Photovoltaic Power Converter
Functional Description and Complete System Block Diagram
Date: 10/6/11

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1. Introduction

Today the search for alternative energy is on the minds of people all around the world. Harvesting energy from the sun through Photovoltaic (PV) systems is one way to do this. In our project we will design and build a PV system. Our design will include a boost converter controlled by a maximum power point tracking (MPPT) system and an inverter. A DSP board will control both the DC and AC subsystem switching.

2. Project Goals

The project goal is to make a photovoltaic system that produces DC and AC power. The system will utilize PV panels to generate DC power. The DC voltage output from the PV panel will be stepped up using a boost converter. The DC power will then be inverted to AC, to potentially be fed into the grid.

3. Functional Block Diagram

The following figure is a functional block diagram of our system.
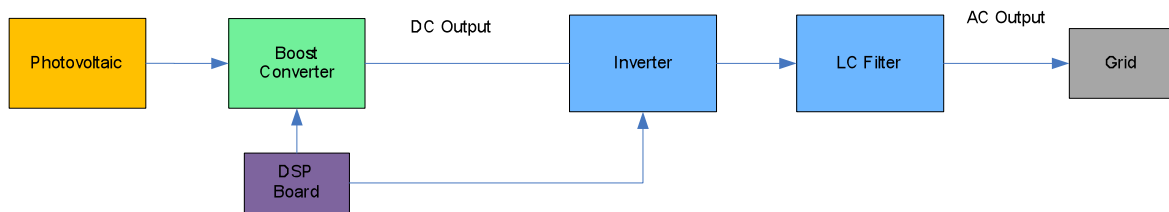

Figure 1 – Functional Block Diagram

The total system is broken down into two groups of subsystems, DC and AC. The DC subsystem is shown on the left side of the block diagram in Figure 1, and the AC subsystem is shown on the right side.

3.1 DC Subsystem

The DC subsystem is composed of a step up converter and an MPPT system. The photovoltaic provides a voltage and current, which then goes through a DC-DC boost converter (step up). The DSP input to the DC subsystem controls the MOSFET in the boost converter with a PWM signal. The output from the boost converter is measured, and the duty-cycle of the PWM is altered by the MPPT system later discussed in the DC Software section.

3.1.1 DC Hardware

Simulation of the DC subsystem will be simulated in PSIM before any hardware is built. A PV panel in the Power Electronics lab will be used in our project. The panel is a BP 350 rated at a maximum power of 50 Watts and a nominal voltage level of 12 Volts. Additional panels will need to be purchased to increase the power of the system.

3.1.2 DC Software

Certain factors affect the performance of photovoltaic systems. The amount of sunlight and ambient temperature can affect the output of the photovoltaic panels. We need to include a system to compensate for these changes and find the operating point of our system that yields maximum power. MPPT is one way to accomplish this compensation. There are four variables that need to be kept track of to accomplish this tracking system: the current and past output power of the system, and the current and past duty cycle of the boost converter PWM.
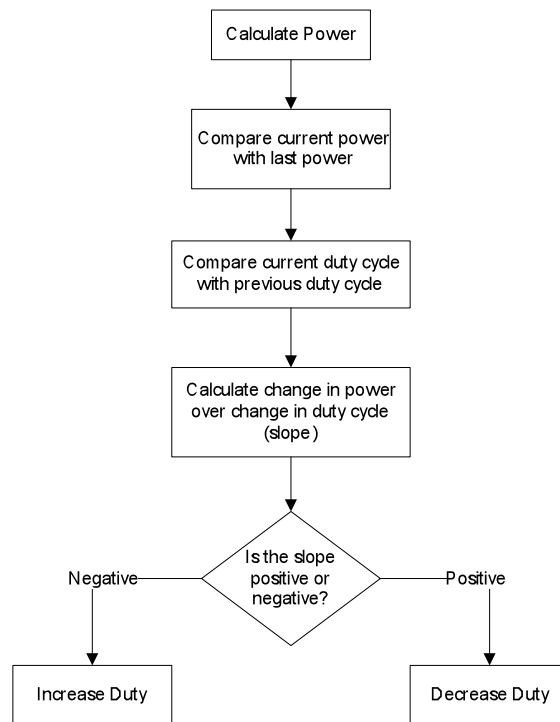

Figure 2 – MPPT Flowchart

Using this algorithm should allow us to keep the PWM duty cycle of the boost converter at the point that yields the maximum output power.

3.2   AC Subsystem

The AC subsystem inverts the DC output into 120 Vrms AC power for AC appliances. Additionally, excess AC power can be fed into the grid. This subsystem contains four IGBTs controlled by a DSP board, and an LC filter.

3.2.1 AC Hardware

The AC subsystem produces 120Vrms 60Hz AC power by inverting the DC power from the DC subsystem. The inverter utilizes four IGBTs (Insulated Gate Bipolar Transistor) in a H-bridge configuration. The IGBTs will be rapidly switched on and off by the DSP board to create an AC waveform. This action will introduce noise onto the AC power output at the frequency of the switching signals. The switching frequency will be much higher than the 60Hz output frequency, so a LC low-pass filter will be used to eliminate this noise at the output. The subsystem will also incorporate protective circuitry to isolate the system in the event of a failure or abnormal condition.

3.2.2 AC Software

The DSP board, controlled by software, generates the PWM signals to control the inverter IGBTs. The PWM signals directly determine the phase and frequency of the AC power output. The duty-cycle of the PWM signals is varied based on the instantaneous voltage of the desired AC output. When the instantaneous voltage of the desired AC signal is at maximum value, the duty-cycle of the PWM signal is at 100%. When the instantaneous voltage of the AC signal is at minimum value, the duty-cycle of the PWM signal is at 0%. By varying the duty-cycle appropriately an AC waveform can be approximated. Because we will be feeding back power into the grid, the DSP board software will sense the phase of the grid and synchronize the PWM signals to match the phase of the grid.

References

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