

1. Introduction

There is a growing demand for renewable energy sources, wind energy has become one of the most important renewable energy sources. 10% of the worlds total electrical power generation can be generated by the current installed global wind capacity of 1047 Giga Watts [1]. This project is focused on the research into wind turbines with the implications of being incorrectly faced into the wind. The research contains information on wind turbines, yaw systems, aerodynamics and yawing efficiency.

Hardware had been chosen and developed into a prototype device using a PIC microcontroller to measure the power generation and impact of incorrect yaw alignment on power generation within a wind turbine.

Data was collected using a multi-meter due to limitations of the LCD display connected to the circuit.

2. Aim

The project aim is to design and create a circuit to analyse power generation of a wind turbine at different angles and power consumption of a motor to yaw the turbine.

3. Objectives

- Produce a literature review on wind turbine operation, yaw mechanisms and the pact they have on performance.
- Evaluate hardware and software initial ideas.
- Create a working prototype of a turbine power generator circuit.
- Test the circuit under certain input conditions, record and analyse the results
- Discuss improvements which could be done in the future

4. Research

Wind turbines consist of various components areas which are important for the operation of the turbine to work, this includes:

- Wind energy production and wind turbine systems, looking at how important they are for global energy production, how wind turbines work to generate electricity and the components found within them.
- Aerodynamics of a wind turbine, how a turbine moves using kinetic energy, a calculation on how much power a turbine can produce from the wind, how much power a turbine can extract from the wind using the Betz limit [2] and the importance of facing a turbine into the wind.
- Yaw control systems, the reason to have one within a turbine, how it operates and the implications of incorrectly controlling the yaw position of a turbine.
- Energy needed to move the turbine in a yawing motion, how much energy is needed to move it and information on yaw deadbands to stop excessive movement [3].
- DC motors, how a DC motor works, different types of DC motor and improvements on DC motors such as brushless motors.

5. Design and implementation

The final prototype had been created within a proteus simulation to simulate if the hardware and software were working together. This was then implemented into a hardware design, using a PIC18F45K22 programmed to detect an analogue input from the wind turbine and to turn that value into voltage and current whilst monitoring if the voltage went above a certain threshold to control the motor, and what the 8-bit LEDs would output as a binary value representing the current voltage output from the turbine.

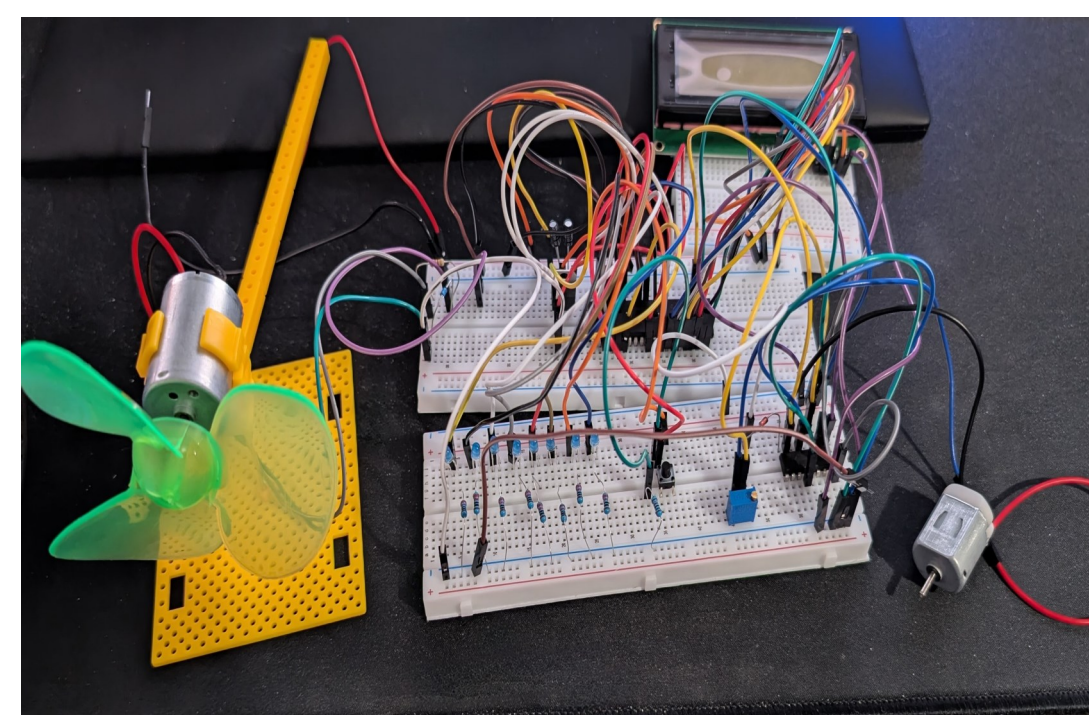


Figure 1 - Hardware Design

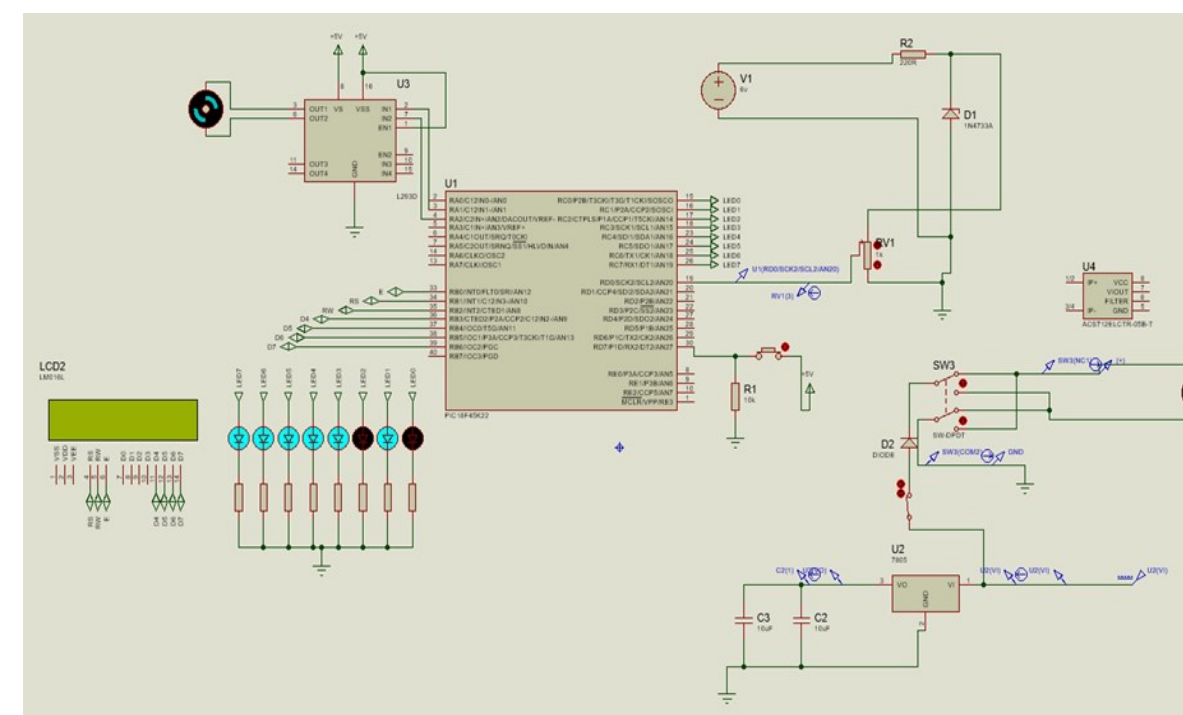


Figure 2 - Proteus Simulation Design

6. Testing and results

Testing had been completed with first testing if the simulation was able to correctly show the data needed to be gathered from circuit. The hardware was tested using a multi-meter due to limitations of the circuit. The power equation of $P = V \cdot I$ was used to calculate the DC power across a load from the wind turbine, to see what results would occur at 3 different wind speeds at a full alignment of 0° and misalignment of 20° .

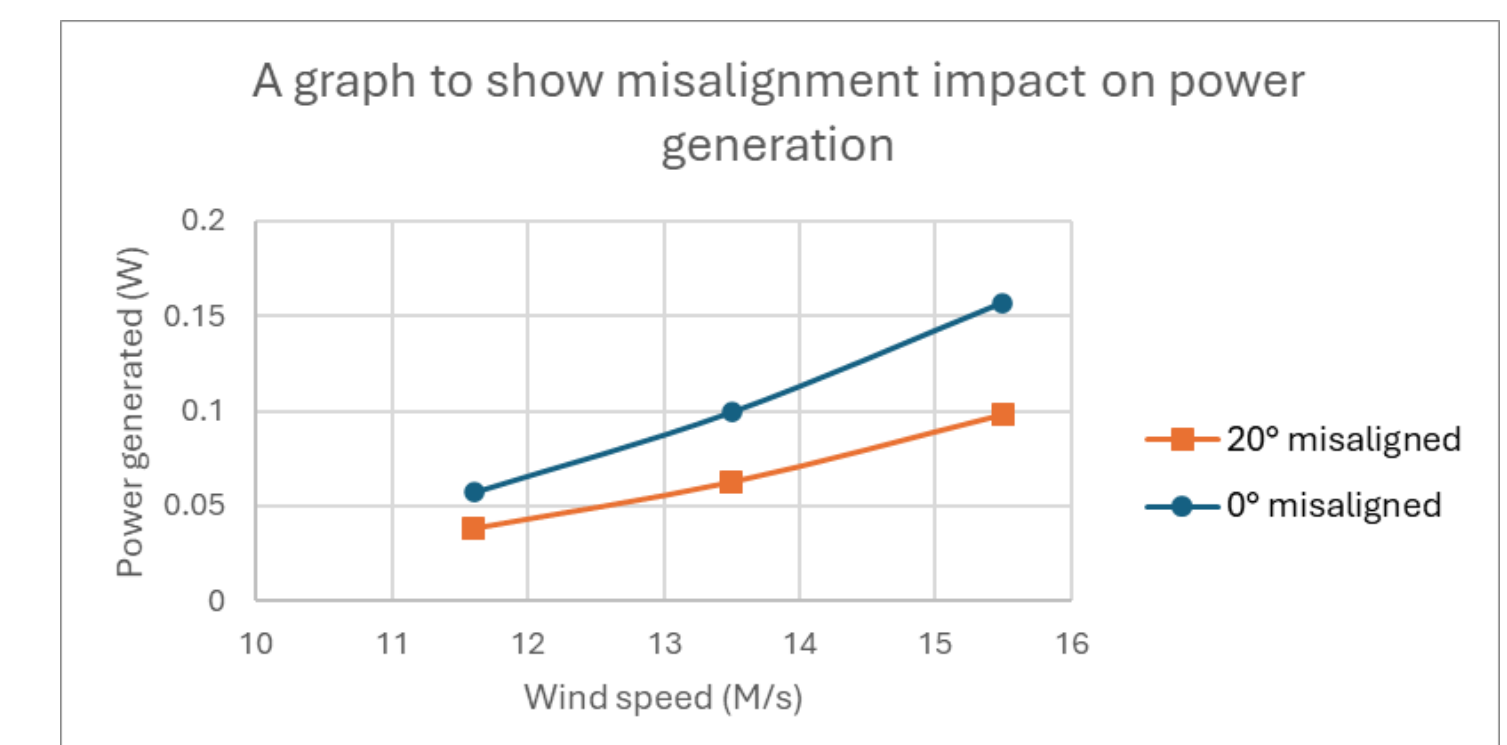


Figure 3 - Power generation results from the wind turbine

7. Conclusion

The project overall did not work ad intended, the LCD display did not work to a suspected driver issue and the DC motor would need to be replaced with a higher torque motor to move the wind turbine around when it is activated such as using a stepper motor.

Some results were able to be gathered through other means of using a multi-meter showing the impact yaw misalignment can have on power generation. Majority of the aim was achieved as well as the objectives. Any future improvements could be to do more research into the LCD driver, more testing of different DC motors and to implement the wind turbine into a bigger scale to see the impact a larger turbine has on power generation.

References

- [1] World Wind Energy Association "WWEA Annual Report 2023: Record year for Windpower," Mar. 27, 2024. [Online]. Available: <https://wwindea.org/AnnualReport2023> (Accessed Jan. 03, 2025)
- [2] Energy Education "Betz limit" [Online]. Available: https://energyeducation.ca/encyclopedia/Betz_limit (Accessed Jan. 05, 2025)
- [3] Ervin Bossanyi "Optimising yaw control at wind farm level" 2019. [Online] Available: <https://iopscience.iop.org/article/10.1088/1742-6596/1222/1/012023/meta> (Accessed Mar. 18, 2025)