EE -- 41430 Brian McGee, Dan Mikovits, Kelsey Farr, Maia Nieves, Sylvia Kolda 10/20/20

Senior Design Proposal - Microgrid

Introduction

As our world transitions to cleaner energy in response to climate change, innovative technologies must arise to provide affordable and practical solutions for communities. Solar microgrids are one such emergent technology, and offer clean, resilient energy to a community. Additionally, microgrids can keep money within a community by allowing units that generate a surplus of power to sell it off to other units that need more. However, microgrids (especially solar ones), require a robust energy management and storage system to operate effectively, and microgrid technology and support must be improved to make microgrids more practical to implement.

Problem Description

Main Problem: *microgrids need to be easier and more practical to implement*

Solar cells provide transient energy, but an energy storage device is needed to provide energy when solar cells are inactive. Additionally, a solar microgrid needs to provide enough power to meet community demands that change throughout the day, especially responding to peak loads. The system must also monitor for faults or other errors that may occur and perform power switching to keep all of the loads operational. The power factor of each load/source must also be monitored to determine system efficiency, stay within operational ranges, and determine power cost.

Proposed Solution

The proposed solution is to develop a smart energy storage switching system that monitors and responds to varying power demand, transient power generation, and faults. To do this, we intend to create a model microgrid with multiple homes of varying loads and power generation capabilities. Each home will be modeled with solar panels for power generation. Power not consumed at the load will be sent to a battery storage system where the monitoring and switching will occur.

Demonstrated Features

The following features will be demonstrated:

1. Confirm power inflow and outflow from each source to battery storage
2. Accurately monitor storage availability in relation to power inflow/outflow, as well as power factor at each load, via a digital dashboard

3. Verify that when a fault occurs, it is detected by the monitoring system and shown on the dashboard
4. Recover from the fault by utilizing power switching at the battery storage

Available Technologies

The following list includes parts and devices available for us to implement and make use of to build our system. These possible options all meet our needs and fall within a reasonable price range.

- PCB with voltage monitoring and serial communication capabilities (~$50)
- Wires to represent the cables connecting homes and the storage system
- Rechargeable batteries for the storage system (about $20-$40)
- Solar cells
- Step-down converters to convert the grid voltage to a voltage that can be read by an analog pin on the microcontroller
- Switches to perform the fault recovery power switching (preliminary searches ~$2)
- Inverters to transform 12V DC to 12Vrms AC power battery storage and each load

Engineering Content

In completing this project, our team will need to apply our engineering knowledge. This includes our knowledge of batteries, sensors, microprocessors, power grids, DC and AC power, and power loads. We will build a network of battery cells to meet energy demand. The network will include switching capabilities and sensor capabilities. In addition, we will design a system of sensors to monitor the grid, step-down voltages, and read them into a microprocessor to take real-time samples and communicate them serially to a computer for processing and display. Further, we will build a functioning power grid scaled to run at 12Vrms (downsized by a factor of 10 from real-world transmission systems) and design unique loads with solar generation capabilities, potentially modeling buildings for a miniature Notre Dame campus. Finally, we will design a dashboard that takes the serial communications and clearly displays them to the user.

Conclusions

We have a good handle on our project and plan to start with the expected load profile of our grid. From there we can start to design our energy storage system and determine how we want to perform the fault recovery switching and what our tested faults will be. We may split the work by focusing some members on designing the monitoring/switching system and other members on designing and building the storage apparatus.