Wind Energy System

Functional Requirement List and Performance Specifications

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Project Goals

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 utilize a digital signal processor (DSP) to handle the switching of the IGBT. The basic topology of the circuit is shown in figure 1, and if time permits, modifications will be made to the system in order to improve overall performance.

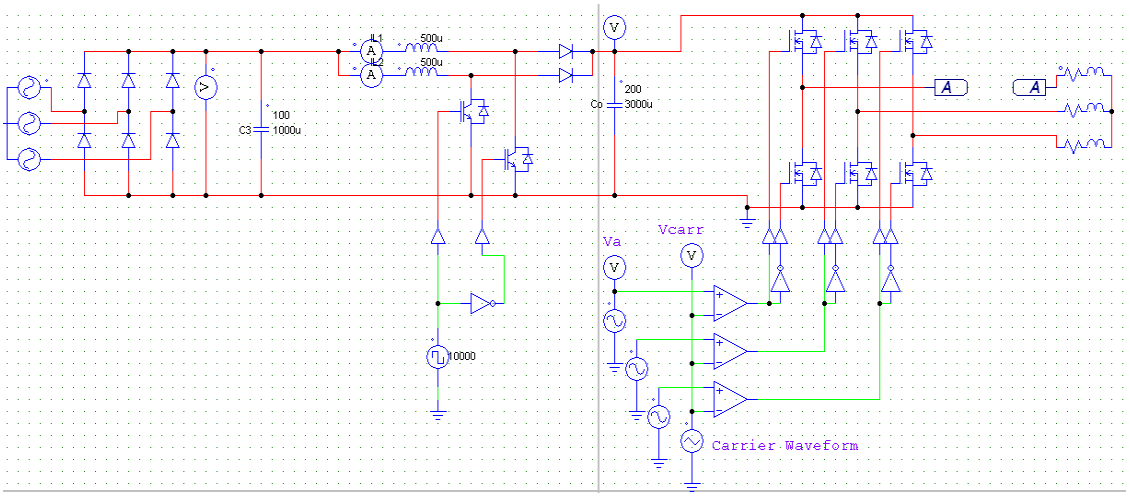

Figure 1 Overall Circuit

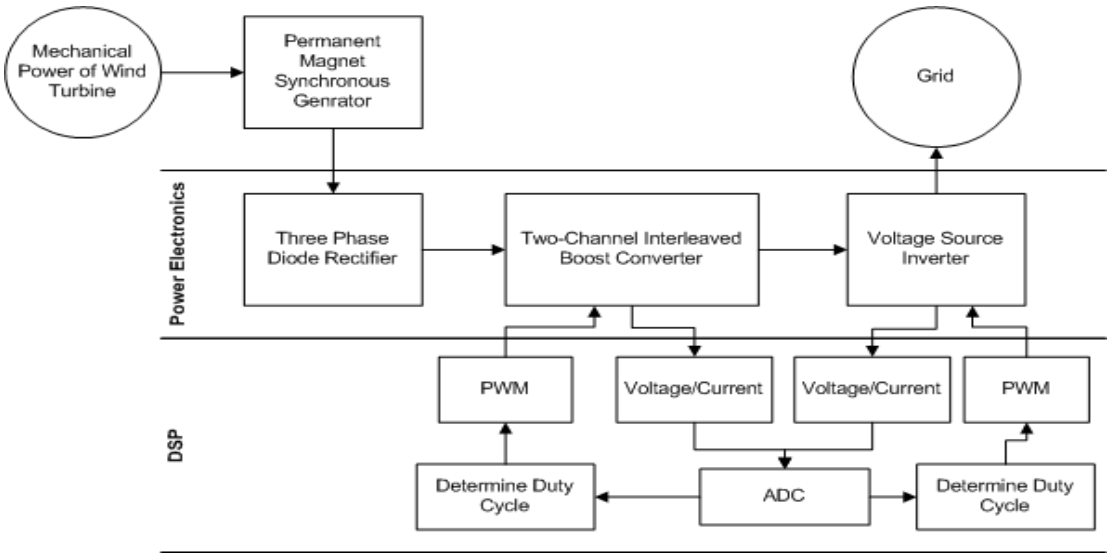

Figure 2 Top Level Diagram

Top Level Description

A typical wind energy system includes a wind turbine, a generator, and power electronic converters as shown in figure 1 and figure 2. This project will use a three phase induction motor that is powerful enough to turn the shaft of the permanent magnet generator to produce the input voltage. The diode rectifier will take the input voltage from the

permanent magnet generator, and turn it into a DC source. Since there are no actively controlled components on this stage, the next stage will turn this into a cleaner power signal. The interleaved DC-DC converter will be a two-channel interleave boost converter, which will regulate the noisy, varying source into a controlled higher DC voltage source. A two-channel interleaved boost converter will be used to improve the power factor, and decrease the total harmonic distortion for the system.

Subcomponent Description

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

A permanent magnet synchronous generator will be used to simulate a permanent magnet generator because of the following reasons: it does not require an additional DC supply for the excitation circuit, it is generally simpler and maintenance free, it will be easier to rectify the power to be used with a grid tie, it will not require condensers are not required to maintain the power factor and it can 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

Since a wind generator produces a varying voltage, this will require a three-phase diode rectifier can transform it to a smooth dc voltage. With this information in hand, the components of the rectifier will depend on the output of the permanent magnet generator.

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.

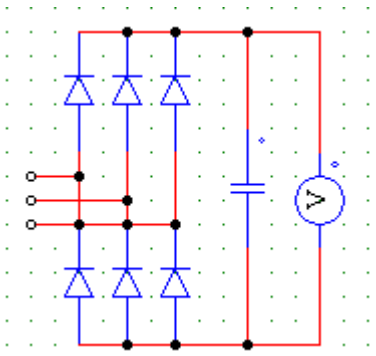

Figure 3 Three-Phase Rectifiers

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

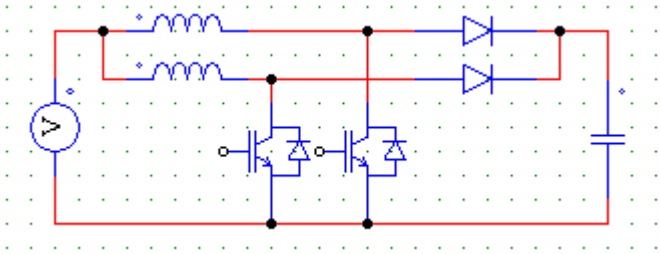

Figure 4 Two Channel Interleaved Boost Converter

Single Phase Grid-Tie Inverter

An inverter will be used convert DC to AC in order to interface this system to the grid. The type of the inverter that will be used is known as a single phase grid-tie inverter. A single phase grid-tie inverter 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

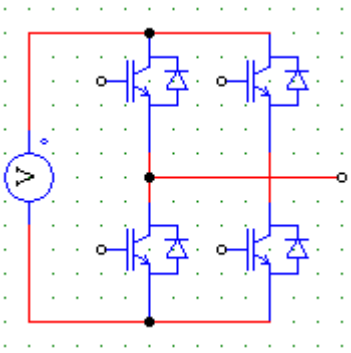

Figure 5 Voltage Inverter

Digital Signal Processor

The IGBT switches in the two-channel interleave boost converter and the voltage inverter will be controlled using a DSP. The controller will produce a PWM signal based on the output voltage and input voltage and current of power electronic converters in order to improve power factor and total harmonic distortion.

Requirements

- ADC input must be between 0 V to 3 V
- Must be capable of outputting a PWM signal of 200 kHz
- Must complete calculations within the sampling period

Conclusion

This paper presents the performance requirements for each subcomponent in this wind energy conversion system. The requirements are chosen in order to achieve steady and high performance even though there are varying conditions such as the variable voltage output from the generator due to varying wind speed.