Vertical axis wind turbine by using two phase stepper motor

Indranil Kadam, Aditya Gokhale, Prof. D.A.patil

Student, Dept. of Electrical Engineering, D.K.T.E Society's Textile and Engineering Institute, Ichalkaranji, India

Asst. Prof. Dept. of Electrical Engineering, D.K.T.E Society's Textile and Engineering Institute, Ichalkaranji, India

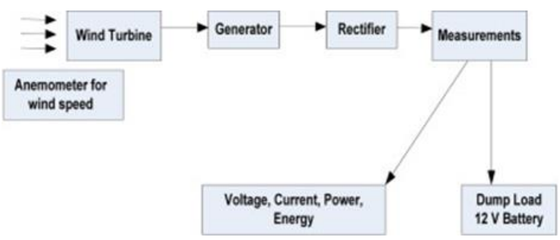
Abstract:

This research paper explores the design, efficiency, and application potential of Vertical Axis Wind Turbines (VAWTs), an alternative to traditional horizontal-axis wind turbines, in harnessing wind energy. Unlike their horizontal counterparts, VAWTs offer advantages in urban and variable wind conditions due to their orientation and ability to capture wind from any direction. This study aims to address the efficiency challenges associated with VAWTs by introducing an innovative blade design and optimizing the turbine's operational parameters. Through computational fluid dynamics simulations and field testing, the study evaluates the performance of the proposed VAWT design in various wind conditions. The results indicate a significant improvement in efficiency and reliability over conventional VAWT models, demonstrating the feasibility of VAWTs in urban settings and small-scale energy generation projects. Furthermore, the research identifies key factors influencing the performance of VAWTs and proposes solutions for scalability and integration into existing energy systems. This study contributes to the renewable energy field by providing valuable insights into the optimization of VAWTs, paving the way for their wider adoption and enhancing the diversification of sustainable energy sources.

Introduction:

Vertical Axis Wind Turbines (VAWTs) represent a unique and innovative approach to harnessing wind energy. Unlike traditional horizontal axis wind turbines (HAWTs), which have blades that rotate around a horizontal axis like those of an airplane propeller,

Block Diagram:



One of the key advantages of VAWTs is their ability to capture wind from any direction, as they do not rely on a facing direction like HAWTs. This omnidirectional capability makes VAWTs well-suited for urban and turbulent wind environments, where wind direction can be unpredictable. Additionally, VAWTs often have a lower visual impact and can be more compact, making them suitable for installations in densely populated areas or where space is limited.

Another advantage of VAWTs is their potential for simplified maintenance and installation. Because the generator and other key components can be located at or near ground level, servicing and repairs are often easier and safer compared to HAWTs, which typically require tall towers and specialized equipment for maintenance.

Despite these advantages, VAWTs also face challenges, including lower overall efficiency compared to HAWTs, due in part to issues with aerodynamic drag and torque variations during rotation. However, ongoing research and development efforts are focused on addressing these challenges and further improving the performance and viability of VAWT technology.

In summary, VAWTs represent a promising alternative to traditional horizontal axis wind turbines, offering unique advantages such as omnidirectional wind capture and simplified maintenance. As renewable energy continues to play a vital role in combating climate change and securing a sustainable future, VAWTs are likely to remain a subject of interest and innovation in the field of wind energy technology.

Hardware Requirements:

PVC pipes (for blades and structure)

1.Flexibility:

PVC pipes have a degree of flexibility, which can be an advantage in absorbing wind forces.

However, it's crucial to balance flexibility with the need for structural integrity.

2.Durability:

While PVC is lightweight and easy to work with, it may not be as durable as some other materials. Consider the wind conditions in your area and reinforce the design if necessary.

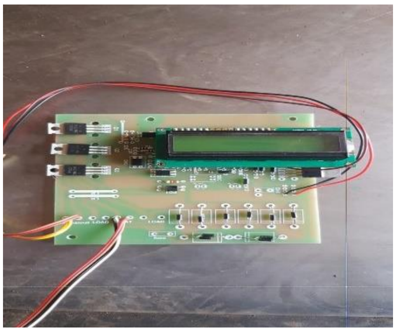
Stepper motor(as a generator):

A two-phase stepper motor is a type of stepper motor that has two windings, often referred to as phase A and phase B. Stepper motors are synchronous motors that move in discrete steps. Each step corresponds to a specific angular displacement, and the motor rotates by sequentially energizing the phases. The two-phase stepper motor has two windings. The stator is the stationary part of the motor, and the rotor is the rotating part.

Stepper motors are used in various applications, including CNC machines, 3D printers, robotics, and other systems where precise control of movement is required. Stepper motors have the advantage of precise control over position and speed. They don't require feedback systems like encoders for position control, making them suitable for open-loop control applications.

Battery:

Charge controller:



A charge controller is a crucial component in renewable energy systems, such as solar and wind power systems, to regulate the charging of batteries and prevent overcharging or excessive discharging. In the context of wind turbine systems, including Vertical Axis Wind Turbines (VAWTs), charge controllers play a similar role in managing the electrical output from the turbine.

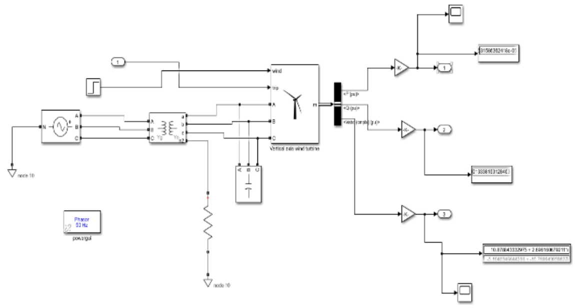
Booster:

A boost converter, also known as a step-up converter, is a type of DC-DC (direct current to direct current) power converter that increases the voltage level of its input power source. This is achieved by storing energy in an inductor during the ON period of a switching cycle and releasing it to the output during the OFF period.

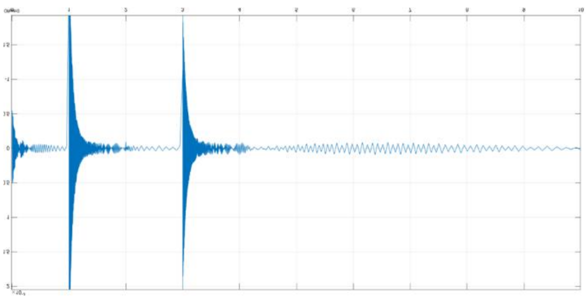
Switching Element (Transistor): The heart of the boost converter is a switching element, usually a transistor. The transistor alternates between an ON state (conducting) and an OFF state (non-conducting) at a high frequency. Inductor (L): The inductor stores energy during the ON period when the transistor is conducting. The energy is released to the output during the OFF period. The inductor is a critical component for energy storage and transfer.

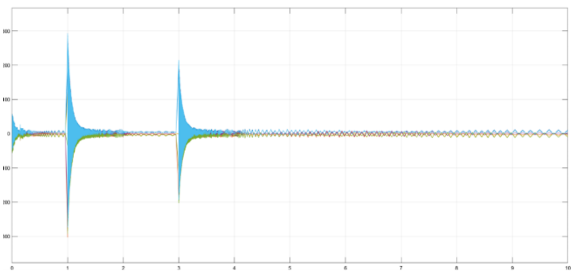
A 12-volt (12V) battery is a common type of lead-acid battery used in various applications, including automotive, marine, and off-grid power systems. It's a standard voltage for many electrical systems, especially in vehicles and small-scale power setups. 12V batteries are widely used in automotive applications (cars, motorcycles, trucks), marine applications, recreational vehicles (RVs), solar power systems, uninterruptible power supply (UPS) systems, and various other off-grid or backup power applications.

Simulation model VAWT:



Result:





Applications:

1.The Indian government recently allowed offshore wind plants for power generation due to drastic energy demands. These plants can be easily installed at seashores and hilly areas.

2.Our main goal is to target industries and use waste air/power from exhaust as input for VAWT.

3. Also we can mount it on the rooftops of our houses, buildings, and normally in wind vicinity areas.

4. The system can also be installed between highway road dividers to act as a power generating station.

5. There are numerous small-scale applications for it.

Advantages and Limitations:

Advantages:

1. Eco-Friendly: Wind energy is eco-friendly, produces no pollution, and is completely clean. In contrast, energy from fossil fuels is an air pollutant and not completely clean.

2. Reliable technology: They can operate in multiple wind directions, making them more reliable in areas with turbulent winds.

3. Space Efficient: Our project is designed to be compact and can easily fit into tight spaces, such as urban environments.

4. Low noise production: It produces zero noise due to its minimal mechanism, unlike other generators and motors.

5. High Efficiency and Output power: As compared to other VAWTs the generator build is a Permanent Magnet Synchronous Generator which gives higher efficiency and about 50-watt output power.

Limitations:

1.Start-Up Torque: Small-scale VAWTs may require a higher start-up torque, meaning they need stronger winds to initiate rotation and begin generating electricity. This can limit their performance in low-wind-speed regions.

2.Lower Efficiency: Small-scale VAWTs generally have lower efficiency compared to larger wind turbines, especially Horizontal Axis Wind Turbines (HAWTs). This is due to factors such as lower tip speeds and higher drag.

3.Limited Power Output: The power output of small-scale VAWTs is generally limited, making them suitable for low to moderate power applications. They may not be sufficient for high-power-demand scenarios.

4.Structural Challenges: The compact and modular design of small-scale VAWTs may pose structural challenges in handling higher wind loads. This can affect the overall durability and longevity of the turbine.

5.Interference with Buildings: When mounted on rooftops or in urban environments, smallscale VAWTs may experience turbulence caused by nearby buildings. This turbulence can reduce the efficiency of the turbine.

Future Scope:

1. Improved Efficiency: Ongoing research and development efforts are focused on improving the efficiency of smallscale VAWTs. This includes optimizing blade designs, enhancing aerodynamics, and incorporating innovative materials to increase energy capture.

2. Smart Grid Integration: Small-scale VAWTs may play a role in future smart grid systems. Integration with advanced grid technologies can enhance the stability and reliability of energy distribution, allowing these turbines to contribute to decentralized and resilient energy networks.

3. Hybrid Systems: The integration of small-scale VAWTs with other renewable energy sources, such as solar panels or energy storage systems, can create hybrid energy solutions. Combining multiple sources can enhance reliability and provide a continuous power supply.

4. Urban Energy Harvesting: With advancements in design and aesthetics, small-scale VAWTs could become more integrated into urban environments, providing localized renewable energy in urban spaces, including rooftops and city landscapes.

5. Small-Scale Wind Farms: The deployment of multiple small-scale VAWTs in wind farms could become more common, especially in areas where larger wind turbines are not feasible. These distributed wind farms could serve local communities or supplement existing energy infrastructure.

6. Advancements in Materials: Continued developments in lightweight and durable materials can lead to the creation of more efficient and cost-effective small-scale VAWTs. Advanced composites and materials with improved fatigue resistance can contribute to longer turbine lifespans.

CONCLUSION:

In conclusion, small-scale Vertical Axis Wind Turbines represent a promising and evolving technology in the renewable energy landscape. While they come with both advantages and limitations, ongoing advancements in design, materials, and technology hold the potential to expand their applications and increase their efficiency. Here are key points to consider in summarizing the role and future prospects of small-scale VAWTs In conclusion, while small-scale VAWTs are not a one-size-fits-all solution, they offer a viable and sustainable option for specific applications and settings. Their continued development and integration into the broader energy landscape will depend on advancements in technology, supportive policies, and a growing commitment to renewable energy solutions.

REFERENCES:

1. **https://ieeexplore.ieee.org/document/9003999**
2. **https://www.elprocus.com/vertical-axis-wind-turbine/**
3. **http://www.iysertenergy.com/vertical-axis-wind-turbine.html**
4. **https://www.youtube.com/watch?v=qVhA-RGfsEc**