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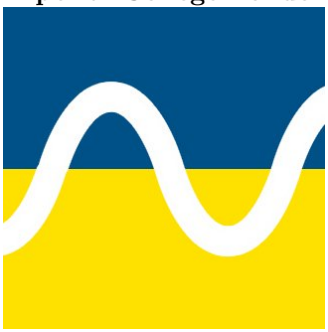
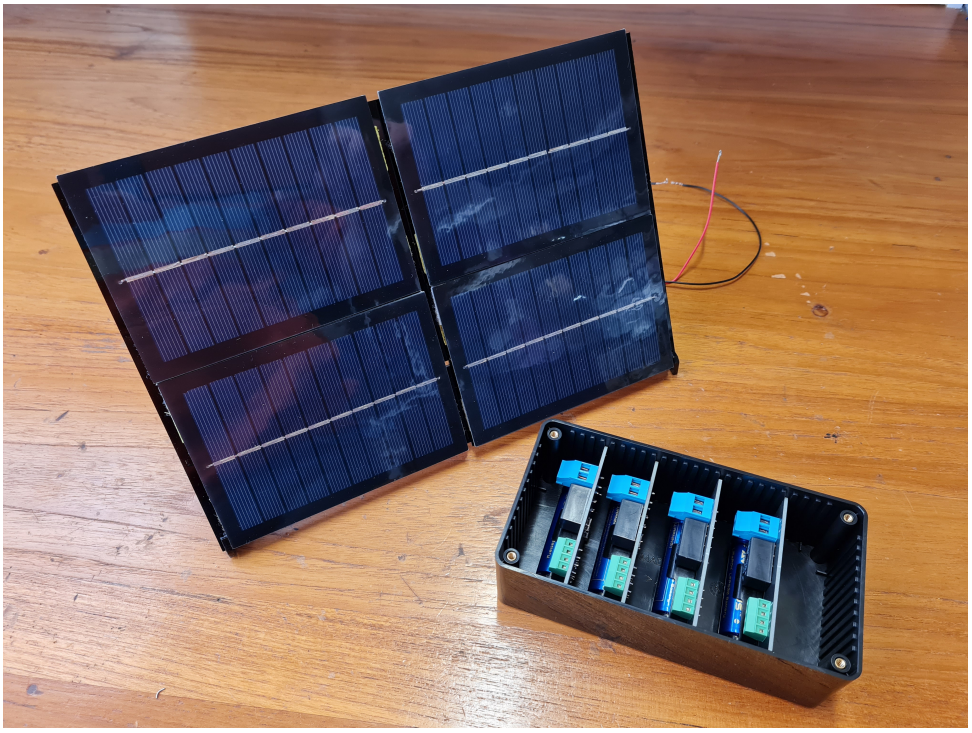


Department of Electrical

and Electronic Engineering

ELEC50003/ELEC50008 - 2nd Year Project Automated Mars Rover

Solar Charging Station



1 Introduction

1.1 What do I have to do?

Your task with the solar charging station is simple: Charge the battery with the solar panels! The solar charging station is a standalone system that uses solar panels to charge one of the provided USB battery packs that can be used to run the rover. You should aim to design a system that is as efficient and effective as possible so that you get the most solar energy into the battery for your rover (if this was really on Mars then there is much less energy available). Below is a diagram of the system you will make, obviously there is a lot of unknown here as you are designing this yourself. Most of your engineering decisions and design will revolve around the power electronics interface circuitry.

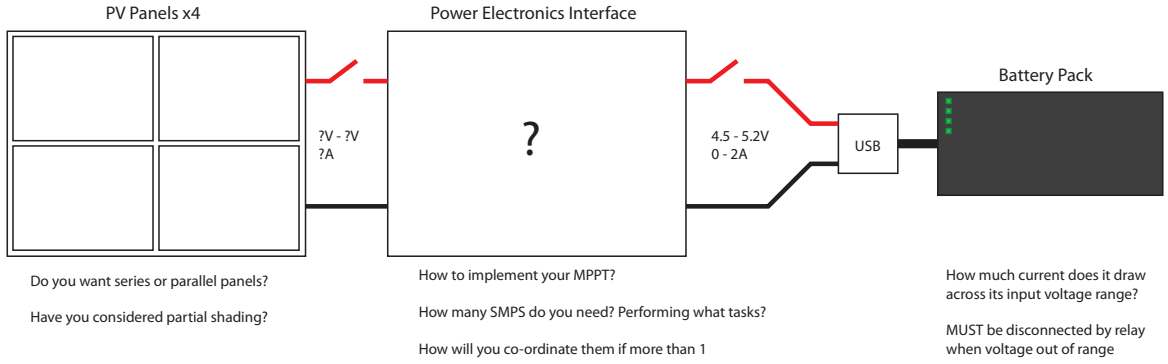


Figure 1: Diagram of the solar charging station

As much as possible has been done to leave important engineering design decisions for the project up to you: key among these are the parallel/series combination for the PV panels and the number and type (Buck or Boost) of SMPS circuits you will use. You must weigh up the pros and cons of each potential system layout, some will perform better than others, some will be simpler to build/manage and some will not be possible due to voltage or current limitations (or other limitations). Some (but definitely not all) of the you must ask yourself are in figure 1, they do not all need to be answered up front (and some decisions will effectively force other decisions for you) and some experimentation will be needed to get to your final best case design.

At the end of the project you will want to include in the report your explanation of what system you have designed and why you think its the best (with evidence!). You will be assessed on whether your system works, overall efficiency, speed of charging and simplicity/elegance of design so you will want to target these factors in your design decisions and write up.

1.2 Where do I start?!

As with all engineering projects you should start by thinking about what your inputs and outputs are along with what you can control and what you cant. Your input is a PV panel array with its voltage and current varying with the amount of insolation (that you can characterise). Your output is a USB battery with a defined

voltage spec and current behaviour that you must also characterise yourself. Once you know what these are you can bridge between them with your SMPS circuit(s). A good rule to remember is that for each SMPS there is only one thing you can change (or program the arduino to change for you), the duty cycle. This means that an SMPS can only control one thing at their output, a current OR a voltage. Once you've decided how you plan to bridge the input to the output then you need to work out how you will instruct your Arduino(s) to achieve that and how you will measure and report the effectiveness of your system. Once you have tested the first iteration, you can improve it and test again, repeating this process until you are out of time or happy with the result!

1.3 Where can I get some more info?

This document contains a brief set of tips and warnings to get you on your way and hopefully prevent the worst pitfalls. Also included is the circuit diagram for the Arduino Adapter board, data tables for your key components and the packing list for your boxes.

During the project timeline you will be able to ask me (Phil) or the other staff members during booked sessions and whenever I am wandering around the lab.

2 Tips and Warnings

The tips and warnings in this section are things I think will help you get started and help prevent too many accidents. They aren't in any particular order and they aren't a comprehensive list.

2.1 Tips

- Take time to characterise the operation of your PV panel (s), what is its V-I and P-I curve under different light levels (you can use a lamp in the lab but should move to outside sunlight ASAP)
- You should also test how much current your battery draws at different voltages in the acceptable range
- You only have one adapter board so you should use it carefully when using 2 SMPS boards. It gives you free access to a lot of Arduino inputs that are otherwise blocked if you connect the Arduino directly. It also gives you an SD card connection.
- Save lots of data to your SD card, easier to discard data later than have to re-run the test
- Use the Fast-loop in the SMPS for updating the duty cycle (in open-loop or closed loop mode). Use the slow loop to do things like MPPT or relay operations or the like.
- Develop and test MPPT and battery charging separately before combining them, but make sure theyre going to be compatible!
- Think about the voltage and current rating of all of your devices to figure out what combinations of PV and Buck/Boost that will work

2.2 Warnings

- Do not connect your battery to the circuit if the voltage is not within the acceptable range
- Be aware that the SMPS was not strictly designed for this purpose so you may need to be a little creative. For example, you will likely want to use it with the left hand switch turned to "OFF" (think about why)
- Connecting to Serial on Arduino resets it (this can be annoying when running long projects). Use LEDs to give indication when running longer tests rather than connecting a PC
- Watch out for loop timing. The loops are timed using interrupts, if you use too much time your code will get interrupted and behave in unexpected ways! You can check this using a digital output to confirm your loop has some spare time (on at start, off at end, if it doesn't turn off then your loop is interrupted).
- The PWM setup for the SMPS changes some timing which means that Arduino real time functions such as delays will not work correctly, use the timing structure provided (counting 1ms loops)
- Arduino analogue inputs must be 0-5V (0-4V if using the "accurate" voltage reference included on the SMPS), you may need to use potential dividers before connecting to the analogue inputs or you may damage them

3 What Equipment Will You Have?

3.1 In the Box

- 4x Solar panels - to make some electricity
- Solar panel stand - to hold the panels
- Mini breadboard - for general circuit making
- Arduino adapter board - see below for details
- 2-channel relay board - for isolating the battery and panels
- USB breakout board - to interface from SMPS to battery
- SD card reader and SD card - to log data

3.2 From Lab or SMPS Lab Kit

- SMPS circuit - you can use as many as you have in your group
- Arduino Nano Every - to control everything
- Wires and terminal blocks - to wire it all up
- Multimeter - best way to measure your currents for reporting
- Lab power supplies - a good way to test parts of your system
- Lab variable resistors - a good way to load parts of your system
- Other useful stuff - be inventive!

4 Useful Info about whats in your box

4.1 Arduino Adapter

The Arduino Adapter board allows you to access all of the available digital and analogue pins on the Arduino whilst maintaining the connection to the current sensor on the SMPS board(i2c link using SDA and SCL), the PWM drivers for the MOSFETs and the OL/CL switch to give you some input options. PLEASE NOTE D10 ON THE BOARD IS ACTUALLY D3. The adapter board also allows you to plug in an SD card adapter for recording data.

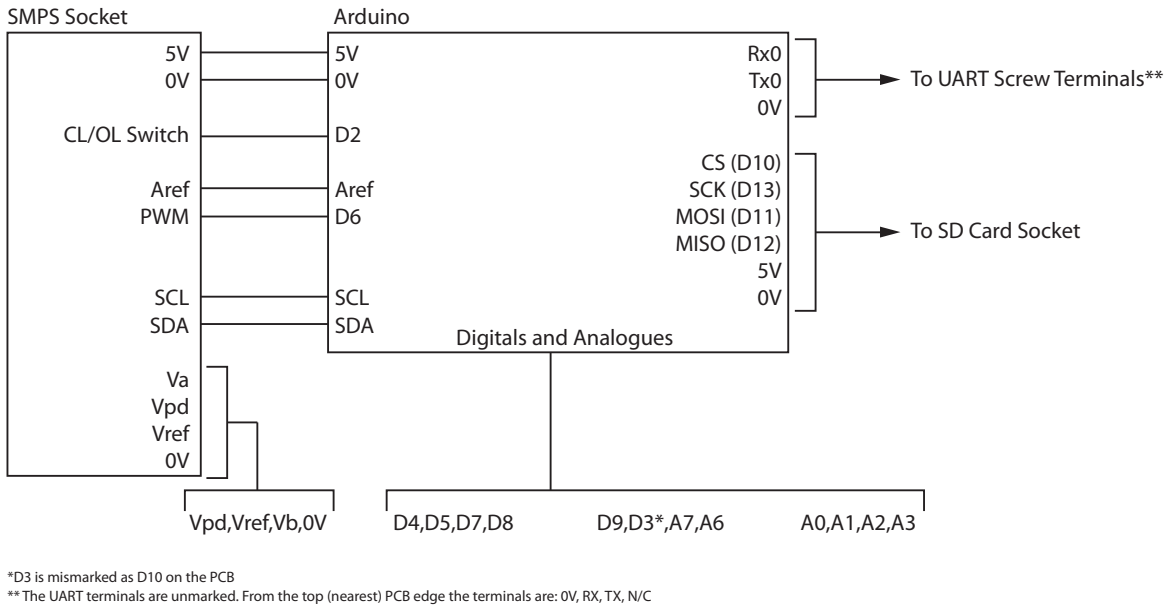


Figure 2: Arduino Adapter board circuit diagram

4.2 PV Panels

Your PV panels are TruOpto OPL50A23101 from Rapid Electronics, if you want to look up the full datasheet. The table below gives optimal values for a single panel, you should characterise your panels to confirm.

Specification	Value	Unit
Voltage	5.0	V
Current	230	mA
Power	1.15	W
Dimensions	90 x 125	mm
Power Tolerance	± 3	%
Temperature Coefficient	-0.45	%/°C

Table 1: Data table for the PV panel

4.3 Battery Pack

The battery pack you have is a 5000mAh USB portable power bank. The ratings for this are in the table below but you should definitely check and confirm the performance of your battery before making too many assumptions.

Specification	Value	Unit
Max USB Voltage	5.2	V
Min USB Voltage	4.5	V
Max Charge Current	2000	mA
Max Discharge Current	2100	mA
Rated Capacity	5000	mAh
Input Port	Micro USB-B	
Output Port	USB-A	

Table 2: Data table for the Battery Pack