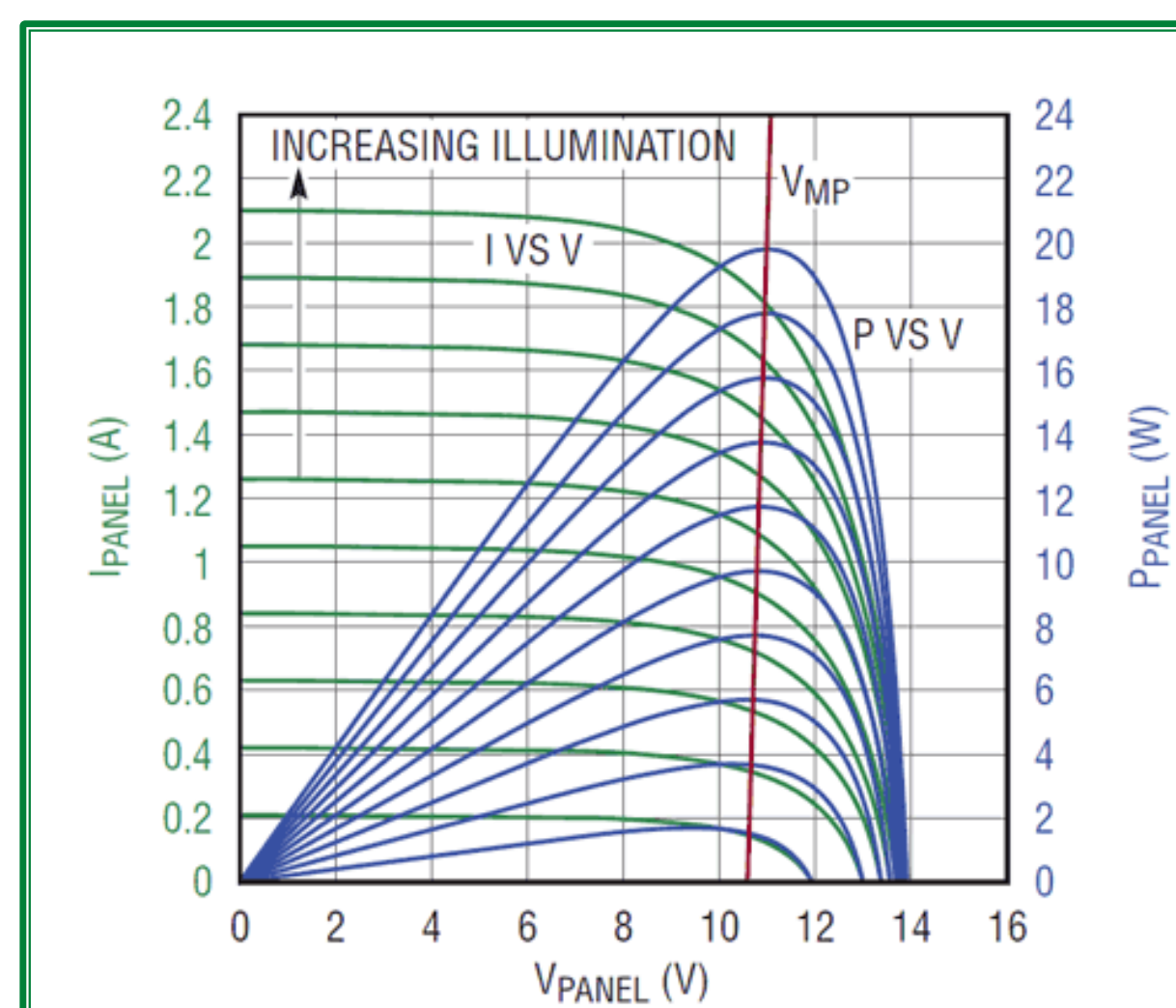
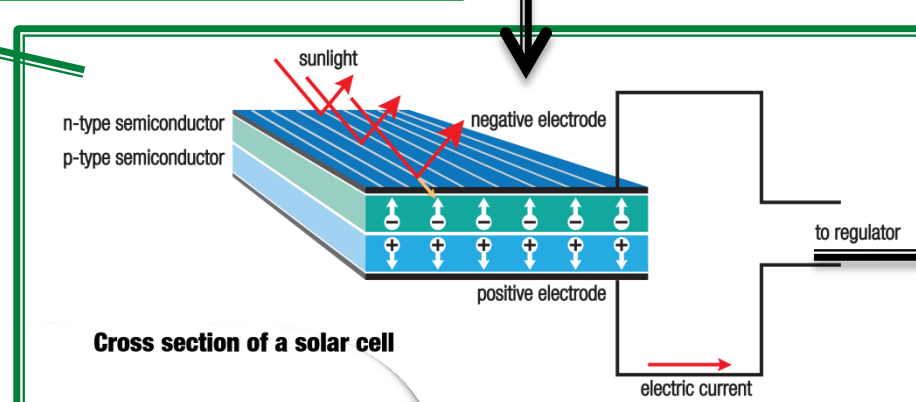


MAXIMUM POWER POINT TRACKER



Characteristic of Solar Arrays

Solar arrays are sensitive to the change in temperature and illumination. The **green curves** show how the current of the solar panel increases as illumination increases; it also shows that for a given illumination, the current decreases as the voltage of the solar panel increases. There is only one maximum power point for a given illumination level since the power harvested from the solar panel equals to the product of the current and voltage of the solar array. The **blue curves** show the relationship of the power versus the change in current and voltage. The **red line** shows the maximum power point for all continuous illumination. This is where the idea of maximum power point tracking begins. The MPPT will be able to adjust the operation voltage of the solar arrays to harvest the maximum power.



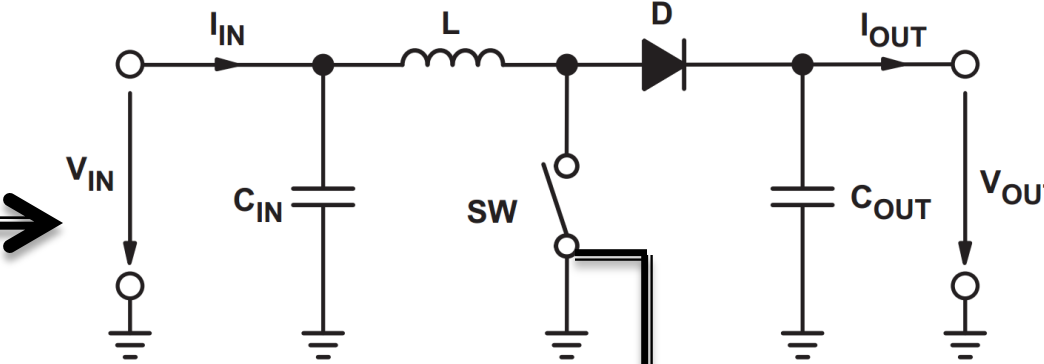
Characteristic of Photons

The sunlight irradiates miniscule particles that are known as photons, which have energy that is transferred inside the solar cells as the photons hit the semi-conductor layer. Thus, energy is transfer from light form to electrical form. An MPPT is essential because of two reason: First, is that the solar cell efficiency is no so high. Second, environmental changes also affects the performance of the solar array.



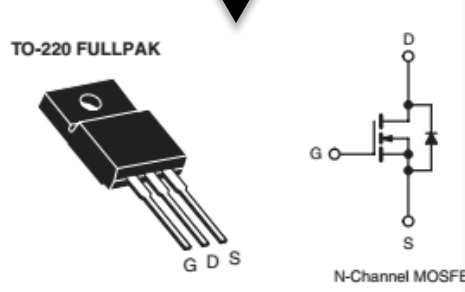
What is a MPPT?

The maximum power point tracker consist of a DC-DC boost converter, a microcontroller, and several current sensing and voltage sensing modules. The function of a DC-DC boost converter is to boost the output voltage from the solar arrays to match the input voltage of the battery. This is done using a switching mechanism. As shown in the figure below, energy is stored in the inductor (L) when the switch (SW) is closed. Both the stored energy and the constant input energy from the solar array flows in to the output capacitor (C_{out}) and load once the switch (SW) is open. The on and of state of the switching mechanism happens several thousand times a second via the combination of a power MOSFET and a Pulse-Width-Module (PWM).



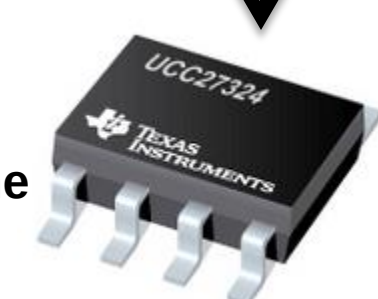
MOSFET as Switch

A power MOSFET can be implement as a switch. The figure on the right shows the package of an actual MOSFET(left) and its theoretical schematic(right). The basic principle for an n-type MOSFET is that current will flow from the drain (D) to source (S) when the MOSFET is on (i.e. switch closed). Similarly, the MOSFET can be evaluate as an open circuit when it is in off state (i.e. switch open)



MOSFET Driver

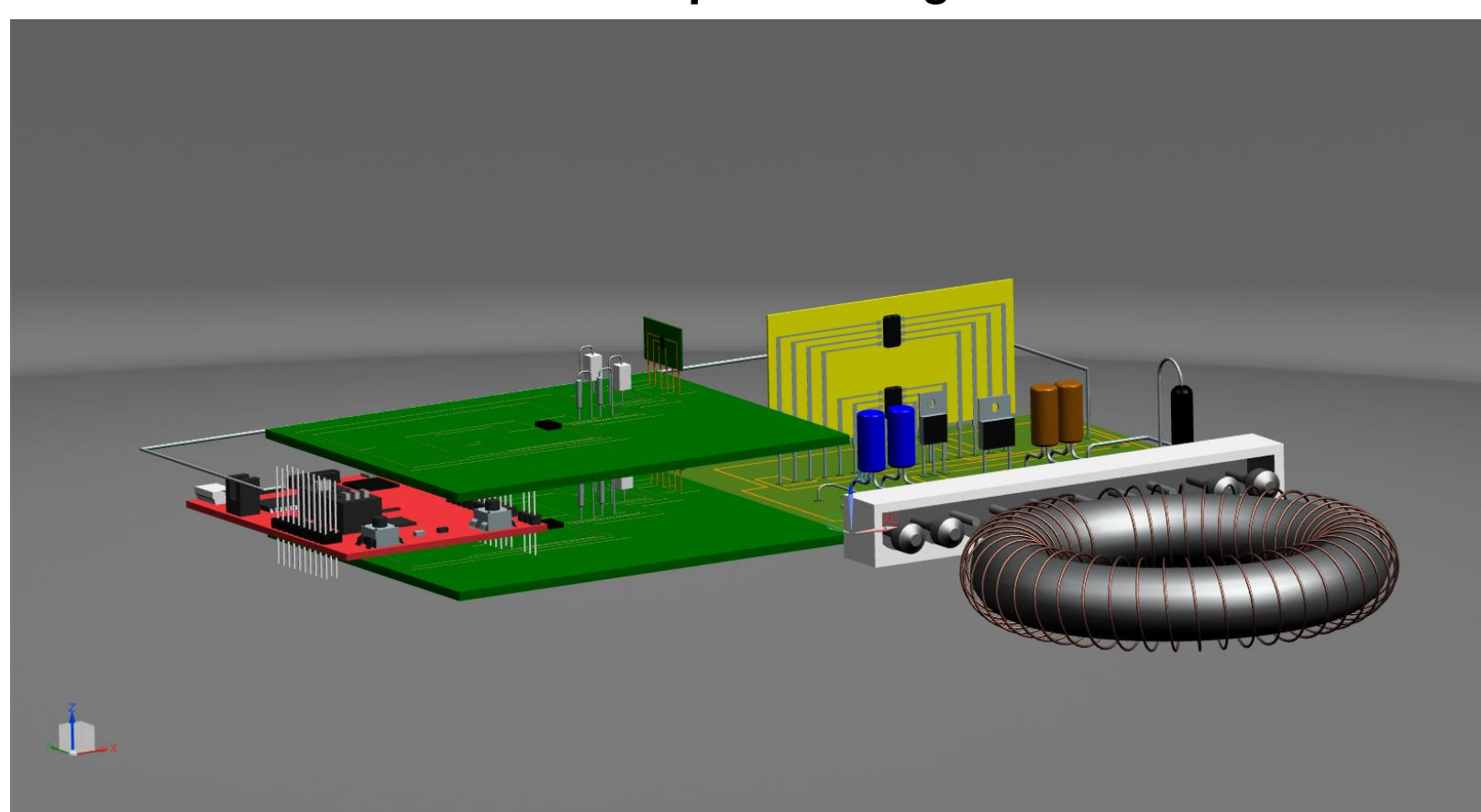
A MOSFET Driver is require to drive a power MOSFET. This is required because the PWM from the microcontroller's output voltage is too small (3.3V) and the required voltage to switch the MOSFET is 10V. Therefore, the MOSFET Driver boost the smaller PWM signal of 3.3V peak-to-peak to 11.0V peak-to-peak to enable switching capability of the MOSFET



Summary

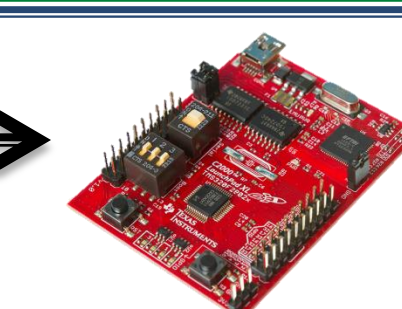
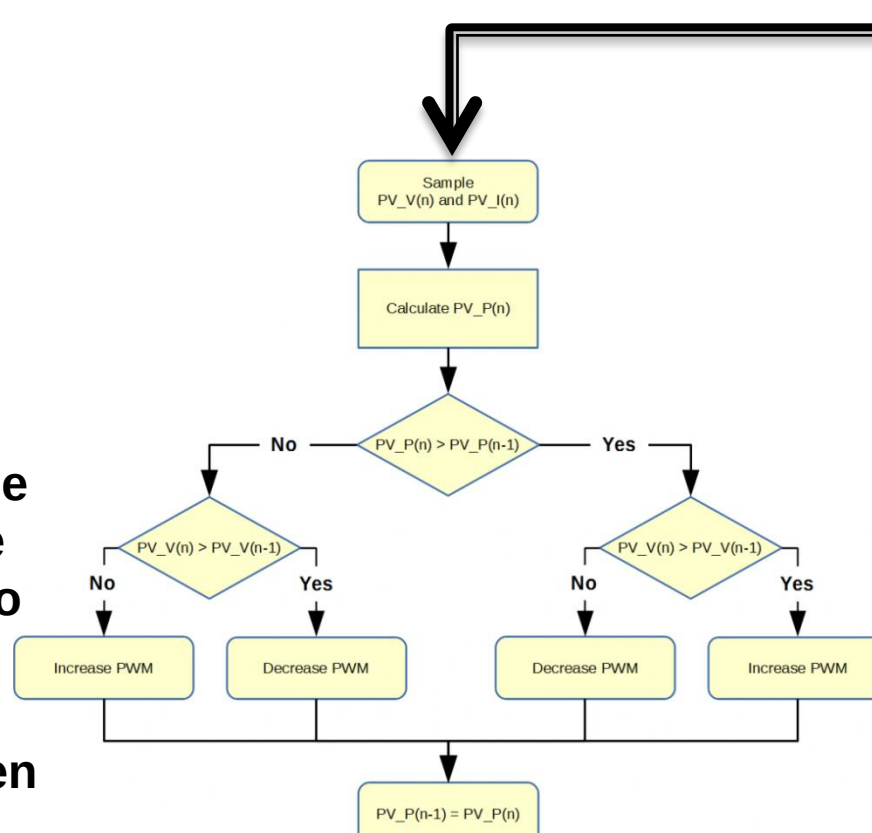
The MPPT project is divided into three stages: DC-DC Boost Converter, Microcontroller, and Printed Circuit Board layout. The goal is to have all stages progress in parallel so the integration of all three stages can take place later in the project phase. However, the integration of all three stages will require more time and effort to be accomplished. At the moment, all three stages are functional when they operate individually. The DC-DC Boost Converter is functional when it is operated without integration with other components. It can boost smaller input voltages to higher output voltages as expected. The microcontroller is partially working where the perturb and observe algorithm is functional but the sensing mechanism requires more time to troubleshoot and program. The PCB stages has been delay due to the fact that the integration of all circuitry is not functional. The achievement is still valuable for future continuation on the project. This is because individual component testing have been done to study why the integration of all stages did not work.

Conceptual Design



The perturb and observe algorithm

The perturb and observe algorithm is shown on the right. This method of tracking the maximum power point of the solar array has two advantages — the simplicity of implementation and comparably high conversion efficiency. The basic idea is to have the microcontroller sample the voltage and current from the output of the solar array and then calculate the power for comparison. At the second comparison, the microcontroller will compare the most recent voltage value with the previous value to determine whether to increase or decrease the Pulse-Width-Modulation (PWM). The theory behind the comparison logic comes from the characteristic of the solar array. When PWM increases, the array output voltage increases. Vice versa, when PWM decreases, the array output voltage decreases.



C2000 Microcontroller

On the top is the C2000 piccolo launch pad from Texas Instruments. The microcontroller will utilize four channels of analog-to-digital converter (ADC) to measure the actual input values from the solar panel. With the values collected in the ADC register, the microcontroller then utilizes the “perturb and observe”(P&O) algorithm that is capable of tracking the maximum power point of the solar array. With calculation and comparison of the change in power, it is going to adjust the output Pulse-Width-Module(PWM) that controls the switching duty cycle of the DC-DC boost converter.

Project Description

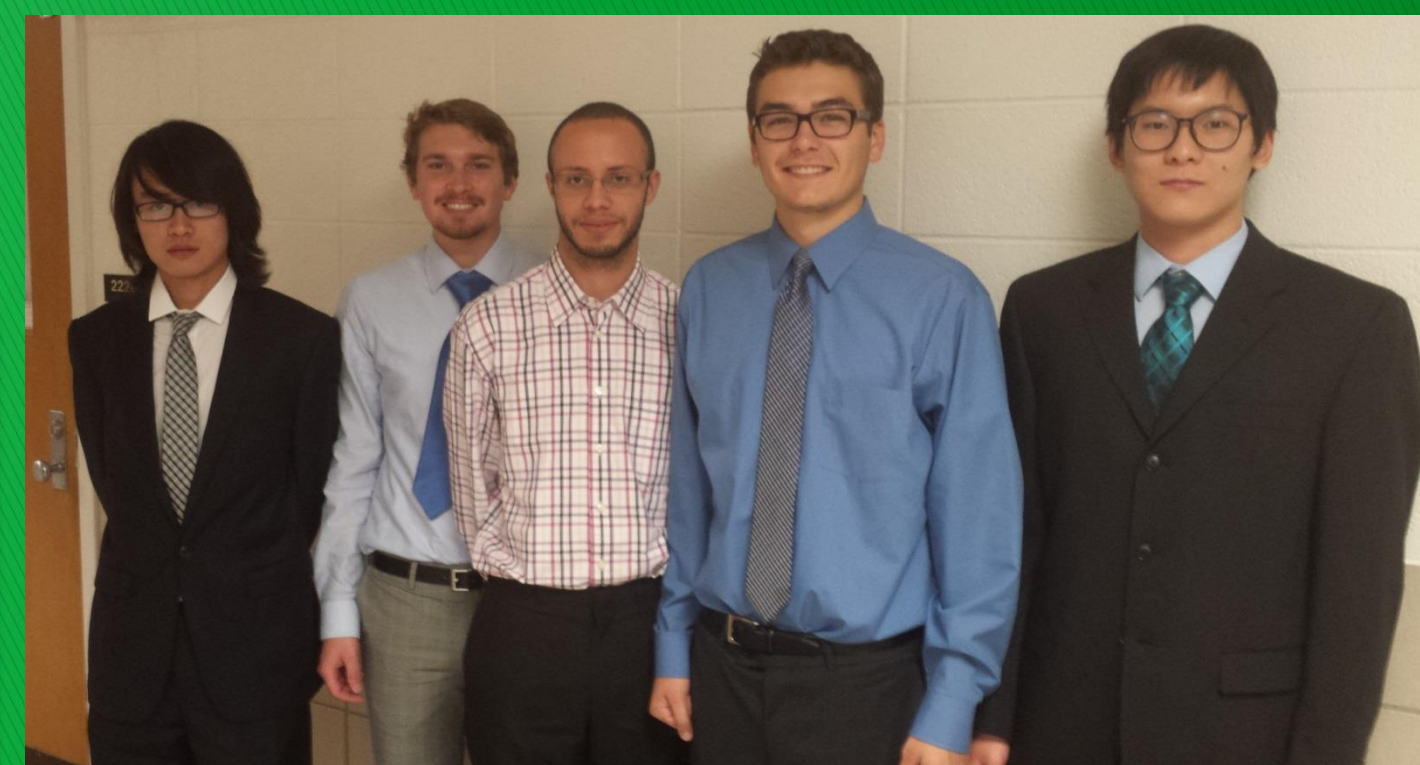
A maximum PowerPoint tracker (MPPT) is an electronic circuit that is the link between the solar array (power generation) and the battery (power storage). It consists of a DC-DC boost converter to take the lower voltage of the solar array and match the higher voltage of the battery, and a microprocessor controlled tracking algorithm to find the maximum Power Point by adjusting the voltage slightly. As the illumination changes, so does the voltage at which the maximum PowerPoint occurs. An MPPT can produce the maximum output power possible regardless of illumination level or temperature.

Design Requirements

- Input Voltage 20-60 Volts
- Input Current 6 Amps (maximum)
- Output Voltage 110 Volts (battery)
- Conversion Efficiency of 95% or above
- PCB Integration
- Lightweight & Small Dimension



Facilitator: Dr. Bingsen Wang



Team Member (From Left)	Responsibility
Yue Guo	Lab Coordinator
Brenton Sirowatka	Documentation Preparation
Louis Kalaff	Team Leader
Jacob Mills	Web Design
Daniel Chen	Presentation Preparation