

**DEVELOPMENT AND SIMULATION OF A WIND GENERATOR TEST BENCH SYSTEM/  
РАЗРАБОТКА И МОДЕЛИРОВАНИЕ ИСПЫТАТЕЛЬНОГО СТЕНДА ДЛЯ  
ВЕТРОГЕНЕРАТОРА**

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**Introduction.** Wind energy is a widely used renewable energy source, but it faces challenges due to the unpredictable nature of wind, leading to variable mechanical power output, making it difficult to analyze and optimize wind turbine performance in real-world environments. To address this challenge, Wind Turbine Emulators (WTEs) are developed. These emulators provide a controlled and repeatable test platform allow testing, developing and evaluating Maximum Power Point Tracking (MPPT) algorithms[1], power electronics, and generator performance in a controlled environment without relying on natural wind conditions. Previous research has employed different types of motors (DC, permanent magnet synchronous, and induction motors) to replicate real wind turbine behavior[2]. However, this study focuses on using a DC motor controlled via a full-bridge DC-DC converter, which offers better low-speed performance, ease of control, and enhanced efficiency for MPPT research.

**Main Part.** The study presents the design and development of a Wind Turbine Emulator (WTE) that replicates the performance of a real wind turbine under variable wind conditions. The emulator consists of:

- Mathematical modeling of wind turbine characteristics using compute reference speeds based on wind speed, rotor radius, and air density[3]
- Control system design with two PI controllers (speed and current control) to ensure the motor accurately tracks theoretical wind turbine rotor speeds derived from aerodynamic models.
- A full-bridge DC-DC power converter for controlled power supply
- A DC motor as the prime mover, replacing the actual wind turbine rotor

The proposed system allows researchers to simulate wind speed variations, test control algorithms, and analyze WECS performance efficiently. Compared to previous WTE implementations, this approach enhances flexibility, improves low-speed accuracy, and provides a cost-effective alternative for laboratory research and system validation.

**Conclusions.** The results of this study confirm that the Wind Turbine Emulator (WTE) accurately replicates the behavior of a real wind turbine. A comparative analysis between a generator directly connected to a wind turbine model and a generator connected to a DC motor-based emulator demonstrated nearly identical power, speed, and torque characteristics under the same operating conditions. This validates the effectiveness of the emulator in replicating the dynamic behavior of actual wind turbines and establishes it as a reliable platform for MPPT research and performance optimization of wind energy systems under a wide range of simulated wind conditions.

## References

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- [3] K. Liao, D. Lu, M. Wang, and J. Yang, “A Low-Pass Virtual Filter for Output Power Smoothing of Wind Energy Conversion Systems,” *IEEE Trans. Ind. Electron.*, vol. 69, no. 12, pp. 12874–12885, Dec. 2022, doi: 10.1109/TIE.2021.3139177.