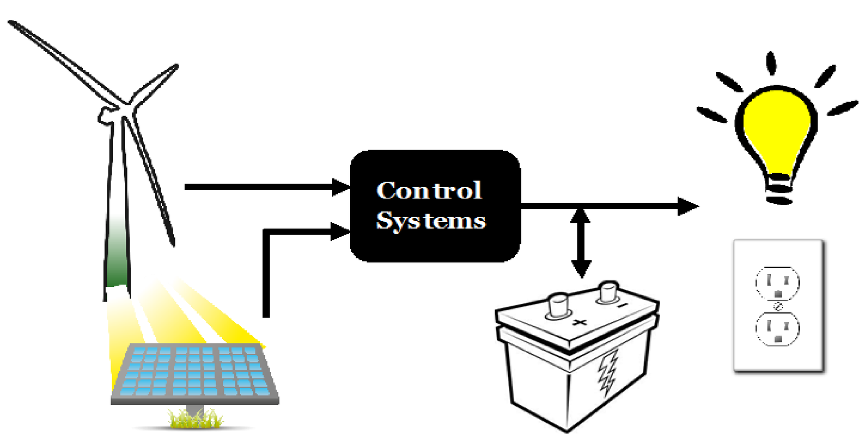
May1727 - Standalone Hybrid Wind & Solar Generation System

Members: Nathaniel Byrne, Eric Cole, Brian Gronseth, Matthew Lee, Jeffrey Szostak, Michael Trischan
Advisor: Dr. Ajjarapu
Mentors: Pranav Sharma and Ankit Singhal

INTRODUCTION

Our design project developed lab manuals and curriculum pertaining to hybrid wind and solar power generation. Specifically, EE 452, the Power Electronics class at Iowa State, has the means through hardware and software to give students this learning opportunity, but is lacking lab materials that cover important topics pertaining to renewable energy and microgrid environments. We accomplished this by first building simulations of a wind energy system, as well as a solar PV system in Simulink to gain a better understanding of our hardware. After we were certain that these simulations were working on an individual level, we integrated the two systems and documented the outcome to produce an array of lab manuals pertaining to:

- PV generation hardware and software
- Wind generation software
- Hybrid wind and solar generation software



An underlying goal of this project is to benefit the electrical engineering power department by leaving a usable lab document, as well as the hardware that goes along with it. We have the solar panel hardware functioning for the usage of the 452 lab and have gained access to a WESO wind turbine for future groups to use.

INTENDED USERS AND USES

Users

- This project is intended to supplement student learning for those who are taking EE 452 in the power department. Therefore, at the professor's discretion, students will be the primary users of the project deliverables in a lab setting. Lab experiments will be done under the guidance of a TA who is knowledgeable on the PV hardware system, as well as the software simulation portion of the experiments.

Uses

- The deliverables of this project are designed to be supplemental learning tools for EE 452 students who are studying renewable energy.
- The wind and solar power generation simulations can model current trends in a microgrid both individually and combined as a hybrid system.
- Solar hardware is capable generating energy that is sufficient enough to simulate a 120 VAC wall outlet through a combination of PV energy and battery supply. With proper irradiance, the system can power between one and three lightbulbs.
  - National Instruments software can track real time irradiance measurements.

TESTING

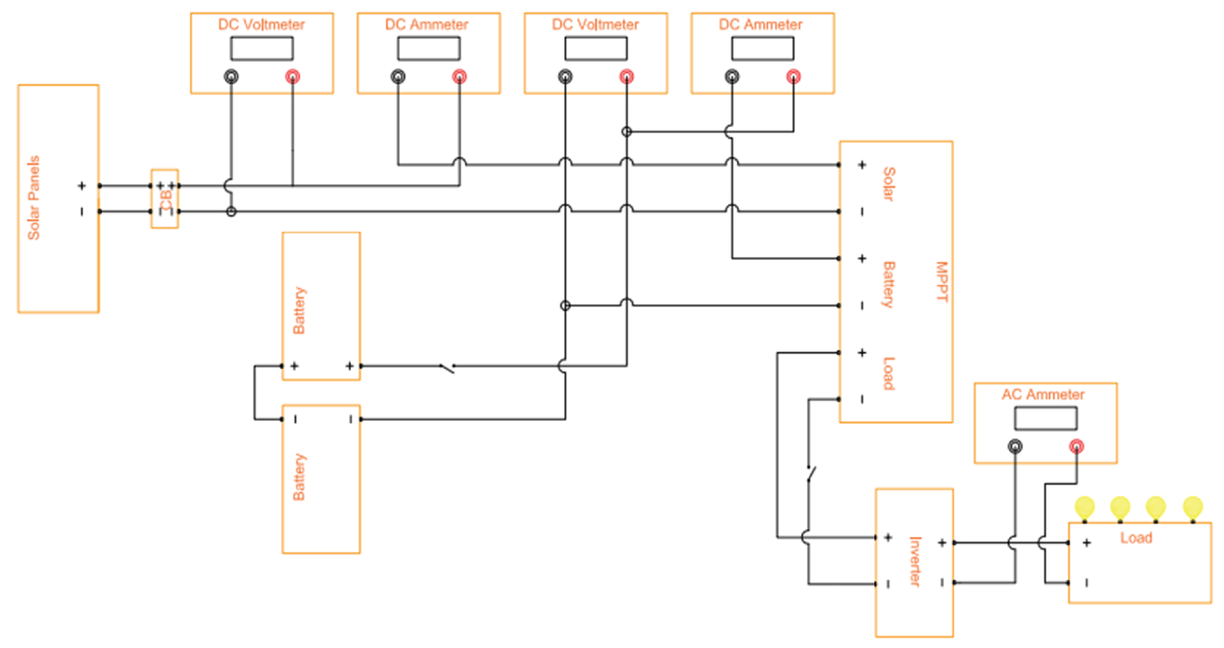
Testing Environment

- MatLab Simulink - System testing was performed in various simulated weather profiles generated through a scripted MatLab interface.
- Hardware - Real inputs were used to analyze the system's response in actual weather conditions.

Testing Strategy

- Both software and hardware components were tested on a per unit basis prior to assembling the system. Validation of Kirchoff's Laws and the Conservation of Energy verified that our system was working properly.

Solar Hardware Circuit Diagram



Simulation Results

Input Power	300.94
Output Power	300.81
Power Loss	-0.12
Efficiency	99.96%

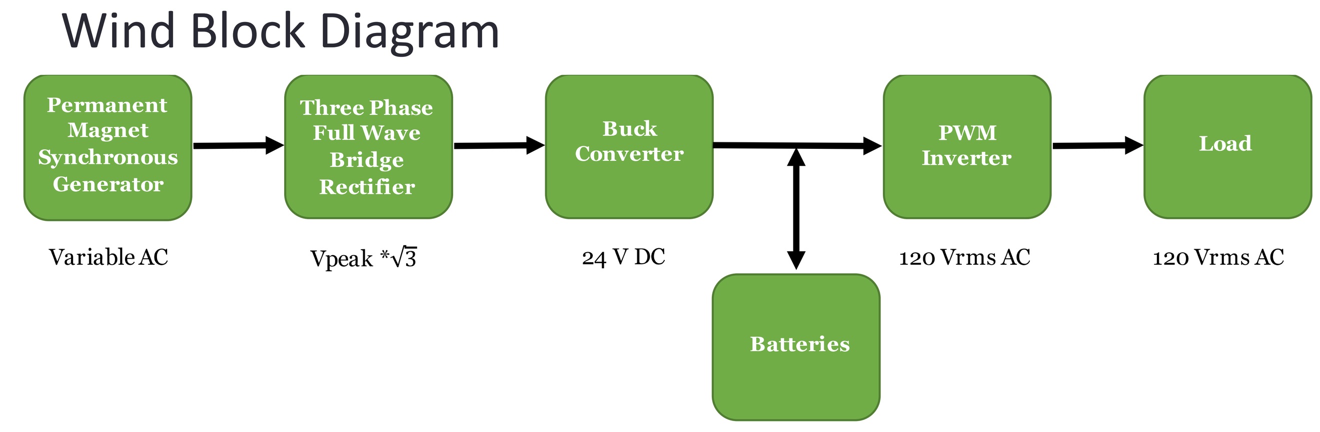
Hardware Results

Input Power	246.97
Output Power	202.85
Power Loss	-44.12
Efficiency	82.14%

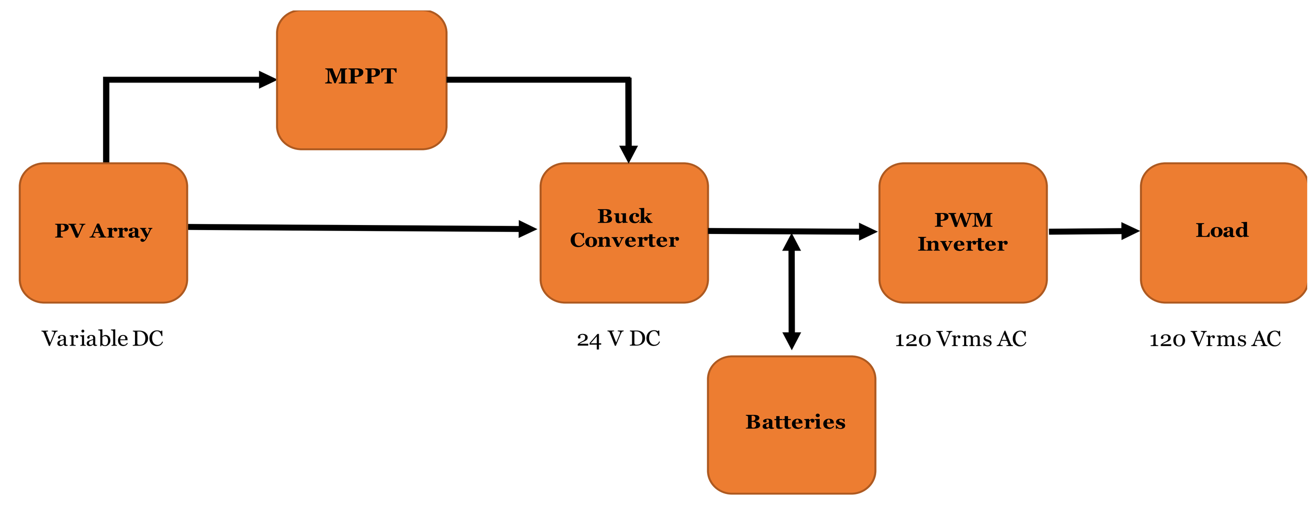
DESIGN

- Power generated in PV Array and Wind Turbine
- PV Array generates DC voltage and is stepped down to 24 VDC via Buck Converter
- Wind Turbine generates AC voltage and is converted to 24 VDC via Rectifier and Buck Converter
- Batteries provide power when PV/Turbine aren't producing enough; stores power when PV/Turbine are producing excess power
- Inverter converts 24 VDC to 120 VAC and supplies power to load

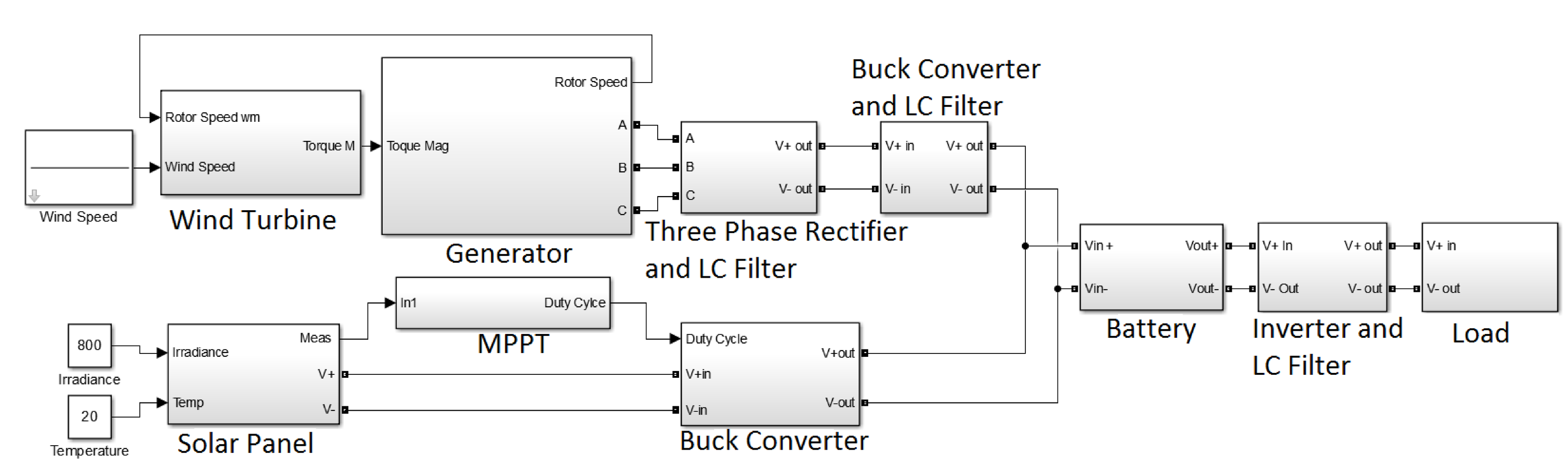
Wind Block Diagram



Solar Block Diagram



Hybrid Block Diagram



TECHNICAL DETAILS

Power Generation

- Kyocera KD125GX-LPU: Photo-Voltaic array generates 136 W, 22.1 V open circuit, 8.37 A short circuit
- Simulink: Permanent Magnet Synchronous Generator produces voltage from blade driven rotation from wind flow

Power Control

- SunSaver SS-MPPT-15L: Maximum Power Point Tracking (MPPT) of continuous power flow via feedback loop with built in conversion

Power Storage

- Universal Battery UB12900 12 V, 90 AH & SigmasTek SP12-100 12V, 100 AH: Two lead acid battery units wired in series to create a 24 VDC module

Load

- Filament based light bulbs (144 ohm, 100 W) and modeled as a purely resistive load

Power Converters

- (Integrated within MPPT): Buck converter driven by PWM output from MPPT
- Samlex Power DC-AC Inverter: 600 W, 24 VDC input, 120 VAC output at 60 Hz
- Simulink: Three Phase Full Wave Rectifier for AC to DC conversion and voltage control

Sensors

- National Instruments NI WLS-9163: Microcontroller Sensor port bank operating with National Instruments Software Suite 2010
- LI-COR Pyranometer: PY 73079, 75 µA sensitivity up to 100 W/m^2, +/-3% uncertainty after calibration, -40° to 65° operating temperature range