Background

The goal of Experiment 3 Part 2 is to design, construct, test, and demonstrate maximum power point tracking, to charge the battery at a faster rate than would be attained with direct energy transfer.

Laboratory Procedure

1. **Battery current and voltage sensing**
   Design circuitry to sense the battery voltage and current. Include a complete schematic of this circuitry in your report. To sense the converter output current, employ the current sense resistor and the INA194 current sense amplifier included in your parts kit. The circuit should have two output signals that will be used as inputs to the TI MSP430 ADC channels. Be sure to include the following considerations:
   - The voltages at the MSP430 ADC input channels must always stay within the range 0 to 3.3 V.
   - The high side current sense circuit should have RC filtering at the INA194 input and the MSP430 ADC input.
   - Include numerical values for all components.
   - Include the pin header labels for connecting the sense signals to the MSP430.
   - Write expressions for the ADC input voltages as functions of the battery current and voltage.

   Implement your design on your buck power stage circuit board. Connect the two sense signals using twisted pairs to appropriate ADC input channels on the MSP430 development board. In addition, it is strongly recommended that you include on your MSP430 board an RC input noise filter, plus an additional 3.3 V zener diode to protect the MSP430 ADC input(s), to ensure that the voltages applied to these pins never exceed 3.3 V.

   Drive the converter input with a bench power supply. Operate the converter at a constant duty cycle in order to test and de-bug the battery sensing and sampling circuitry. Pass the battery sense signals through the MSP430 and output them on the PWM channel for debugging and validation. Operate the converter at full power (rated PV panel power) to validate acceptable performance and noise rejection. In your report, explain and document your test data proving that you are able to capture the battery current and voltage inside the MSP430.

2. **Peak power tracking with the PV system cart**
   The goal of this section is to demonstrate peak power tracking and battery charging with the PV panel outside. The tasks required to achieve this goal include: verifying operation with the PV cart battery as the load, modifying, testing and de-bugging the MSP430 code to include a peak power tracking algorithm, evaluating system operation with the PV panel. Carefully monitor the battery voltage: **DO NOT OVERCHARGE THE BATTERY**. Here are a couple of suggestions for development and debugging: all peak power tracking algorithm tests should be performed with the battery as a load (not with the resistive load)

and debugging the peak power tracking algorithm may be easier indoors with the computer interface to the MSP430 using the bench top power supply with a series power resistor as an approximate PV panel emulator.

Include the following items in your report:

- Description of your testing, de-bugging and evaluation procedure.
- Full schematic clearly indicating which board each component is located on (power stage, control or microcontroller) and any twisted pair wires.
- When operating successfully around the peak power point:
  - Capture an oscilloscope waveform of the PV panel voltage and the MSP430 PWM output signal of the duty cycle, showing perturb-and-observe operation around the peak power point.
  - Explain what measurements and data were collected to validate that your PV system was operating at the peak power point.
  - Measure the output power of the PV panel, input power to the battery and calculate the converter efficiency.
- With no shading on the panel, are you able to harvest more energy with or without your converter? Explain why. (Compare the battery input power using your converter to a direct connection between the PV panel and the battery).
- Shade four series cells on the panel. Are you able to harvest more energy with your converter? Suggest a way to improve the system under this condition.