frequently found in these systems, including resistors, capacitors, inductors, gears, bearings, springs, and hydraulic valves.

The Simscape blocks are intended to be physically correct, which means that they faithfully simulate the behaviour of the components they depict. Compared to conventional simulation techniques, this enables engineers to model and analyse the behaviour of physical systems in a way that is far more accurate.

Building Simscape models involves connecting Simscape blocks in a Simulink model, much like putting together a real system from individual parts. The model is then run to mimic the behavior of the system under various circumstances once the blocks have been joined to form a full system.

2.3.2 Hardware

5 small turbines of 12 W each. A multimeter for V-I measurement. Plywood for stability

2.4 Goals

The goal of this project is to find a viable and practical way to harness the wind for generation of electricity so that we can extend the range of the car and decrease the time between charges.

CHAPTER 3

TECHNICAL SPECIFICATION

3.1 Working

3.1.1 How the DC motor generates electricity:

A DC generator, commonly referred to as a DC dynamo, may use the wind or any other external source of mechanical power to transform mechanical energy into electrical energy.

A rotating coil of wire (the armature), housed inside a stationary magnetic field, is how a DC generator operates. A voltage differential is produced across the ends of the wire when the armature spins, cutting through the magnetic field. The electromotive force, or EMF, created by this voltage differential causes an electrical current to flow through the wire.

The blades of a wind turbine are attached to a rotor, which rotates a shaft that powers a DC generator. The generator is turned by the rotor of the blades rotating in response to the wind's blowing motion.

A small DC motor powered by the wind will typically generate a DC voltage and current proportionate to the wind's strength and speed. The voltage and current output of the motor will increase as the wind speed and strength increase.

It is likely to have a very low voltage and current output because these motors are normally made for low-power applications like toy motors, tiny fans, and similar gadgets. Additionally, depending on the wind speed and rotor design, the output voltage and current may be vary varied.

It could be required to employ a voltage regulator, amplifier, or other electronics to amplify or convert the voltage and current in order to utilize the output from a tiny DC motor powered by wind. This can make it more helpful for powering other devices or charging batteries by stabilizing and increasing the output voltage and current.

3.1.2 Working of Buck-Boost converter:

A DC-DC converter known as a ”buck-boost” may increase or decrease input voltage in order to produce a specified output voltage. The switch that links the input voltage to the output load—typically a MOSFET or a transistor—is controlled by the converter by modulating its duty cycle. Here are the fundamental steps in the operation of a buck-boost converter:

1)When the switch is turned on, the input voltage is applied to the output load, and the inductor (L) in the circuit stores energy from the input voltage.

2)When the switch is turned off, the stored energy in the inductor causes a voltage spike across it. This voltage spike charges the output capacitor (C) and supplies power to the load.

3)The duty cycle of the switch is adjusted by a control circuit, which monitors the output voltage and adjusts the switch's on-time and off-time to maintain a stable output voltage.

4)If the output voltage is lower than the desired value, the duty cycle is increased to increase the output voltage. If the output voltage is higher than the desired value, the duty cycle is decreased to decrease the output voltage.

5)The inductor and capacitor values in the circuit are chosen to achieve the desired output voltage and to limit the ripple voltage on the output.

The buck-boost converter is beneficial in situations where the input voltage might change significantly or when the output voltage must be either greater or lower than the input voltage. Common applications include power supply for LED lights, where the output voltage has to be accurately regulated, and battery-operated devices, where the battery voltage may change as the battery drains.

3.1.3 Working of a DC-3 phase AC inverter:

A DC to 3-phase AC inverter is a device that changes a DC voltage into a 3-phase AC voltage, which is often used to drive AC motors in industrial applications. Three AC voltage waveforms that are out of phase with one another are produced by the inverter using a combination of phase shifting and pulse width modulation (PWM).

Here is a brief explanation of the operation of a DC to 3-phase AC inverter: 1)Using an oscillator circuit, the DC input voltage is first transformed into a high-frequency AC waveform. Then, a group of switches (often MOSFETs or IGBTs) that are placed in a bridge arrangement receive this high-frequency AC waveform.

2)A microprocessor or other control circuit, which controls the switches, utilises PWM to change the width of the voltage pulses supplied to each switch. The inverter may produce a sinusoidal voltage waveform that resembles a sine wave by adjusting the pulse width.

3)The PWM signals that are applied to each switch are timed differently by the control circuit, which also modifies the phase of the voltage waveforms. The inverter may produce three voltage waveforms that are 120 degrees out of phase with one another by adjusting the phase of the voltage waveforms.

4)The load, which is normally an AC motor, receives the three-phase AC output voltage after that. The frequency and phase of the AC voltage waveform may be changed to alter the motor's speed and direction.

In conclusion, a DC to 3-phase AC inverter creates a 3-phase AC voltage waveform by converting a DC input voltage to a high-frequency AC waveform then shaping and shifting it using PWM. Then, AC motors or other 3-phase AC loads are driven using this waveform.

3.2 The MATLAB Simscape model

3.2.1 Turbine:

We have used a DC motor of Crouzet company rated at, 35W and 48V at 0.72 A rated current. The rotor is connected to a wind turbine with a diameter of 12 cm. This wind turbine is brought into motion with the help of a wind profile that goes from 0-60 kmph in 25 seconds.

A rate limiter is set to hold the wind speed at exactly 60kmph this way extra noise and voltage is not generated. The pitch angle here is given as 0 degrees and a rotational reference of the turbine is given to the turbine. The output of the turbine is given as rotational input to the DC motor with the same rotational reference as the turbine.

All 3 turbines have a similar configuration and thus create almost the same amount of energy. The 3 turbines are connected in parallel in case any one of them stops working properly and so that the currents are added up together. The output of the turbines are connected to a DC-DC converter. The voltage comes out to be from 0-275V and the current output is from 0.04-0.375A.

Hence necessary calculations need to be done for the boost converter to step up the voltage

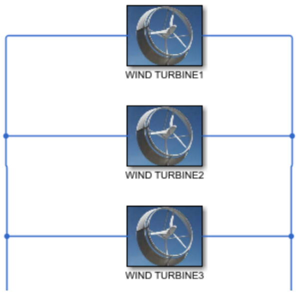


Fig. 3.1 Turbine overview

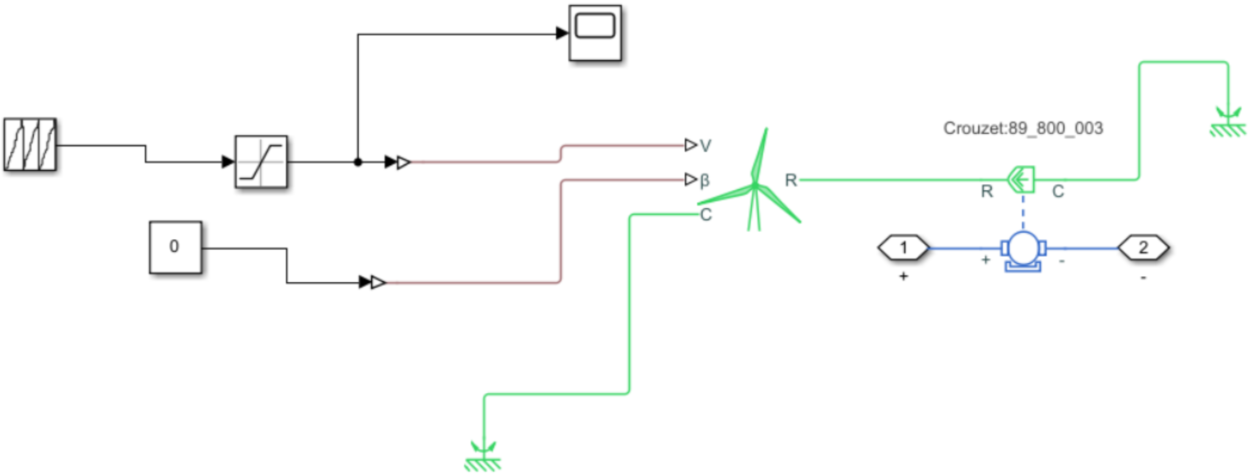


Fig. 3.2 Turbine model

3.2.2 DC-DC converter:

The voltage from the turbines comes out to be from 0-275V and the current output is from 0.04-0.375A. Hence necessary calculations need to be done for the buck-boost converter to step up the voltage to give the output as 220V.

We have taken the frequency as 10kHz and inductor and capacitor sizes to be 100uH and 2200uF respectively. The input value of voltage to the converter is given as input to the DC-DC voltage controller as a label and a constant value of 220V is given as reference.

Rate transitioning blocks are used for handling data transfer between different rates and tasks. The FF and Reset are both given as constant 0 values. The output of the controller gives a duty cycle which is given to the PWM generator to make the required signal for MOSFET gate operation.

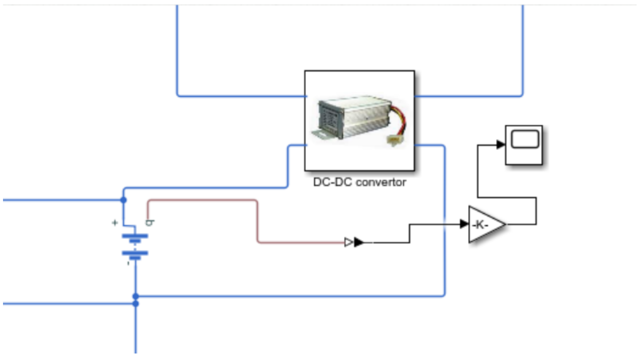


Fig. 3.3 Overview of dc-dc convertor

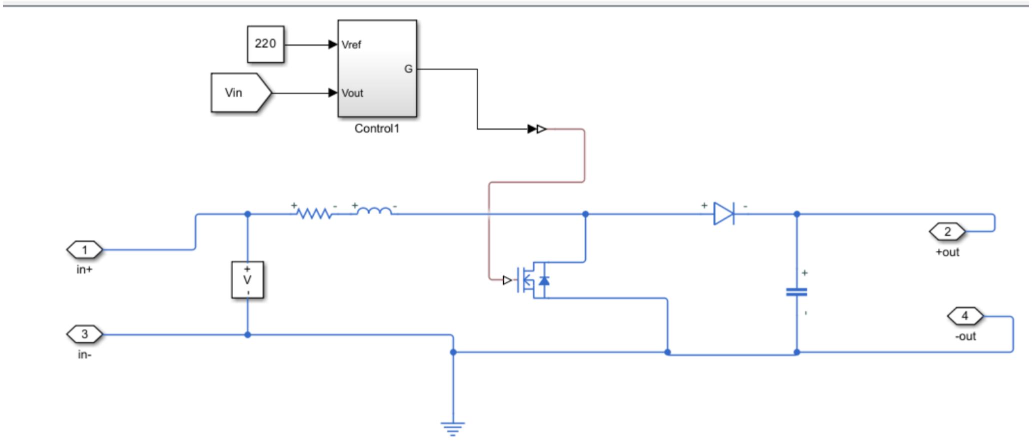
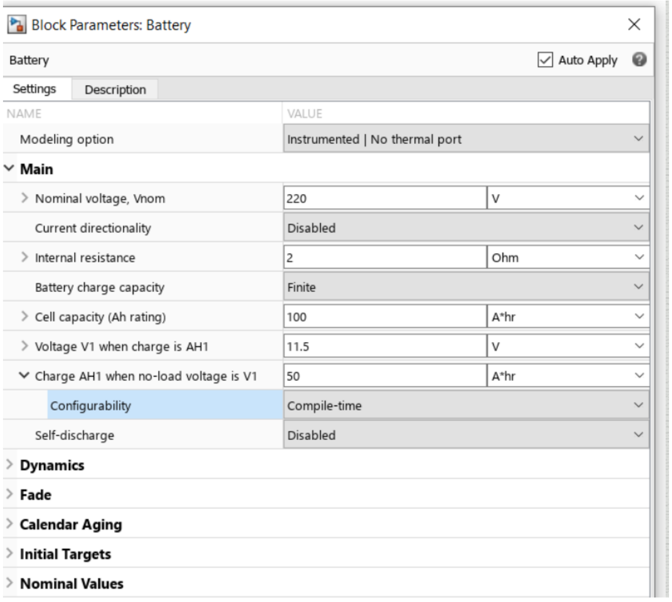


Fig. 3.4 DC-DC converter

3.2.3 Battery

50Ah battery starting at 50 percent SOC. The battery has an output of q which outputs the battery charge level in Coulombs. The battery charge level is converted into SOC by multiplying with a gain of 1/(3600* Ah of the battery i.e 50Ah) and hence the scope outputs the battery SOC.


Block Parameters: Battery

Battery

☑ Auto Apply

Modeling option: Instrumented | No thermal port

Main

Nominal voltage, Vnom: 220 V

Current directionality: Disabled

Internal resistance: 2 Ohm

Battery charge capacity: Finite

Cell capacity (Ah rating): 100 A*hr

Voltage V1 when charge is AH1: 11.5 V

Charge AH1 when no-load voltage is V1: 50 A*hr

Configurability: Compile-time

Self-discharge: Disabled

Fig. 3.5 Battery Parameters

3.2.4 Inverter

The output of the battery is connected to an Inverter which converts DC voltage to 3 phase AC voltage. The design is made in such a way that it is first connected to the Buck-Boost converter and then the inverter and then the motor. The motor has a fixed mechanical reference and the rotational output is measured using the sensors.

First, one is a basic torque sensor and the second is the hall sensor and the third is the ideal rotational motion sensor which gives the RPM of the machine. The hall sensors are used to determine the position of the rotor and depending on that the phases that need to be energized are fixed.

The theta angle is converted into degrees and a series of relational blocks determine the position of the rotor. The output of the Hall sensor is then given to the communication block and depending on the requested rpm a certain energizing pattern is chosen and is converted to the gate signal by the Gate Driver and finally given to the inverter.

The measured rpm is compared with the requested rpm and passed on as in input to the speed controller where it gives a required voltage level to maintain the rpm. The measured voltage is then compared with the required voltage and accordingly the voltage controller gives a duty cycle as an output which is converted to a PWM signal and passed through the gate driver and to the Buck-Boost converter as the gate pulse.

So, as a whole this block converts and regulates DC voltage according to the rpm required and accordingly with the help of hall sensors also converts the DC voltage into 3 phase AC voltage for motor usage.

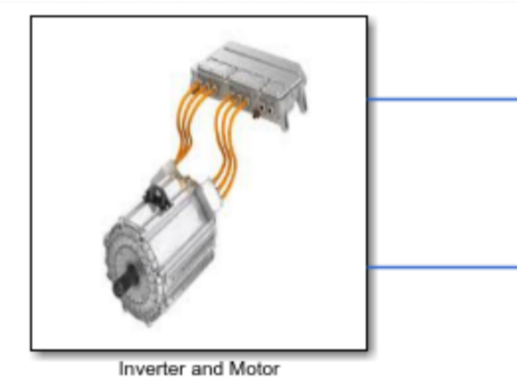


Fig. 3.6 Overview of invertor

3.2.5 Motor

BLDC motor of Anaheim automations with rated speed of 12000 rpm 24 V and 131 W power. Inertia is given to the rotational output of the motor. It also consist of various sensors mentioned above to measure RPM, angular position, torque.

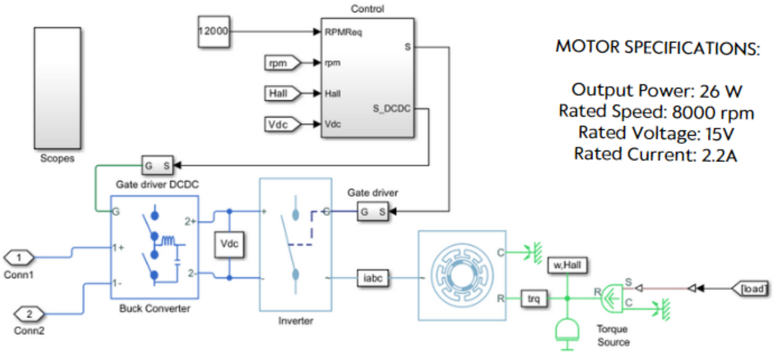


Fig. 3.7 Motor

3.3 Hardware Specification

Five 12 W cooling fans rated at 12 V each, all connected in series and held together with the help of ply wood. A multimeter to check the voltage and current generated by the turbine. The model is made to stand out of the sunroof of the car while the car is accelerating and around 15kmph of the car, the blades of the fan start rotating and a voltage is generated across the terminals of the 5 fans.

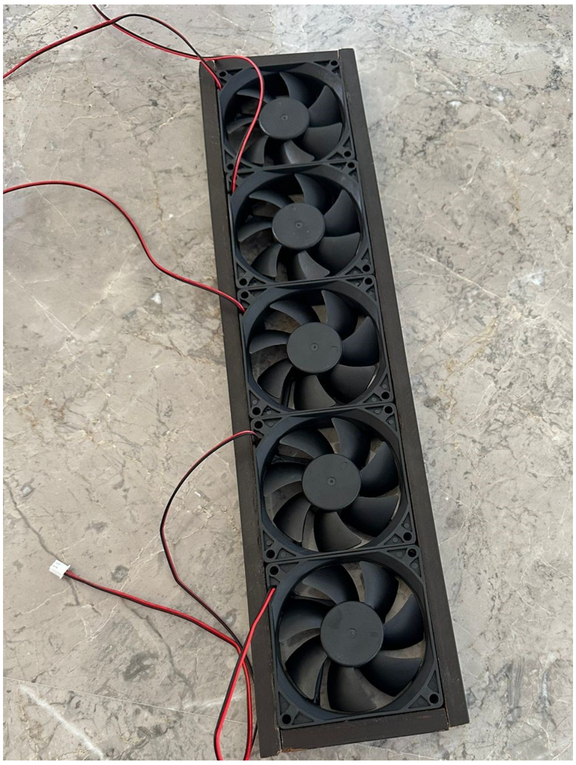


Fig. 3.8 12W cooling fans rated at 12V each

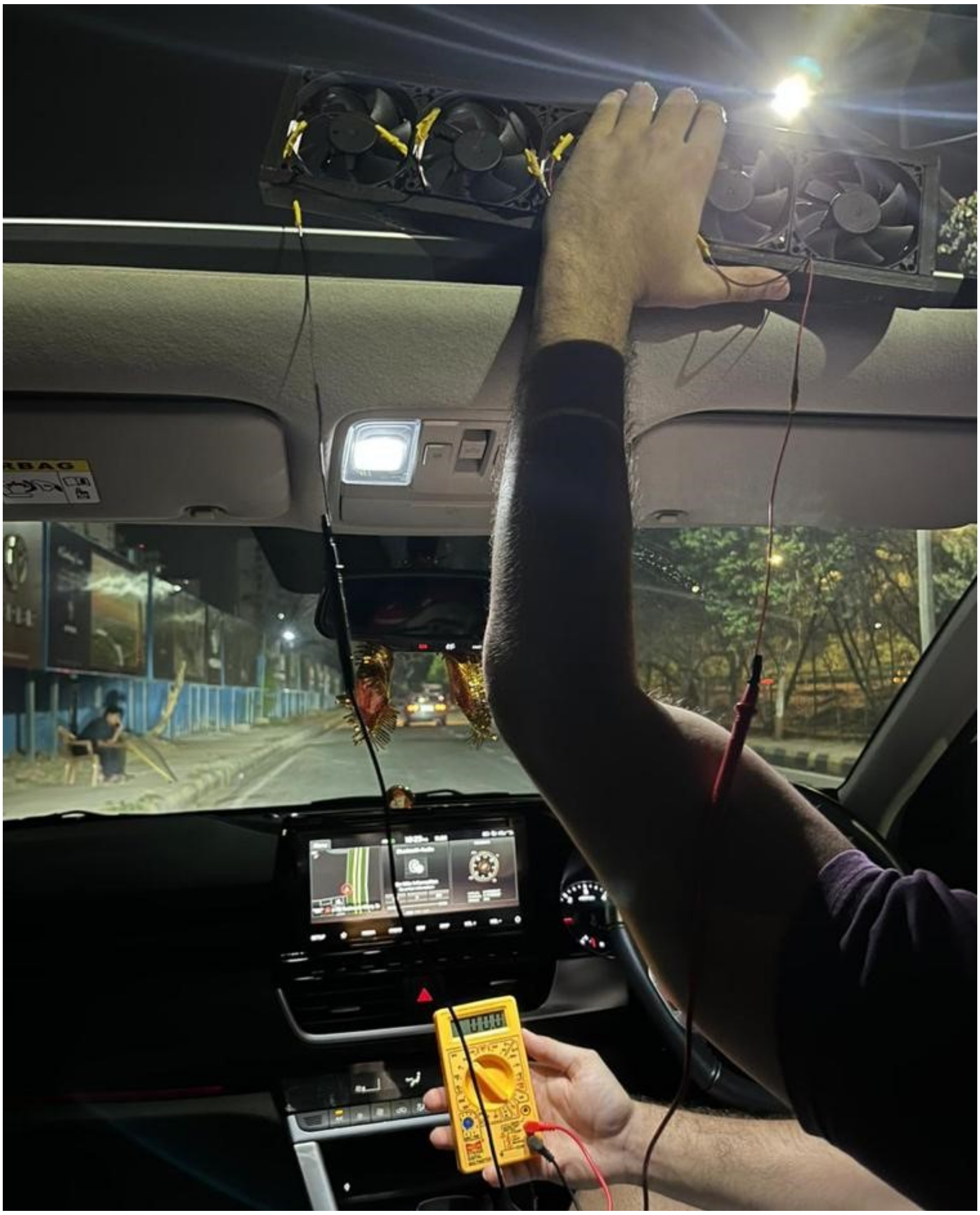


Fig. 3.9 Multimeter

CHAPTER 4

DESIGN APPROACH AND DETAILS

4.1 Design Approach / Materials and Methods

In our hardware model we took smaller fans with a small generating capacity while in simulation we could generate upto 85W of power per second. The aerodynamics of the can get distorted if fans of bigger size are used thus car air ducts can be ideal for placement of the fans.

4.2 Constraints, Alternatives and Tradeoffs

4.2.1 Constraints

While working on the hardware we noticed the noise generated by the small turbines was really loud to ignore and it increased exponentially. Wear and tear and heat generated due to use of the turbines at a high speed were ignored in software calculations.

4.2.2 Alternatives

Instead of placing the turbines on the roof of the car, it can be placed in the air ducts of the car.

4.2.3 Tradeoffs

If we continue with using a bigger turbine for sunroof wind power generation with a bigger motor, no doubt the power generated would be more, but the drag would increase significantly and more energy would be spent on moving forward. Thus, bigger turbines are not effective.

CHAPTER 5

SCHEDULE, TASKS AND MILESTONES

5.1 Schedule

January ‘23- start on brainstorming ideas reviewing research papers, reviewing solar cars, noticing wind profiles and drag on sunroof. Software simulation moving into the initial phase where Simulink is used for the output of turbines.

February ‘23- ran into technical problems with Simulink software and switched to Simscape for real time simulation. Specification of motors and addition and calculation of DC-DC converter. Working on efficiency, to generate maximum output by trying a variety of motors and turbine sizes.

March ‘23- completion of software simulation by addition of battery by studying about the size specifications of an EV, designing of inverter, and addition of required motor for translation, Checking and adjusting parameters to fit the output that we wanted. Overall debugging, compilation and running the simulation. Simulation was of the duration of 25 seconds and would run at a speed of 0.01 second due to the addition of smaller devices(inverter- which had a time period of 0.00001 second).

Apr ‘23- Working on a scaled down wind powered prototype to generate electricity. Checking of V-I of the prototype

5.2 Tasks and Milestones

- Review 0- Study of literature and basic calculations for the same.
- Review 1- 25 percent completion of software simulation
- Review 2- 85 percent completion of software simulation and proposal of hardware
- Final Review- Complete demonstration of software simulation and hardware output

CHAPTER 6

PROJECT DEMONSTRATION

6.1 Software Model

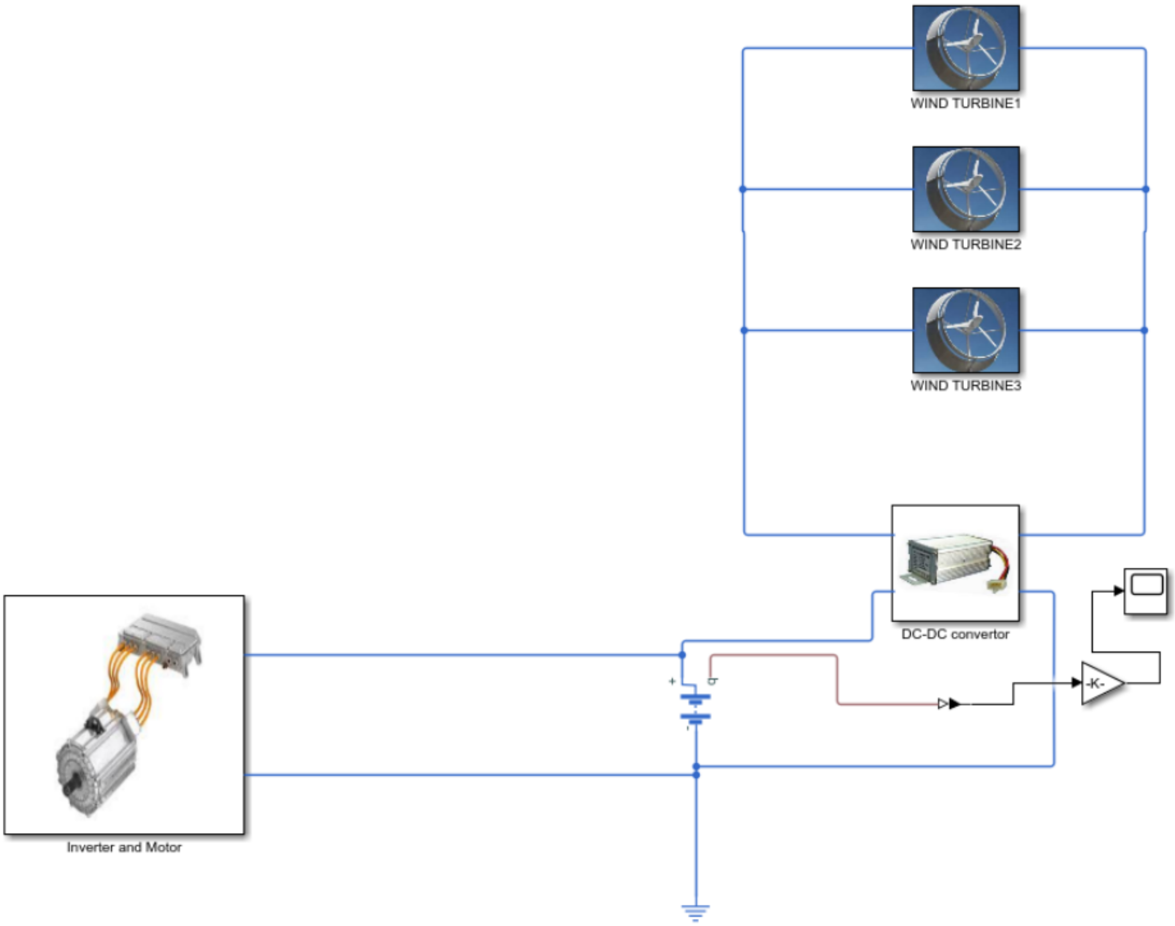


Fig. 6.1 Overview of Model

6.2 Wind Profile

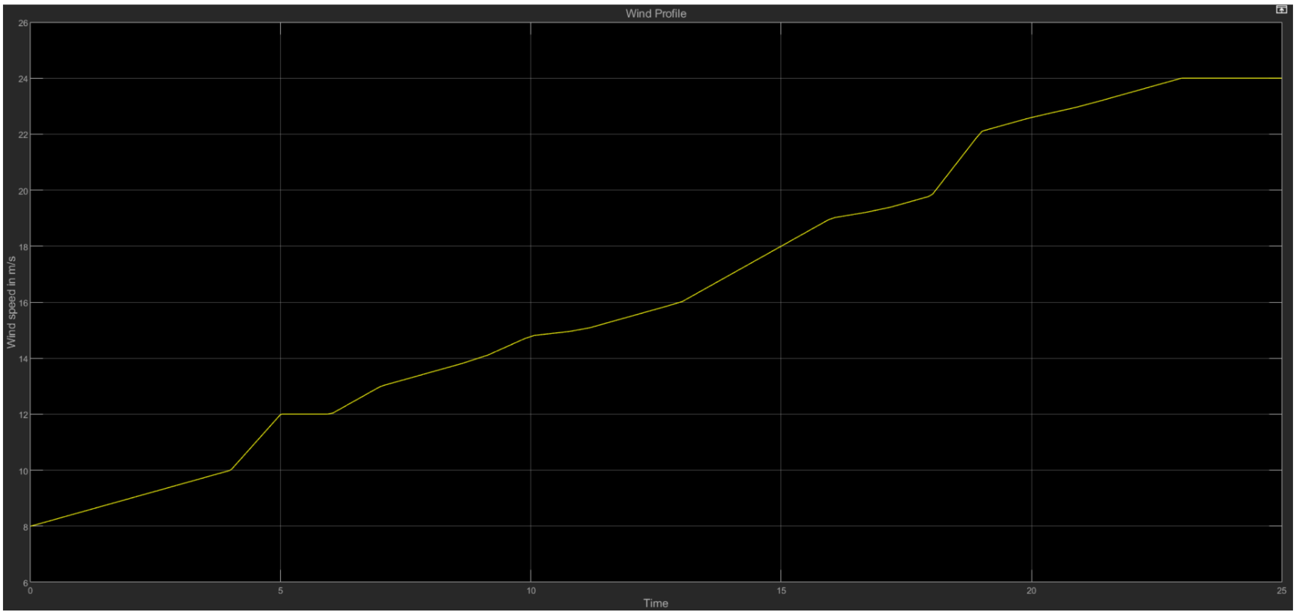


Fig. 6.2 Wind profile

6.3 Voltage output of turbine

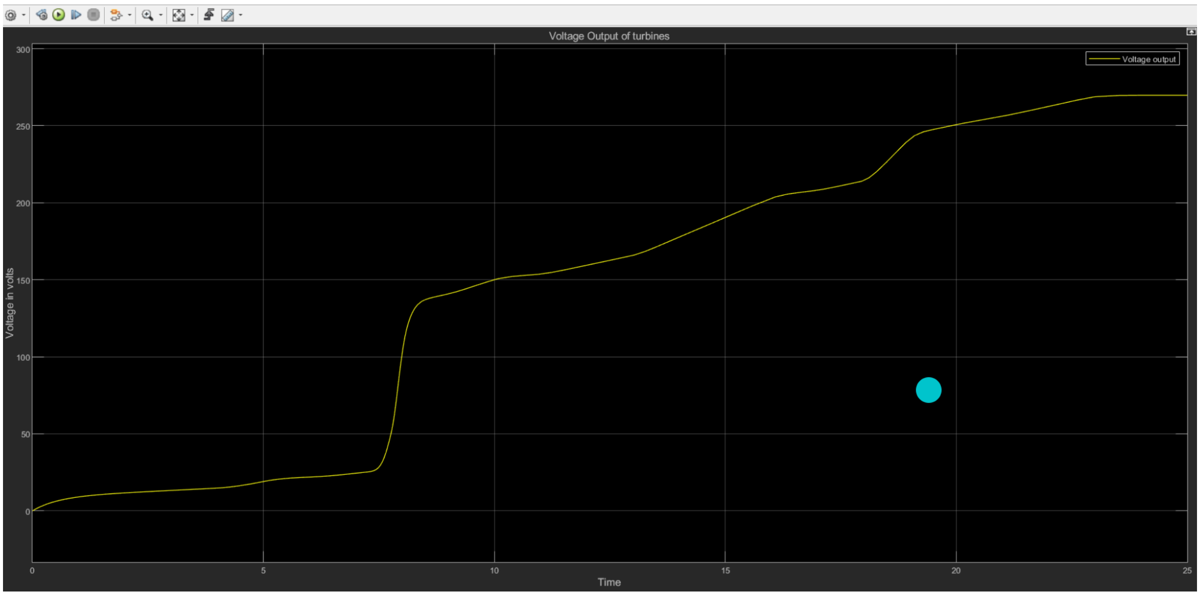


Fig. 6.3 Voltage output of turbine

In the fig.6.3 The voltage of the turbines is erratic because the wind is not the same throughout the course of 25 seconds. The output goes as high as upto 275 V.

6.4 Current output of turbine

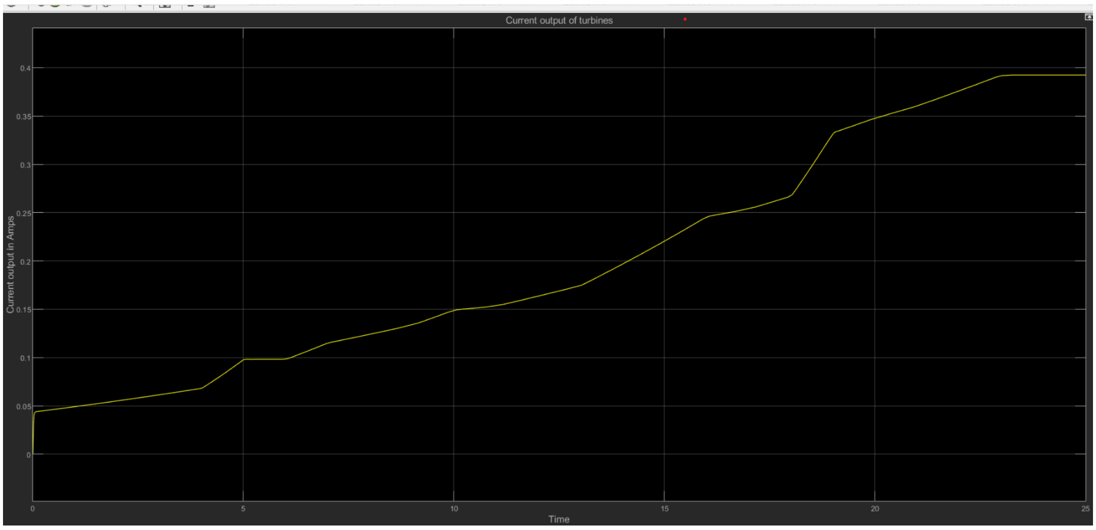


Fig. 6.4 Current output of turbine

In the fig.6.4 since the turbines are small with less magnetic potential, only a small amount of current is generated. With bigger motors the output can give an output upto 1A.

Output of turbine on a cruising speed of 60km/h for 1 hour: Voltage: 275 V Current: 0.375A Power: 103.125W Energy: 0.413 kWh

6.5 Convertor Output

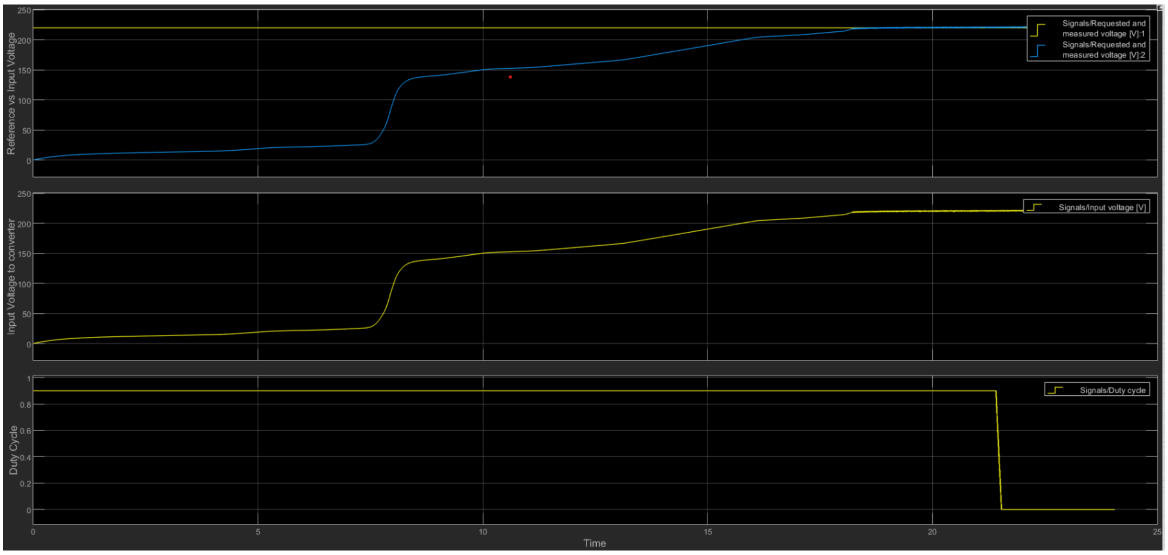


Fig. 6.5 Convertor output

In the fig.6.14 Since the reference voltage is 220 V, the Duty Cycle starts with its practical maximum that we have given i.e 0.9 or 90 percent. Slowly as the output voltage increases upto the required voltage the same duty cycle is no longer required to maintain the voltage and hence a steep downhill is noticed in the Duty Cycle as soon as the measured and reference voltage coincide.

6.6 DC-DC Converter

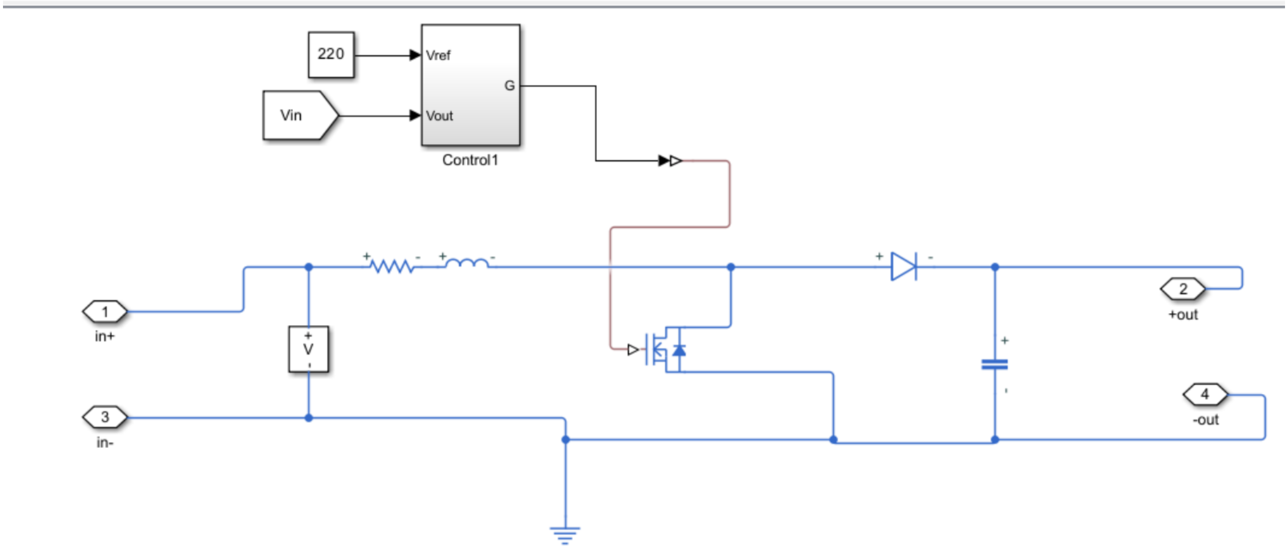


Fig. 6.6 Dc-Dc convertor

In the fig.6.6 Input from turbine (0-275V) is stepped up/down by DC-DC converter to 220V to be supplied to the battery for charging

6.7 PID closed loop convertor

In the fig.6.7 The voltage controller generates a duty cycle based on the reference and input voltage which is then given to the PWM block for supplying it to the gates of the MOSFET.

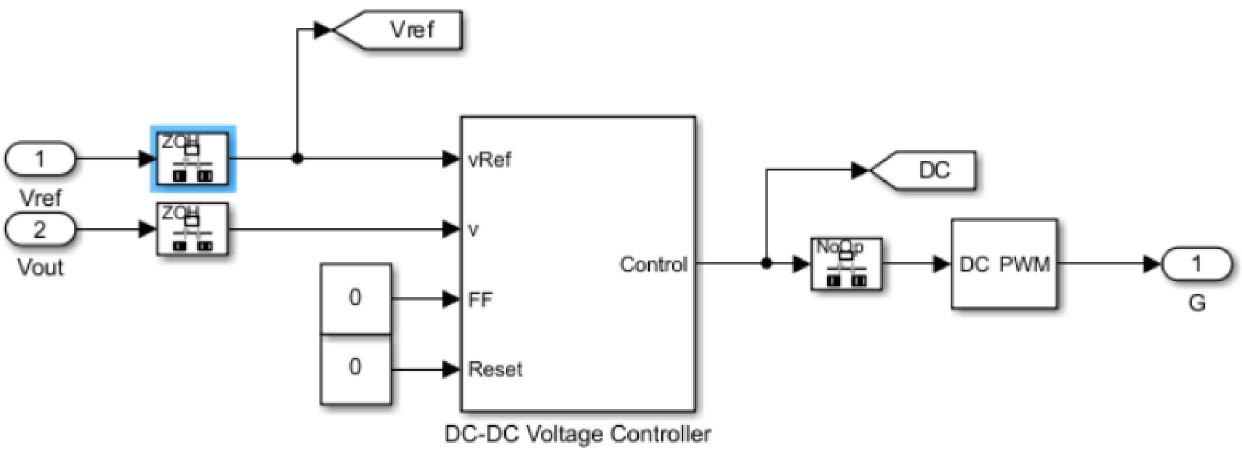


Fig. 6.7 PID closed loop convertor

6.8 Output when no rpm is requested

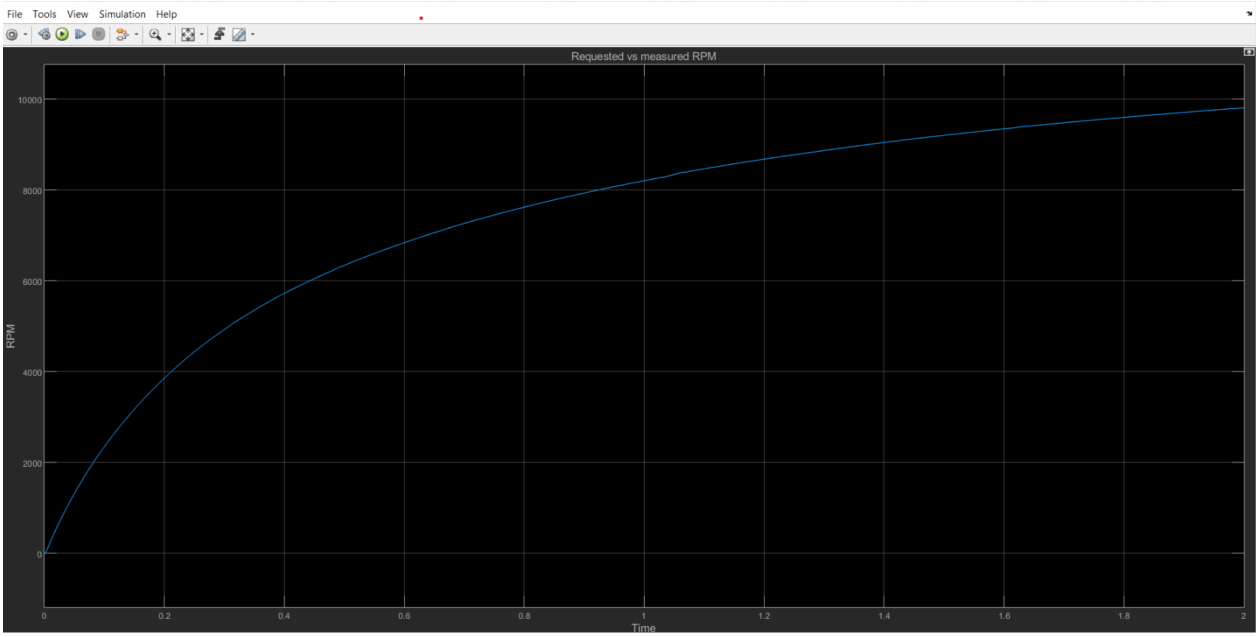


Fig. 6.8 Output when no rpm is requested

6.9 Phase voltage when no rpm is requested

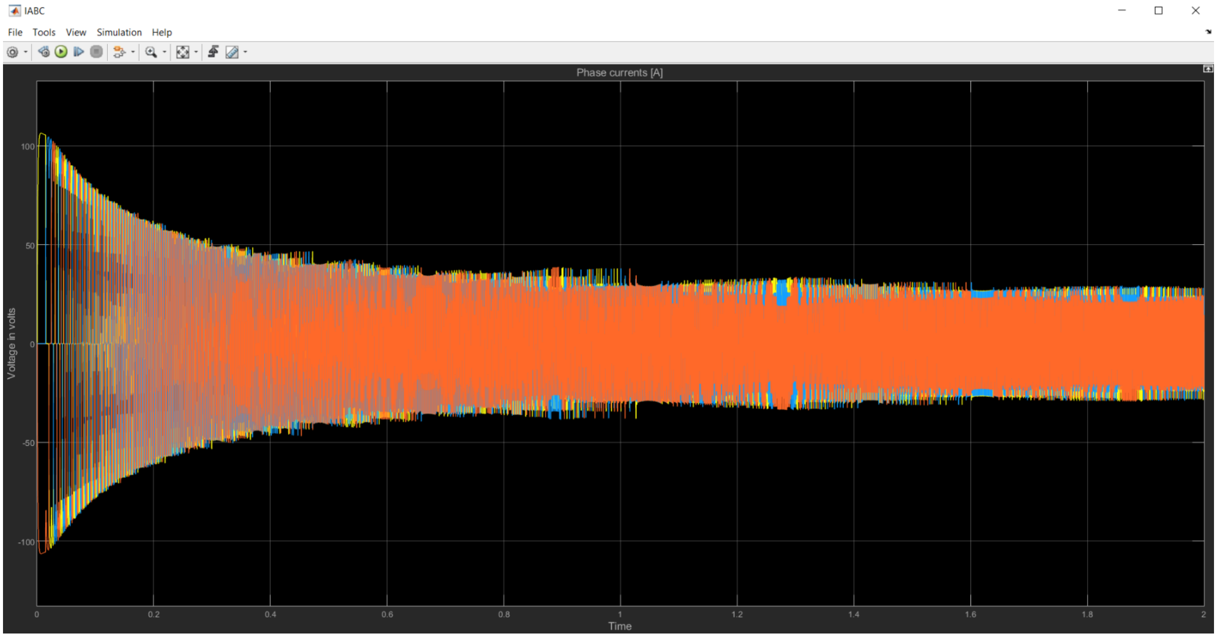


Fig. 6.9 phase voltage when no rpm is requested

6.10 Output when 12000rpm is requested

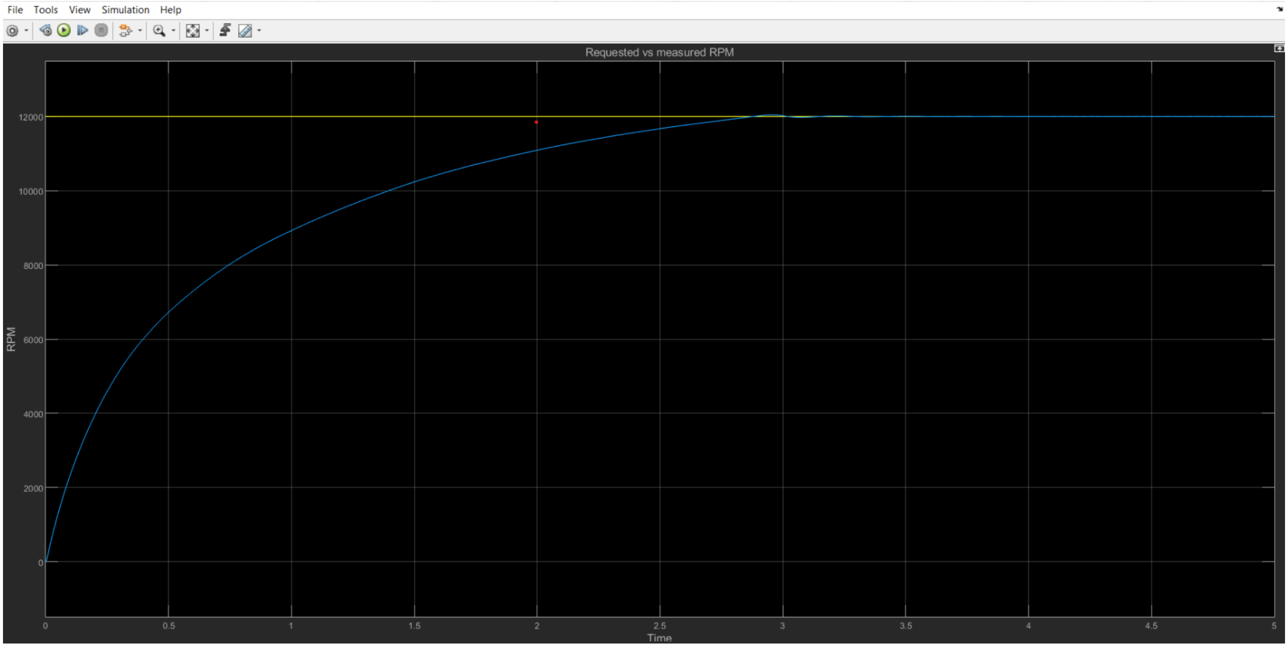


Fig. 6.10 Output when 12000rpm is requested

6.11 Phase voltage when 12000rpm is requested

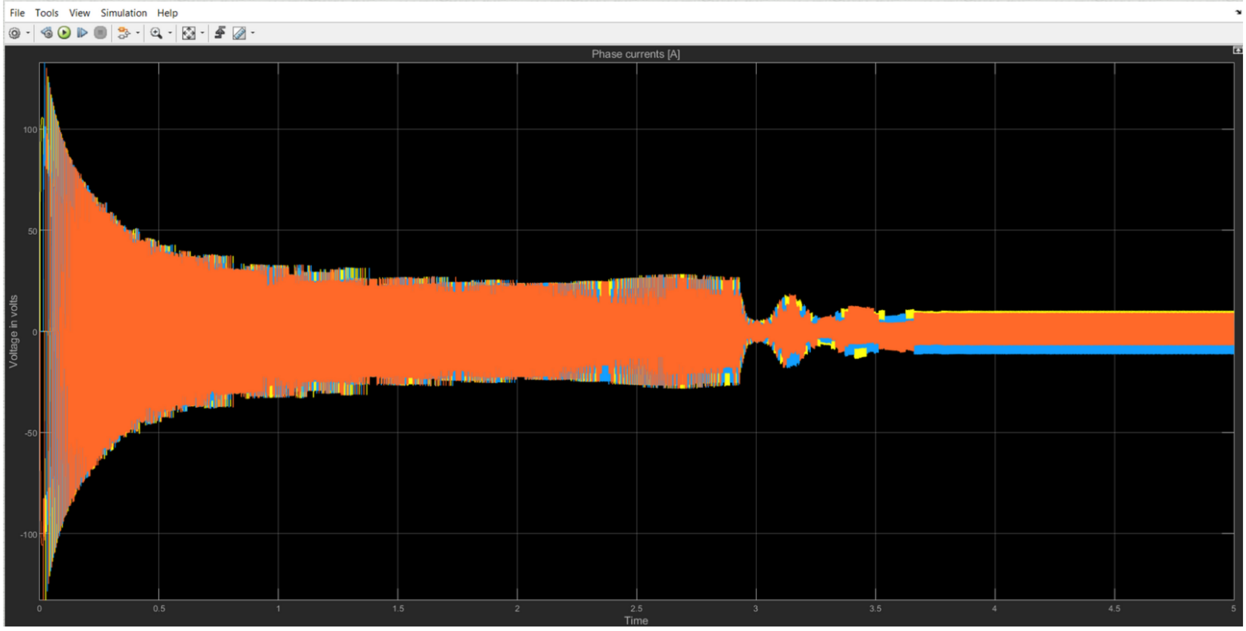


Fig. 6.11 Phase voltage when 12000rpm is requested

In the fig.6.11 At around 3.1 seconds the voltage experiences a minor disturbance cause the RPM as been satisfied and the DC voltage has coincided with its required votage

6.12 Reference and measured DC-Link voltage

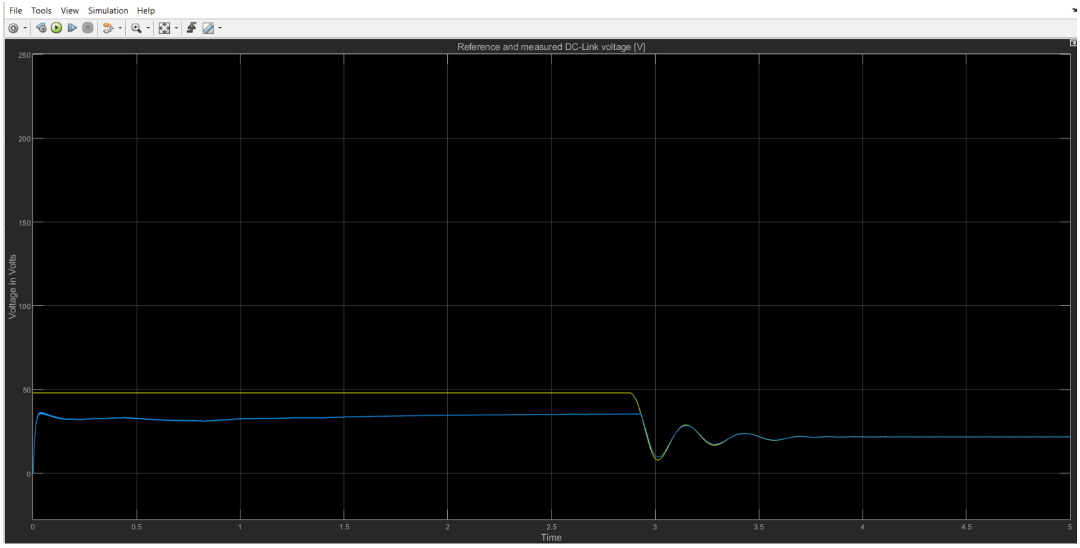


Fig. 6.12 Reference and measured DC-Link voltage

6.13 Final conclusion of simulation

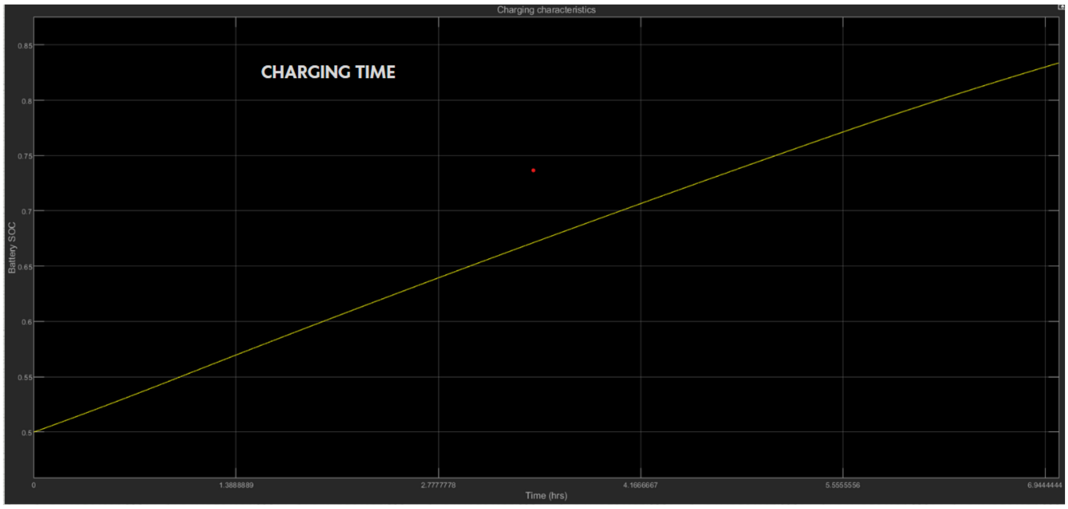


Fig. 6.13 final conclusion of simulation

In the fig.6.13 We can see that the turbines charge the battery of 50Ah from 50 percent to 84 percent in a time span of 7 hrs with an average output of 0.413kWh at cruising speed of 60km/h this however might seem small at first but with better motors this can be increased significantly.

6.14 Hardware output and conclusion

Drive link for the whole video:
https://drive.google.com/drive/folders/1wgle6Jc6a-XdfIETEgxJjpEZnegu4oF1?usp=sharing

In our hardware simulation we have got the following output:

Max Voltage(excluding erroneous voltages): 70V

Max Current: 0.35A

Max Power obtained: 25.4W

Fig. 6.14 Ammeter reading of 0.25A

Fig. 6.15 Voltage reading of 62V

Fig. 6.16 Fans in full motion

CHAPTER 7

COST ANALYSIS / RESULT AND DISCUSSION

7.1 Cost Analysis

For the Software: Since the entire project was executed on MATLAB/Simulink, this component is free of cost as they come with a university license. For the Hardware: Rs.500/- for the fans, Rs.300/- for the multimeter, Rs.600/- for the carpentry and miscellaneous costs. A total of Rs.1400/-

7.2 Results and Discussion

- Comparison with existing Solar powered cars:

  The Lightyear One is an electric vehicle that has integrated solar cells on its roof and hood, which are used to charge the vehicle's battery. The exact amount of solar output energy per hour will depend on several factors, such as the size and efficiency of the solar cells, the angle of the sunlight, and any shading or obstruction of the solar cells.

  According to the specifications provided by Lightyear, the solar cells on the Lightyear One have a total surface area of 5.0 square meters and a maximum power output of 1.3 kW under ideal conditions.

  However, the actual solar output energy per hour will vary depending on the environmental conditions. Assuming ideal conditions, the solar output energy per hour can be calculated as follows: 1.3 kW x 1 hour = 1.3 kWh.

  Therefore, under ideal conditions, the Lightyear One's solar cells can generate 1.3 kWh of energy per hour. However, this is a theoretical maximum and the actual solar output energy per hour will depend on the environmental conditions and other factors mentioned earlier.

- Our model: It is important to note that our output comprises of just 3 turbines rotating in non-ideal conditions hence our power output is 1/3rd of their ideal output. However, solar-powered cars are always subjected to weather conditions which make them unusable throughout the year.

The main advantage that wind power offers is that it doesn't depend on the surrounding weather conditions a lot, as long as the car is moving the turbine will keep generating energy however we were limited by the type of motor that we could use for simulation which contributed to a lower current and therefore a lower power output.

We might be one of the pioneers to harvest wind energy as a source of power and it still could be researched and perfected on a larger scale like adding multiple motors, adding geared motors, adding wind concentrators, effective utilization of the aerodynamics of the car.

CHAPTER 8

SUMMARY

8.1 Summary

- Wind-powered cars with turbines on the sunroof are an interesting concept that could potentially reduce the reliance on fossil fuels and minimize emissions. However, there are several feasibility and practicality concerns associated with this technology.

- One of the main advantages of wind-powered cars is that they could potentially generate clean and renewable energy while driving. This would help to reduce greenhouse gas emissions and the dependence on non-renewable energy sources. Furthermore, the small size of the wind turbines makes them less obtrusive than large wind turbines and could allow for more localized energy production.

- However, there are several challenges that need to be addressed to make this technology feasible and practical. Firstly, the amount of energy generated by the small wind turbines mounted on the car's sunroof is limited, and the wind direction and speed are variable, making it difficult to generate consistent energy. Additionally, the added weight and height of the turbine on the car's roof can increase drag and reduce overall efficiency.

- Moreover, there are safety concerns associated with the use of wind turbines on cars. The turbine blades can pose a risk to pedestrians and other vehicles on the road, and there is a risk of the turbine falling off or becoming dislodged during high winds or collisions. Furthermore, the cost of materials, design, and installation can be prohibitively expensive, making it difficult to justify the investment.

- In summary, while wind-powered cars with turbines on the sunroof have the potential to generate clean and renewable energy, there are significant technical and practical challenges that need to be addressed to make this technology feasible and practical. Therefore, electric and hybrid vehicles with more established technologies are likely to remain the primary means of reducing reliance on fossil fuels in transportation for the foreseeable future.

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LIST OF PUBLICATIONS

Appendices

Appendix A

CHI SQUARE DISTRIBUTION TABLE

df	**0.995**	**0.99**	**0.975**	**0.95**	**0.9**	**0.1**	**0.05**	**0.025**	**0.01**	**0.005**
1	0.000	0.000	0.001	0.004	0.016	2.706	3.841	5.024	6.635	7.879
2	0.01	0.02	0.051	0.103	0.211	4.605	5.991	7.378	9.21	10.597
3	0.072	0.115	0.216	0.352	0.584	6.251	7.815	9.348	11.345	12.838
4	0.207	0.297	0.484	0.711	1.064	7.779	9.488	11.143	13.277	14.86
5	0.412	0.554	0.831	1.145	1.61	9.236	11.07	12.833	15.086	16.75
6	0.676	0.872	1.237	1.635	2.204	10.645	12.592	14.449	16.812	18.548
7	0.989	1.239	1.69	2.167	2.833	12.017	14.067	16.013	18.475	20.278
8	1.344	1.646	2.18	2.733	3.49	13.362	15.507	17.535	20.09	21.955
9	1.735	2.088	2.7	3.325	4.168	14.684	16.919	19.023	21.666	23.589
10	2.156	2.558	3.247	3.94	4.865	15.987	18.307	20.483	23.209	25.188
11	2.603	3.053	3.816	4.575	5.578	17.275	19.675	21.92	24.725	26.757
12	3.074	3.571	4.404	5.226	6.304	18.549	21.026	23.337	26.217	28.3
13	3.565	4.107	5.009	5.892	7.042	19.812	22.362	24.736	27.688	29.819
14	4.075	4.66	5.629	6.571	7.79	21.064	23.685	26.119	29.141	31.319
15	4.601	5.229	6.262	7.261	8.547	22.307	24.996	27.488	30.578	32.801
16	5.142	5.812	6.908	7.962	9.312	23.542	26.296	28.845	32	34.267
17	5.697	6.408	7.564	8.672	10.085	24.769	27.587	30.191	33.409	35.718
18	6.265	7.015	8.231	9.39	10.865	25.989	28.869	31.526	34.805	37.156
19	6.844	7.633	8.907	10.117	11.651	27.204	30.144	32.852	36.191	38.582
20	7.434	8.26	9.591	10.851	12.443	28.412	31.41	34.17	37.566	39.997
21	8.034	8.897	10.283	11.591	13.24	29.615	32.671	35.479	38.932	41.401
22	8.643	9.542	10.982	12.338	14.041	30.813	33.924	36.781	40.289	42.796
23	9.26	10.196	11.689	13.091	14.848	32.007	35.172	38.076	41.638	44.181
24	9.886	10.856	12.401	13.848	15.659	33.196	36.415	39.364	42.98	45.559
25	10.52	11.524	13.12	14.611	16.473	34.382	37.652	40.646	44.314	46.928
26	11.16	12.198	13.844	15.379	17.292	35.563	38.885	41.923	45.642	48.29
27	11.808	12.879	14.573	16.151	18.114	36.741	40.113	43.195	46.963	49.645
28	12.461	13.565	15.308	16.928	18.939	37.916	41.337	44.461	48.278	50.993
29	13.121	14.256	16.047	17.708	19.768	39.087	42.557	45.722	49.588	52.336
30	13.787	14.953	16.791	18.493	20.599	40.256	43.773	46.979	50.892	53.672
40	20.707	22.164	24.433	26.509	29.051	51.805	55.758	59.342	63.691	66.766
50	27.991	29.707	32.357	34.764	37.689	63.167	67.505	71.42	76.154	79.49
60	35.534	37.485	40.482	43.188	46.459	74.397	79.082	83.298	88.379	91.952
70	43.275	45.442	48.758	51.739	55.329	85.527	90.531	95.023	100.425	104.215
80	51.172	53.54	57.153	60.391	64.278	96.578	101.879	106.629	112.329	116.321
90	59.196	61.754	65.647	69.126	73.291	107.565	113.145	118.136	124.116	128.299
100	67.328	70.065	74.222	77.929	82.358	118.498	124.342	129.561	135.807	140.169

Appendix B

't' TABLE

Tail Probability		Degrees of Freedom																			Confidence Levels	
		1	2	3	4	5	6	7	8	9	10	12	15	20	25	30	40	50	1 00	1000		
1-tail	2-tail																			$\approx \infty$	2-sided	1-sided
0.5	1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		
0.4	0.8	0.325	0.289	0.277	0.271	0.267	0.265	0.263	0.262	0.261	0.260	0.259	0.258	0.257	0.256	0.256	0.255	0.255	0.254	0.253		
0.3	0.6	0.727	0.617	0.584	0.569	0.559	0.553	0.549	0.546	0.543	0.542	0.539	0.536	0.533	0.531	0.530	0.529	0.528	0.526	0.525		
0.25	0.5	1.000	0.816	0.765	0.741	0.727	0.718	0.711	0.706	0.703	0.700	0.695	0.691	0.687	0.684	0.683	0.681	0.679	0.677	0.675		
0.2	0.4	1.376	1.061	0.978	0.941	0.920	0.906	0.896	0.889	0.883	0.879	0.873	0.866	0.860	0.856	0.854	0.851	0.849	0.845	0.842		80%
0.17	0.34	1.691	1.242	1.132	1.082	1.054	1.036	1.024	1.015	1.008	1.002	0.994	0.986	0.977	0.973	0.970	0.966	0.963	0.959	0.955		
0.15	0.3	1.963	1.386	1.250	1.190	1.156	1.134	1.119	1.108	1.100	1.093	1.083	1.074	1.064	1.058	1.055	1.050	1.047	1.042	1.037		
0.14	0.28	2.125	1.467	1.315	1.248	1.211	1.187	1.171	1.159	1.149	1.142	1.131	1.121	1.110	1.104	1.100	1.095	1.092	1.086	1.081		
0.13	0.26	2.311	1.556	1.385	1.311	1.270	1.244	1.226	1.212	1.202	1.194	1.182	1.171	1.159	1.153	1.148	1.143	1.139	1.133	1.127		
0.12	0.24	2.526	1.654	1.462	1.379	1.333	1.304	1.284	1.269	1.258	1.249	1.236	1.224	1.211	1.204	1.199	1.193	1.189	1.182	1.176		
0.11	0.22	2.778	1.763	1.545	1.453	1.401	1.369	1.347	1.331	1.318	1.308	1.294	1.280	1.266	1.258	1.253	1.246	1.242	1.234	1.227		
0.1	0.2	3.078	1.886	1.638	1.533	1.476	1.440	1.415	1.397	1.383	1.372	1.356	1.341	1.325	1.316	1.310	1.303	1.299	1.290	1.282	80%	90%
0.09	0.18	3.442	2.026	1.741	1.623	1.558	1.517	1.489	1.469	1.454	1.442	1.424	1.406	1.389	1.379	1.373	1.365	1.360	1.350	1.342		
0.08	0.16	3.895	2.189	1.859	1.723	1.649	1.603	1.572	1.549	1.532	1.518	1.498	1.478	1.459	1.448	1.441	1.432	1.426	1.416	1.406		
0.075	0.15	4.165	2.282	1.924	1.778	1.699	1.650	1.617	1.592	1.574	1.559	1.538	1.517	1.497	1.485	1.477	1.468	1.462	1.451	1.441		
0.07	0.14	4.474	2.383	1.995	1.838	1.753	1.700	1.664	1.638	1.619	1.603	1.580	1.558	1.537	1.524	1.516	1.506	1.500	1.488	1.477		
0.065	0.13	4.829	2.495	2.072	1.902	1.810	1.754	1.715	1.687	1.666	1.650	1.626	1.602	1.579	1.566	1.557	1.546	1.539	1.527	1.515		
0.06	0.12	5.242	2.620	2.156	1.971	1.873	1.812	1.770	1.740	1.718	1.700	1.674	1.649	1.624	1.610	1.600	1.589	1.582	1.568	1.556		
0.055	0.11	5.730	2.760	2.249	2.048	1.941	1.874	1.830	1.797	1.773	1.754	1.726	1.699	1.672	1.657	1.647	1.635	1.627	1.613	1.600		
0.05	0.1	6.314	2.920	2.353	2.132	2.015	1.943	1.895	1.860	1.833	1.812	1.782	1.753	1.725	1.708	1.697	1.684	1.676	1.660	1.646	90%	95%
0.045	0.09	7.026	3.104	2.471	2.226	2.098	2.019	1.966	1.928	1.899	1.877	1.844	1.812	1.782	1.764	1.752	1.737	1.729	1.712	1.697		
0.04	0.08	7.916	3.320	2.605	2.333	2.191	2.104	2.046	2.004	1.973	1.948	1.912	1.878	1.844	1.825	1.812	1.796	1.787	1.769	1.752		
0.035	0.07	9.058	3.578	2.763	2.456	2.297	2.201	2.136	2.090	2.055	2.028	1.989	1.951	1.914	1.893	1.879	1.862	1.852	1.832	1.814		
0.03	0.06	10.57	3.896	2.951	2.601	2.422	2.313	2.241	2.189	2.150	2.120	2.076	2.034	1.994	1.970	1.955	1.936	1.924	1.902	1.883		
0.025	0.05	12.70	4.303	3.182	2.776	2.571	2.447	2.365	2.306	2.262	2.228	2.179	2.131	2.086	2.060	2.042	2.021	2.009	1.984	1.962	95%	
0.02	0.04	15.89	4.849	3.482	2.999	2.757	2.612	2.517	2.449	2.398	2.359	2.303	2.249	2.197	2.167	2.147	2.123	2.109	2.081	2.056		98%
0.017	0.034	18.71	5.284	3.712	3.166	2.895	2.734	2.628	2.553	2.498	2.454	2.392	2.333	2.276	2.243	2.222	2.195	2.180	2.150	2.123		
0.015	0.03	21.21	5.643	3.896	3.298	3.003	2.829	2.715	2.634	2.574	2.527	2.461	2.397	2.336	2.301	2.278	2.250	2.234	2.202	2.173		
0.012	0.024	26.51	6.338	4.241	3.541	3.200	3.000	2.870	2.778	2.710	2.658	2.582	2.511	2.442	2.403	2.378	2.346	2.328	2.292	2.261		
0.01	0.02	31.82	6.965	4.541	3.747	3.365	3.143	2.998	2.896	2.821	2.764	2.681	2.602	2.528	2.485	2.457	2.423	2.403	2.364	2.330	98%	99%
0.007	0.014	45.47	8.363	5.175	4.173	3.700	3.428	3.253	3.131	3.041	2.972	2.873	2.781	2.693	2.642	2.610	2.570	2.547	2.501	2.462		
0.005	0.01	63.65	9.925	5.841	4.604	4.032	3.707	3.499	3.355	3.250	3.169	3.055	2.947	2.845	2.787	2.750	2.704	2.678	2.626	2.581	99%	99.5%
0.003	0.006	106.1	12.85	6.994	5.321	4.570	4.152	3.887	3.705	3.573	3.472	3.330	3.197	3.073	3.003	2.957	2.902	2.870	2.808	2.754		
0.002	0.004	159.2	15.76	8.053	5.951	5.030	4.524	4.207	3.991	3.835	3.716	3.550	3.395	3.251	3.170	3.118	3.055	3.018	2.946	2.885		
0.001	0.002	318.3	22.32	10.21	7.173	5.893	5.208	4.785	4.501	4.297	4.144	3.930	3.733	3.552	3.450	3.385	3.307	3.261	3.174	3.098	99.8%	99.9%
.0005	0.001	636.6	31.59	12.92	8.610	6.869	5.959	5.408	5.041	4.781	4.587	4.318	4.073	3.850	3.725	3.646	3.551	3.496	3.391	3.300	99.9%	99.95%
.0001	.0002	3183	70.70	22.20	13.03	9.678	8.025	7.063	6.442	6.010	5.694	5.263	4.880	4.539	4.352	4.234	4.094	4.014	3.862	3.733		99.99%
5e-5	.0001	6366	99.98	27.99	15.54	11.18	9.082	7.884	7.120	6.594	6.210	5.694	5.239	4.837	4.620	4.482	4.320	4.228	4.053	3.906	99.99%	

Courtesy: Robert J. MacG. Dawson ⋆ Dept.of Math and Computing Science ⋆ St. Mary's University, Halifax, NS, Canada B3H 3C3 ⋆ `rdawson@husky1.stmarys.ca`