Wind Energy System

Senior Project Proposal

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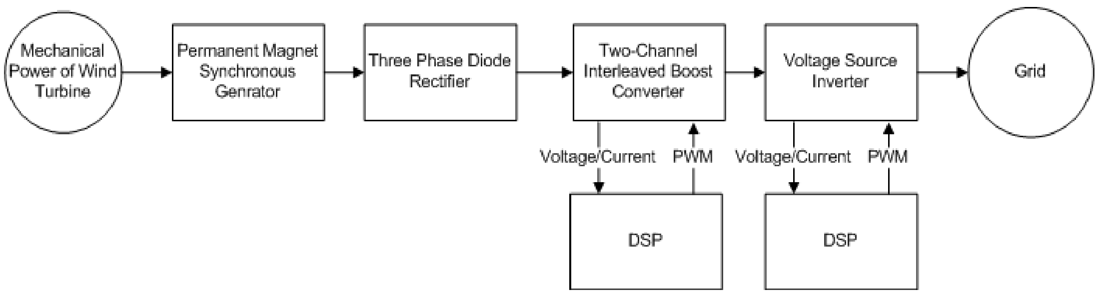
Project Summary:

The purpose of this project is to design and implement a system that converts wind power into a stable AC power source. This will be a three stage system, starting with a diode-rectifier, followed by a two-channel interleaved DC-DC boost converter, and finally another IGBT switched inverter system. In order to implement the DC boost converter, the project will need controlled switches as well as some controller. The controller we want to use for this project is a DSP processor. The basic topology of the circuit is shown below, and if time permits, modifications will be made to the system in order to improve overall performance.

System Block Diagram:

The overall system block diagram is shown in figure 1.



(Figure 1 Top Level Diagram)

This particular system converts wind energy into electrical energy using components such as a permanent magnet synchronous generator, a diode rectifier, a two interleaved boost converter, and a voltage inverter as depicted in Figure 1. The system will begin by harnessing kinetic energy from wind that will rotate the blades of a permanent magnet synchronous generator creating mechanical power. The electrical energy produced from the permanent magnet generator will be output as three-phase AC. From this output, another conversion from AC to DC will take place through the use of a three-phase rectifier that will enable the use of a boost converter to boost our DC voltage. In order to boost the voltage that will be needed to supply the grid, we will use two interleaved boost converters. The DSP board will be responsible for handling the switching process of the boost converters. Moving from the boost converters we will perform yet another conversion from DC to AC by an inverter. Finally, this AC will be supplied to grid power.

Subcomponent Description

A description of the major subcomponents of this system is discussed below. The final implementation will depend on problem determined during actual implementation and testing. However, the overall topology of the system will largely remain unchanged.

Permanent Magnet Synchronous Generator

This project will require the use of a permanent magnet generator because of the following reasons: They do not require an additional DC supply for the excitation circuit, they are generally simpler and maintenance free, it will be easier to rectify the power to be used with a grid tie, condensers are not required to maintain the power factor and operates at a higher efficiency over a wider range of power output.

Requirements

- Capable of producing one Kilowatt of power.
- Must produce output in three phase.
- Must supply a substantial current output. (10A or higher)

Three-Phase Diode Rectifier

In short, a rectifier is an electrical device that converts AC into DC. Since the generator will output a pulsating voltage, and it will vary in both magnitude and frequency. With this information in hand, choosing the diodes that will coordinate effectively with the output of the permanent magnet generator will be a simpler task.

Requirements

- Must be able to handle 400 V and 12 A.
- Must be able to input three phase AC.
- Must be able to handle 2kw of power.

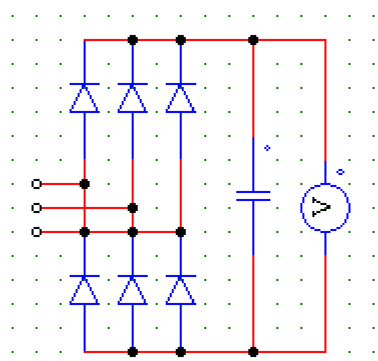


Figure 3 Three-Phase Rectifier

Two Channel Interleaved Boost Converter

The boost converter takes in the varying DC voltage from the three-phase rectifier and outputs a constant voltage into the input terminals of the voltage inverter. The boost converters will be controlled by a DSP board which will handle the switching of the boost converters. We will be using IGBTs to meet the requirement of the high voltage produced form the generator.

Requirements

- Must be capable of handling 400V and 12A
- Must be capable of switching at 100kHz

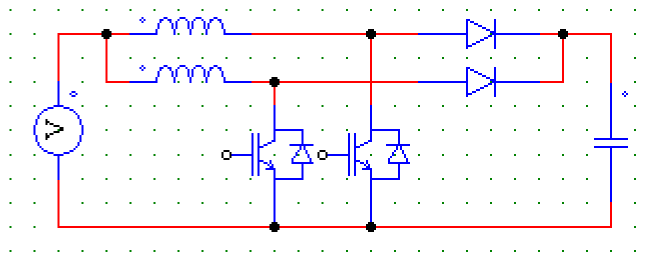


Figure 4 Two Channel Interleaved Boost Converter

Single Phase Grid-Tie Inverter

An inverter is basically the opposite of a rectifier, as in it converts DC into AC. The type of the inverter that will be used is known as a grid-tie inverter. A single phase grid-tie inverter (GTI) is a unique type of inverter that converts DC into AC in which the output is fed into an existing electrical grid. This will be composed of four different IGBTs and four power supplies.

Requirements

- Must be capable of handling 400V and 12A
- Must be capable of switching at 100kHz

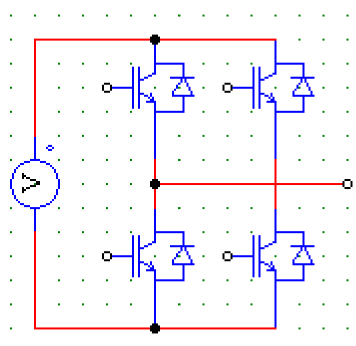


Figure 5 Voltage Inverter

Preliminary Lab Work:

The following tasks have been performed this semester in lab:

- Built a small scale boost converter
- Built both a single and three phase rectifier
- Complete PSim model with results

After checking the design equations against the outputs of the GUI, the GUI was used for first simulation. The simulation with levitation force and levitation height graphs is shown on the next page in figure 4.

Schedule:

- **Weeks 1 & 3 –** Generator Set Up
- **Week 4** – Build Rectifier
- **Week 5 & 6 -** Build Two Channel Interleaved Boost Converters and implement DSP
- **Weeks 7 –** Build Inverter
- **Weeks 8 & 9 –** Voltage and Current Sensors
- **Week 10 –** Overall System Integration
- **Week 11 –** Student expo
- **Week 12 –** Preparation of senior project presentation
- **Week 13 –** Preparation of senior project report
- **Week 14 –** Senior Project Presentations

Equipment List:

- Alternator
- Transformer
- diodes used for Transformer diodes
- Transformer capacitor
- Rectifiers
- Diode Heat Sink
- Inductor
- IGBT
- Fuse
- Fuse Holder
- Traco Power
- Current Transucor
- Gate Driver
- OpAmp
- Voltage Regulator
- IGBT Heat Sink
- DSP Board

Bibliography:

[1] Hart, Daniel W. *Power Electronics*. Boston: McGraw-Hill Higher Education, 2010. Print.

[2] Mohan, Ned. *First Course on Power Electronics*. Minneapolis: MNPERE, 2005. Print.

[3] Mohan, Ned, Tore M. Undeland, and William P. Robbins. *Power Electronics: Converters, Applications, and Design*. Hoboken, NJ: John Wiley & Sons, 2003. Print.