Name/NetID:	Teammate/NetID:

Module 4B: Arduino as Power Supply

Notes:

Laboratory Outline

As you work on through the labs during the semester and some of the modules you may want to continue experimenting at home. Luckily the microprocessor board can be used in place of the bench equipment making your kit a mobile laboratory. This short lab will show you how to power external circuitry with the voltage regulator circuit on the Arduino/RedBoard. If used carefully, knowing the limitations of the microprocessor board you can experiment anywhere.

The Power Circuitry on the Arduino

In the design of the Arduino and its clones the developers integrated a very flexible suite of interface circuitry in addition to the ATmega processor so that users from entry-level to experienced can integrate the board into almost any application. It interfaces with most integrated circuit families and so provides several voltage levels. Within certain limitations these voltages can be assumed to be ideal voltage sources like the power supply. Unlike the power supply only certain values are available – luckily they are commonly used values. There is a separate module that addresses their use.

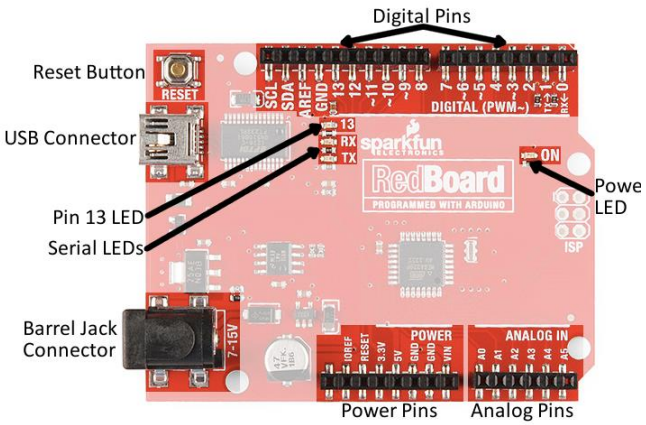
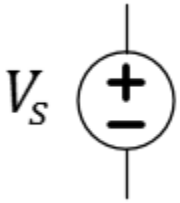


Figure 1: Physical layout of the RedBoard.



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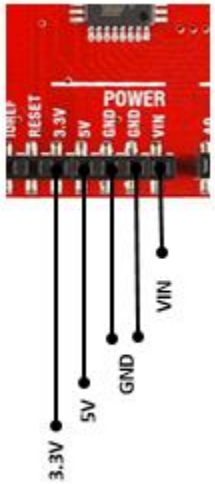
The RedBoard's physical layout is shown in Figure 1 – notice the power pins that provide voltage levels to external circuitry AND the Barrel Jack and USB connector that interface the board with either a battery connected to the Barrel Jack or a computer via a USB port.

Computer Connection



While designing and debugging designs involving the Arduino/RedBoard it is sometimes convenient to keep the board tethered to the computer. So first connect the board using the USB connector that came with the board to any of the USB ports on the computer.

As you can see in the expanded view of the power pins there are 3 pins that deliver different voltage levels – 3.3V, 5V, and one curiously labeled VIN. As you know from experimenting with the power supply and multi-meters voltages are always measured between 2 points. The board provided 2 pins labeled GND that are connected together – all voltages on the board are specified with respect to these GND or ground pins.

Question 1: Using the multimeter measure the voltages between the 3.3V, 5V, VIN pins and ground. Enter them into the table below.

3.3V	
5V	
VIN	

Well the results were not so surprising. The circuitry that takes the voltage supplied by the computer and regulates it to supply 3.3V and 5V is very good and the multi-meters are very nearly ideal measuring devices for this application. What is VIN?

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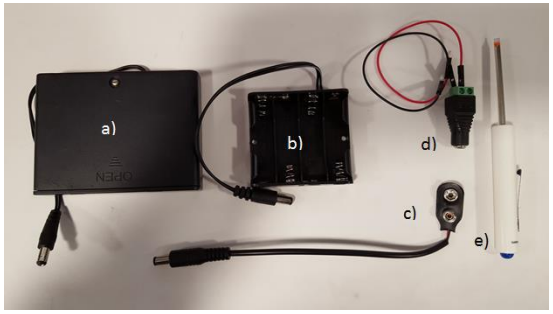
Battery Connection

Question 2: Disconnect the USB connector and plug a battery into the barrel jack connector on the board– you have adapters that can interface a 9V or 4AA batteries in your kits and there are batteries available in the lab. The figure below shows the three types available: a) special rechargeable, b) a cradle for 4AA batteries, and c) an adapter for a 9V battery. For the battery of your choice fill in the table again.

3.3V	
5V	
VIN	

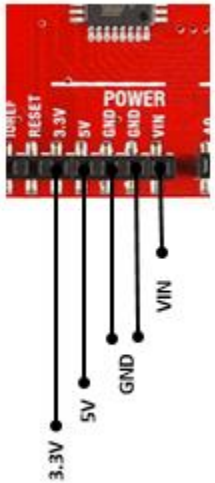


Again the results are not surprising but now you should know the function of VIN. VIN is a pin that provides a direct connection to the power source – the default voltage of 5V for VIN when you used the USB cable is standard for all computers.

Voltage Regulation

The Arduino/Redboard has a special circuit on it call the voltage regulator. This device accepts any voltage within a certain range – in the case of the RedBoard 7-15V and the Arduino 7-12V the pins labelled 3.3V and 5V will ALWAYS deliver the labelled values as long as you work within the current limitations.

Question 3: To check this out repeat the voltage measurements for the other two choices of batteries. Be sure to label the table showing which values were measured using the corresponding battery.



3.3V		
5V		
VIN		

Notes:

Computer and Battery Connection

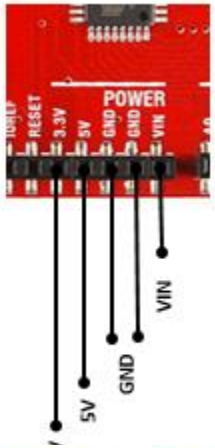
Question 4: Without disconnecting the battery reconnect the board to the computer using the USB cord. Measure VIN. Which connection determines the voltage at the power pins when they are both connected – the battery or the computer?

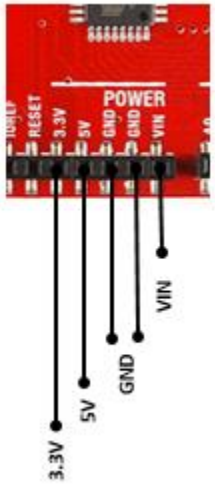
Current Limitations on power pins

The voltage VIN is directly connected to the power source – this allows the use of the battery/computer directly. The flexibility of the power connections on the Arduino/Redboard comes with a vulnerability – there is no protection for the board if you drive too much current through VIN – so we should look at the limitations of these pins so that you don't destroy the board.

It is surprisingly difficult to find a straight forward answer about how much current (or power) can be drawn from the power pins on the Arduino/Redboard. The 3.3V and 5V pins are generated by a device called a voltage regulator. The regulator takes in any voltage within an allowable range – for the Arduino this range is 6 – 20V and produces a robust 3.3V a 5V for reasonable loads – shorting would be bad but the Arduino in particular was designed to interface with most common small signal circuitry. It is quite difficult to find an absolute limitation so it is always best to be conservative.

Limitations when powered by the USB Connection to a PC is conservatively 100mA total from all pins – this limitation is set by the USB hardware to protect your computer. This means that your external circuitry no matter which pins are used – the power





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pins and the digital I/O pins – the total current must be less than 100mA. This is usually not a problem because most of the hardware interfaced with the micro-controller board is designed to operate using a very small amount of current.

The power limitations when the board is connected to a battery is more complicated. There is no one datasheet that describes the limitations for all the devices on the board. The rule for calculating current limits is to find the current limitations of the wimpiest part. Below is a table that I deemed conservative based on the schematic and the information on the forums. By the end of this class you should be able to determine the values yourself. NOTE: the limits on each pin does not mean you can draw the maximum amount of current from each pin. There is a total limit of conservatively 1A that can be drawn from all of the connections that supply power – the 3.3V pin, the 5V pin, the Vin pin, and all of the digital output pins.

Current Usage and Limitation Guide

voltage	*Current limit*	*Limiting part*	*Common usage*
3.3V	50mA	Voltage regulator	ANALOG: the microphone in your kit uses a lower voltage to power the interface. DIGITAL: Used to interface with logic that is powered using 3.3V like CMOS (complementary metal oxide semiconductor) parts and some less commonly used logic families
5V	200mA	Voltage regulator	DIGITAL: Used to interface with logic like TTL (transistor-transistor-logic) used in the hobby community because of the low cost of parts and some CMOS.
V_{IN}	1A	Protection diode or battery which every is the most fragile	Used for the higher power circuitry like the motors you will be using on your robot cars.
GND	Total board limit ~1A	Ground traces and heat sink capability or lack thereof	The total amount of current is about 1A.

Question 5: For each of the power pins enter the value of the smallest resistor that can be connected to each before the current limit is exceeded in the table below– use VIN to be the voltage any one of the battery packs.

3.3V	
5V	
VIN	

- ✓ Power something! Connect the 5V pin from the Arduino to one of the terminal going to the motor and the GND pin to the other terminal. You can use the breadboard and your jumper wires to facilitate making these connections.

NOTE: Despite the caveats the board is well designed and really difficult to damage using any of the equipment in the kits – so experiment away!

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What You Learned

You learned that the Arduino/RedBoard can be used as a voltage regulator and can provide certain voltage levels when you are not in the lab with the power supply.