Hybrid Wind and Solar Generation

Iowa State University

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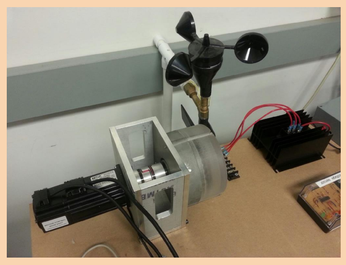


Project Overview

A sustainable, off-the-grid generation system is desirable for many situations. Environmental concerns may turn a consumer away from fossil fuels, or connection to a traditional power grid may be impractical. Wind turbines and photovoltaics have seen a reduction in cost in recent years.

A hybrid wind and solar generation system has many useful applications. It can be used to make an existing grid more environmentally-friendly, or provide power to communities in remote areas. This project is aimed at developing reliable generation for small-scale loads, and providing an educational opportunity for future students.

The purpose of this project was to build a hybrid wind and solar generation system to reliably power a small load. The system will account for different environmental conditions and supply power accordingly. We initially modeled the system in Simulink to test component behavior before starting the hardware design.

Design Requirements

Functional

- Design a working simulation of the generation systems
- Reliably supply provide power to a small load
- Integration of inverter, battery bank, and AC load into the generation system
- Operate under a variety of environmental conditions

Non-Functional

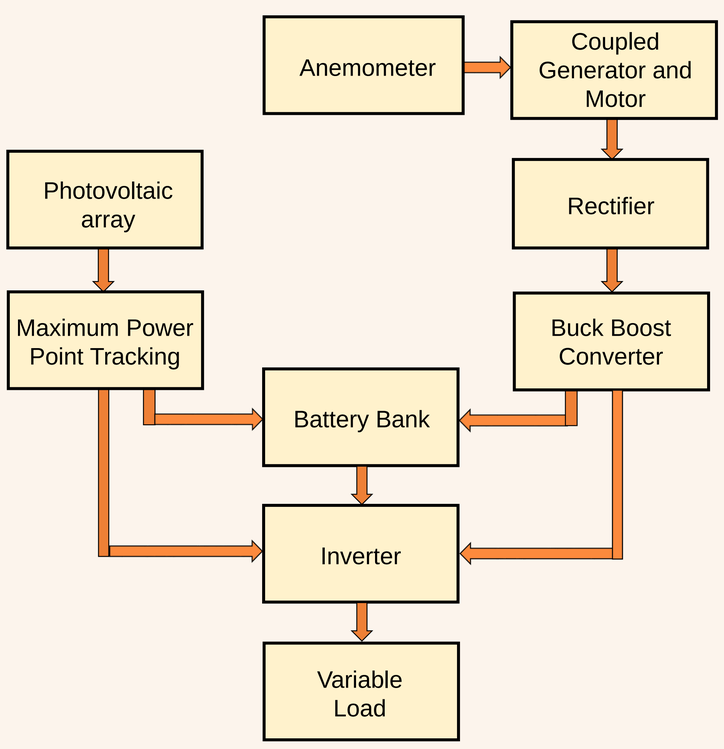
- User friendly, intuitive, and safe
- Document progress for future groups

Operating Environment

- Power systems lab in Coover Hall on Iowa State University Campus

Design Approach

- Photovoltaic panels generate power
- Maximum Power Point Tracking (MPPT) optimizes solar panel output and regulates current flow
- Motor simulates power based on wind speed
- Generator output is rectified, stabilized, then inverted
- Both systems are joined at common DC bus with battery bank
- Battery bank stabilizes voltage and absorbs or provides power as needed
- Inverter converts DC input voltage to 120 Volts AC for variable resistive load



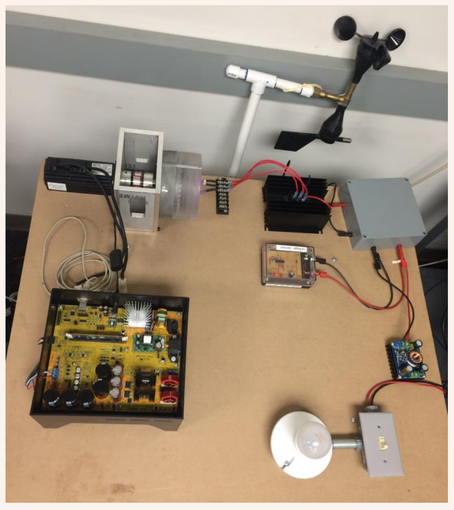
Block diagram of hybrid generation system

Technical details

Solar Generation

- Photons generate current in the photovoltaic cells by exciting electrons in the semiconductor
- Rating of panels depends on number of cells in series (voltage) and in parallel (current)
- Total solar output is dependent on solar intensity and temperature
- MPPT adjusts solar panel voltage to maximize power, and determines the direction of power flow

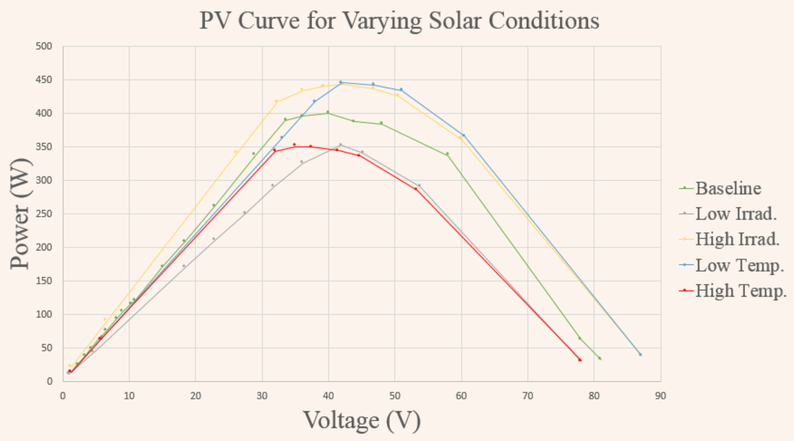
Solar generation system, with inverter and load



Wind generation system, with simplified load

Wind Generation

- Anemometer readings determine motor speed that corresponds to actual wind turbine potential
- Coupled generator produces three-phase power
- Rectifier converts AC to variable DC, based on motor speed
- Boost converter maintains constant 24 Volt DC
- Power diodes prevent backwards flowing current



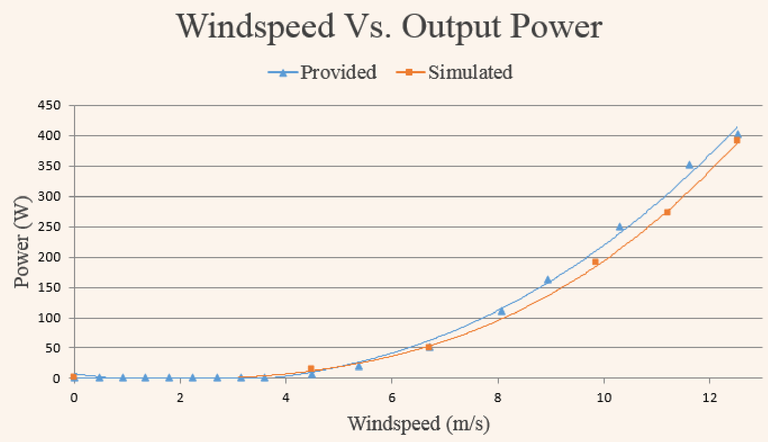
Data gathered from simulation of solar panels

Combined System

- Generation sources complement each other during non-optimal weather conditions
- Battery bank comprised of two 12 Volt lead-acid batteries in series
- Configurable load allows for convenient testing of the complete system

Testing

- Modeled wind and solar generation systems to obtain input and output of individual components
- Tested each hardware component for functionality
- Systematically built and tested each system piece by piece before combining
- Tested the hybrid generation system to supply loads between 100 and 400 Watts



Comparison of provided and simulated wind power