

Development of a low cost Wind Turbine Emulator for Research and Educational purposes

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Abstract:

Humankind has harnessed electricity from the wind since 1887. As of 2021, renewable energy has a 9.2% stake in energy production in the USA. Among renewable energy sources, wind power is one of the most popular resources. As wind speed is intermittent in nature with random variation, it yields variable power. Therefore, it is essential to analyse the performance of real wind energy before installing at the proposed site.

However, it is difficult to install wind turbines for research and development purposes. Factors such as space consumed, costs, time-consumed and the intermittent nature of wind confines the research conducted on wind turbines specially in universities. Therefore, a low-cost wind turbine emulator is developed in this project. It mimics the behaviour of wind turbines for hardware level simulation and addresses the drawbacks involved with a real-life wind turbine, whilst providing a user-friendly interface and providing useful referential analysis. The emulator comprises a software component based on LabVIEW with a hardware interface of a motor driven generator which reproduces the same characteristics of a given wind turbine at any wind velocity. It is designed to allow users input values such as wind speed, pitch angle, temperature, and humidity which are fundamental in calculating the energy generated and provides results like torque, tip speed ratio, coefficient of performance value etc. of the wind energy conversion system.

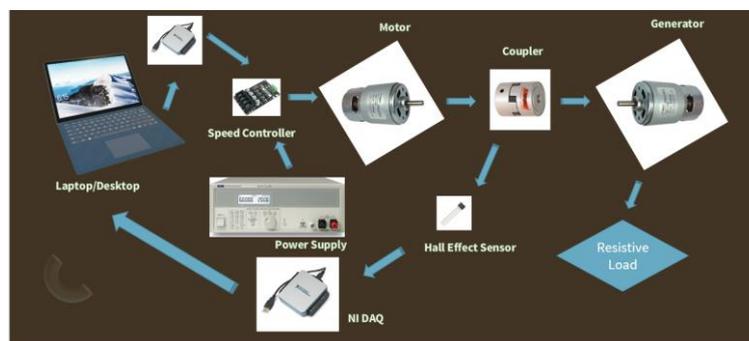


Figure 1: A simple setup of the wind turbine emulator

The physical components include a laptop licensed with the LabVIEW application, as most computations take place on in the back end. An NI DAQ is used as an interface between the

laptop and the motor driver, which uses PWM methods to drive the DC motor with the help of a DC power supply. Power generated by the second DC motor will be used on an electric load whilst the tachometer loops the rotational speed of the turbine for error proofing the run. A recently updated version of the emulator allows the user to input a 24-hour wind profile through an excel file, differentiate between high and low speed wind days, and point out characteristics of the tip speed ratio against the Coefficient of power produced.

Several tests conducted to determine the accuracy of the emulator as follows

- Difference in results between three wind turbines of varied ratings (2.2KW, 850KW, & 5MW)
- Difference between high and low wind speed days on turbine with a rated speed of 12m/s
- Changes in the Coefficient of performance with varied beta

Coefficient of Performance is the measure of the power captured by the turbine from the wind flowing in its cross-sectional area. Beta is the angle of pitch that the turbine blade creates with the axis perpendicular to the surface of the tower. Most emulators available in the market cost upwards of \$10,000. However, total costs associated with the newly developed emulator for the hardware and software is just under \$4000. This emulator will serve as an educational and research tool for students who are interested to learn more about wind turbines. It can also be used to analyze proposed locations before the installation of wind turbines.

References

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