HIGH PHOTO-VOLTAIC PENETRATION AND THE IMPACTS ON DISTRIBUTION SYSTEMS

DESIGN DOCUMENT

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Project Charter

Project Name	High Photo-Voltaic Penetration and the Impacts on Distribution Systems
Project Field	Distribution Protection Systems
Class Group	EE/CprE/SE 491 Senior Design: Dec15 – Group 20

Team Member	Position and Responsibilities
Shane Thompson	Team Leader
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Revision	Date	Description
R1.0	March 13th, 2015	First Iteration of Document

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Project Overview

Abstract

With the increase in consumer green energy there has been a surge in High PV penetration or backflow into distribution systems. The current designs (implemented in the 1950's) of the distribution systems cannot handle the power leaving the customer's inverter and feeding back into the distribution system. This is causing issues to consumer and industry utility equipment changing the power factor and putting the network out of phase. This can also cause issues with customer/utility safety, harmonic imbalance, and fault behavior.

Background

Photovoltaic (PV) solar cells are a cost effective manner to reduce energy costs and carbon emissions. Consequently, this has resulted in an increase in installation of PVs on residential homes and farms. However, there are often times when the PVs generate more power than is being consumed by the resident. To dissipate this excess power, the PV inverters are connected to the distribution grid. This defines a concept called Distributive Generation (DG). DG can result from multiple sources including but not limited to: wind turbines, gas generators, and geothermal generators. However, a vast majority of the DG comes from PV cells.

Initially, the DG was not a huge issue to the power company. In fact, it was beneficial since it allowed the company to provide less power to the distribution feeder. However, with the rapid increase in DG on many distribution feeders, the utilities company have found themselves dealing with a new problem. The DG caused by PV penetration can peak and cause the utility equipment to exceed their rating limit. This can result in damaged equipment, power outages, and loss in capital.

Objective

There are two main objectives to this project. The first involves locating and identifying potential problems to the feeder. Using OpenDSS or equivalent modeling software, tests will be run on the distribution feeder. These tests will determine specific issues that arise when PV penetration increases over time. It will highlight the major issues and where they are located. Once this is determined, the second objective can be completed.

Once the major issues and contingences have been identified, a proper solution can be forged. In order to maintain sustainability and stability, the protection system of this feeder will need to be upgraded to deal with the increase in DG.

System Level Design

System Requirements

Detection and analysis:

The proposed solution would have to be an "active listener." Meaning that we need to use conventional equipment that already exists on current distribution network that would be able to detect when the network is receiving extra DG power-flow across the lines. With light modification we should be able to employ minimal equipment to customer's existing setup thereby hopefully limiting additional cost to Alliant Energy and their customer's.

Functional Requirements and Decomposition

The solution to the issue will require many sub-solutions to achieve our overall goal: Reducing high photo-voltaic feedback through the power distribution grid.

- Phase one:

  Control – this section of the solution will be used to analyze the network and detect potential feedback during peak usage, high demand times, or excess generation by the customer. This system, that may to be added by Alliant Energy, would then send a signal to tell the next phase go into action.

- Phase two:

  Redirecting DC generated power flow – in this portion would tell the customer's solar array to stop inverting the power to an AC form and use the DC generation to be stored in phase three.

- Phase three:

  Storing excess power – As the customer generates power in this phase it will be stored in a bank of batteries, potentially Lithium+, then once the load on the grid exceeds generation the system can then convert stored power into AC and redistribute the electricity back on to the grid.

Once demand has returned to nominal levels the system will resume normal function until it detects a potential issues.

Nonfunctional Requirements

- Battery bank size and charging constraints.
  Once we have determined the power-flow analysis we be able to determine the size and charging constraints needed for battery storage.

- More TBD

System Analysis

Services

The following data will need to be generated on a real-time basis. Then provided to us as a snapshot over a specified time interval.

- Demand on current load
- DG generation by customers
- Power input by generation
- Key peak times

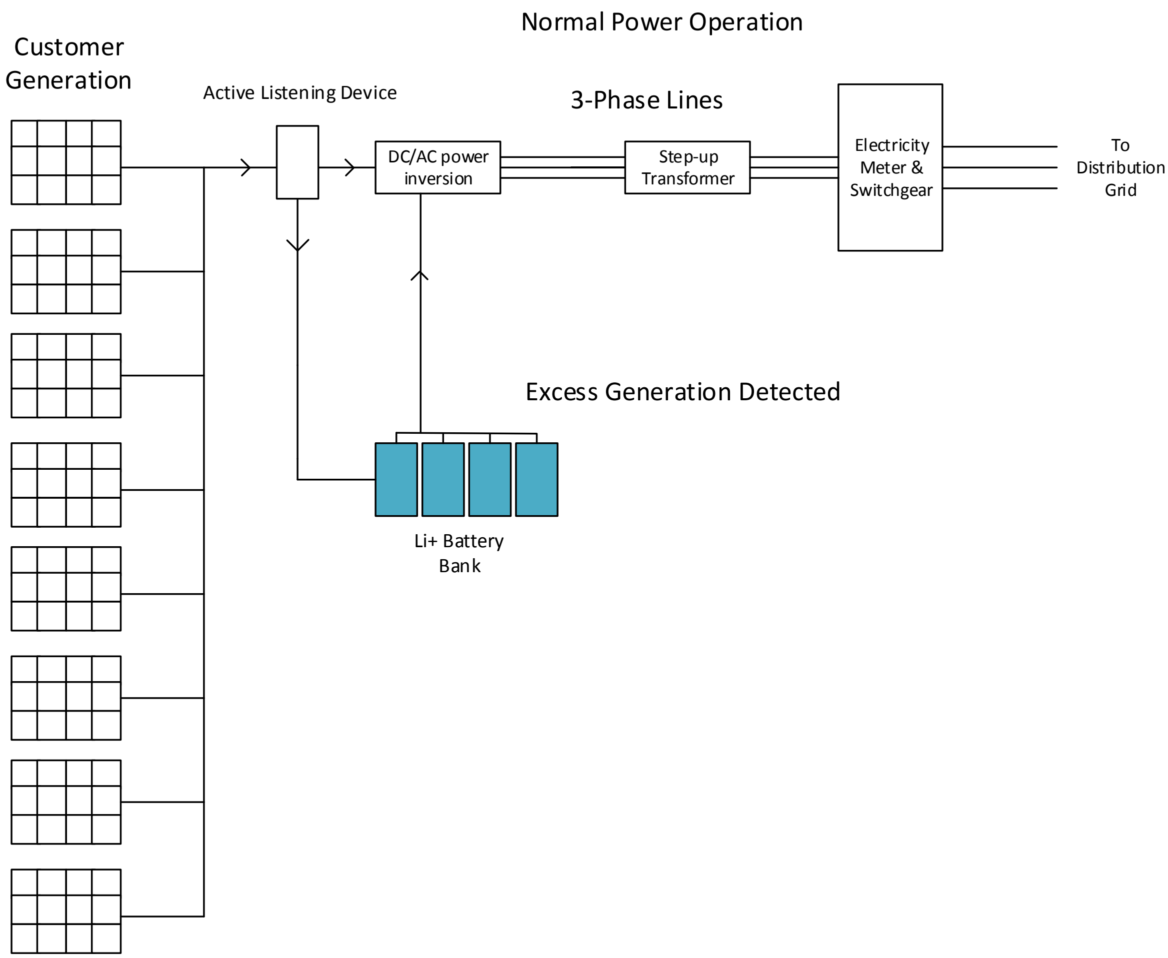
Data

Data will be provided to us from Alliant Energy. Although at this time we do not know how it will be given to us. We do know that will when we do receive it we will most likely have to manually enter it into our distribution analysis tool: OpenDSS. This data will be a snapshot of current demand on the gird and will allow us to execute preliminary analysis. Once this is achieved we will receive updated data weekly to modify and execute our solution.

Interface

Our primary tool will be OpenDSS. This distribution software will allow us to analyze and review our results after each test or simulation.

Block Diagram



Detail Description

Project Description

Our main issue with using Open DSS for this project will be the ease at which all of the points from Alliant can be entered into this software.

Alliant uses a program called “Synergy” to organize the layout of the system. We will need to figure out how to allow synergy and Open DSS to communicate in order to get all of the points in the system from Synergy to wind up in Open DSS for us to analyze. There is the possibility that these two programs will not be able to work together. However, we know how to enter points manually into Open DSS thanks to some tutorials we found on how to set up a basic system. This method will take longer to set up the system, but it may be necessary if all else fails.

Open DSS uses basic coding in order to return the results of a basic simulation, as well as show a visualization of where on the circuit all of the values lie. Since we are waiting for the official design from Alliant (which should arrive soon), we do not have any official simulation of our actual design right now. However, with our knowledge of how Open DSS works, we will be able to have a version of our simulation in no time.

As already noted, we are waiting for the official layout of the system we will be using from Alliant. This obviously is the biggest thing standing in the way of us being able to test the system at this time. However, our group realizes the importance of knowing how we will go about testing. Therefore, we have been learning about Open DSS, and we feel that when the actual layout comes from Alliant, we will be able to test and analyze it quickly.

Our plan, once we get the actual layout from Alliant, is to figure out if Synergy is compatible with Open DSS, and get all of the points from the layout into Open DSS. We will then be able to add windmills or other household items that could cause issues to the grid. We then will test different possible solutions to this problem.

Works Cited

1. Ochoa, Dr Luis. "Https://www.escholar.manchester.ac.uk/api/datastream?publicationPid=uk-ac-man-scw:229196&datastreamId=OpenDSS_Training_-_02_Introduction_to_OpenDSS.PDF." *OpenDSS Training Material*. Dr Luis Ochoa, 1 Feb. 2013. Web. 13 Mar. 2015. <https://www.escholar.manchester.ac.uk/api/datastream?publicationPid=uk-ac-man-scw:229196&datastreamId=OpenDSS_Training_-_02_Introduction_to_OpenDSS.PDF>.