Important links:

purpose	links
Turning off bluetooth	• Bluetooth 1 • Bluetooth 2
Turning off HDMI	• HDMI
Turning off LED	• LED
General power consumption	• power saving • Power saving • Check out Throttle CPU • VERY CLEAR LINK
Cron jobs	• basics

Notes:

Object	abbreviation
RPI connected to the INA219	RPI-C
RPI connected to the sensors	RPI-S

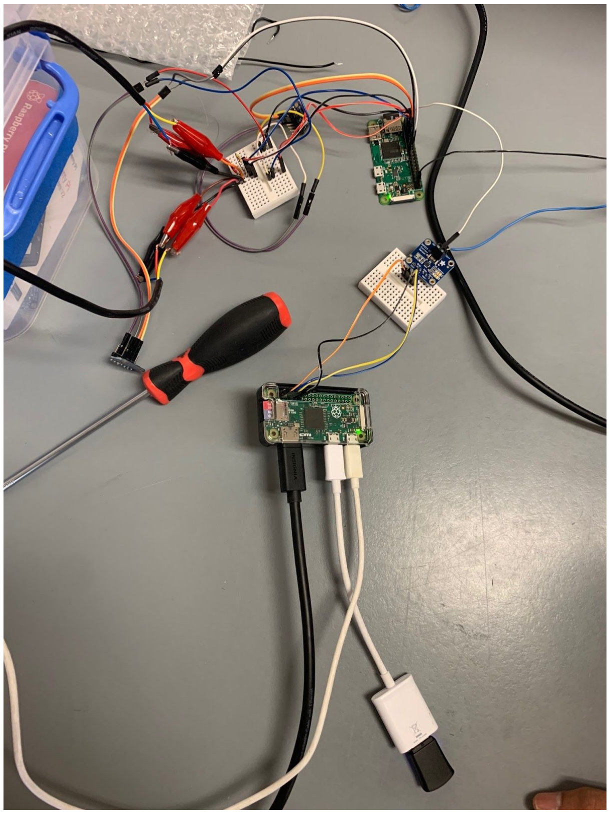
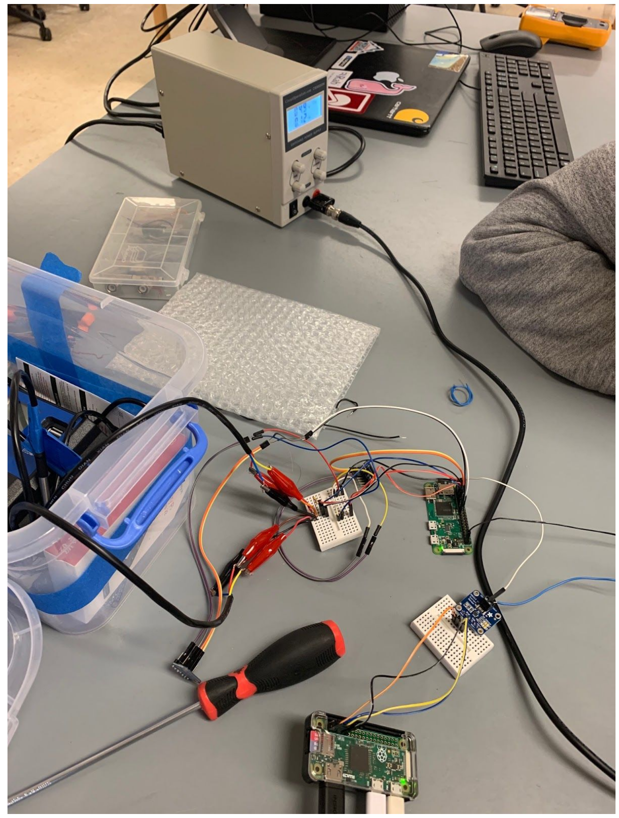
Monday, May 13

Raj bought a new raspberry pi that will be used for this project. Today, we are going to measure the power consumption of the raspberry pi with 4 sensors. Then, we are going to strategically disconnect the sensors such that we can determine the exact power consumption of each sensor.

Raj described to us the wireless SIM card that we will eventually use to cellular transmission of data. This will take a lot of energy so we are going to need to find a way to statigically turn on and off the cellular transmission.

We are starting today by writing python codes and cron jobs to measure the power consumption of a raspberry pi to a google sheet. Once that is done and we have collected data on everything, we are going to write out all of the remaining challenges that we have left in the project and how we plan to address each challenge. Overall, we are struggling primarily with the Linux operating system on the Raspberry Pi and the python codes to be used in the raspberry Pi.

We are now measuring the power consumption of the raspberry pi with all 4 sensors and a transmission every minute using our set up containing a second RPI and the INA 219.

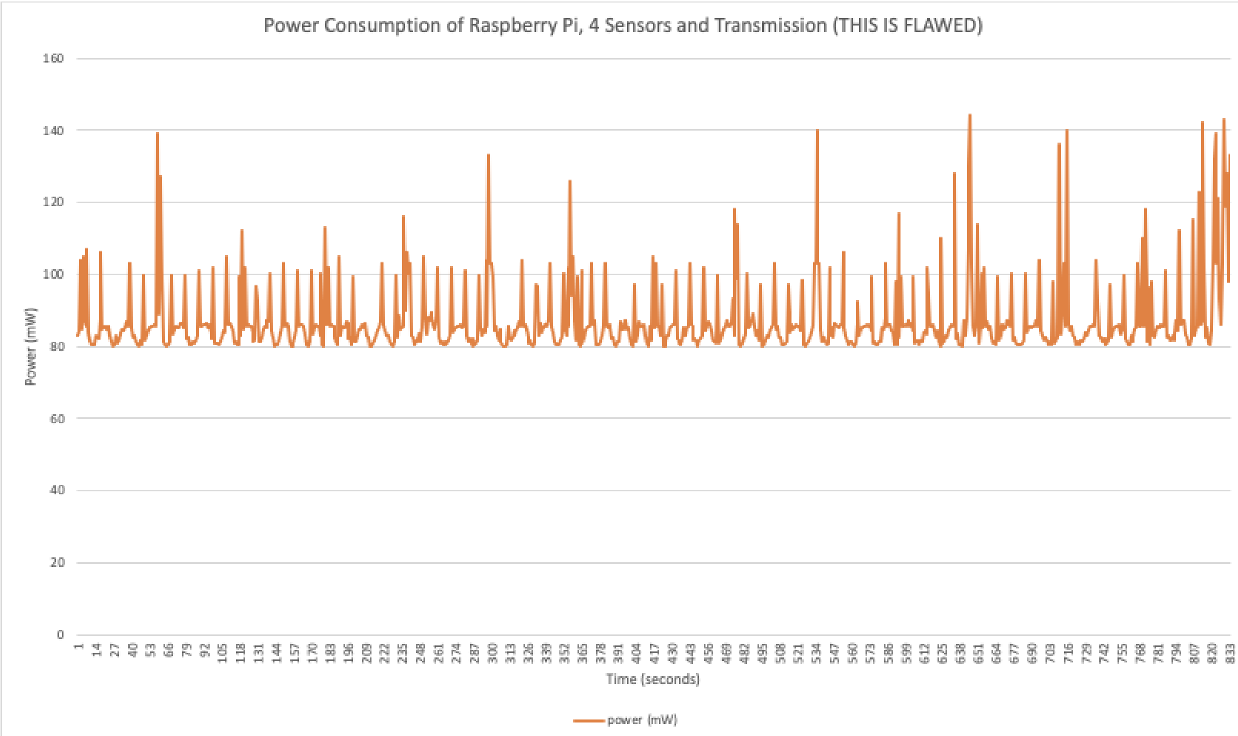



These images above show the original set up that we use to read the power consumption of RPI-S from the RPI-C. We are using a DC power supply to power the RPI-S in series with the INA219 which is being read off of the RPI-C which which independently being powered from the wall.

Time stamp

List of remaining challenges in this project:

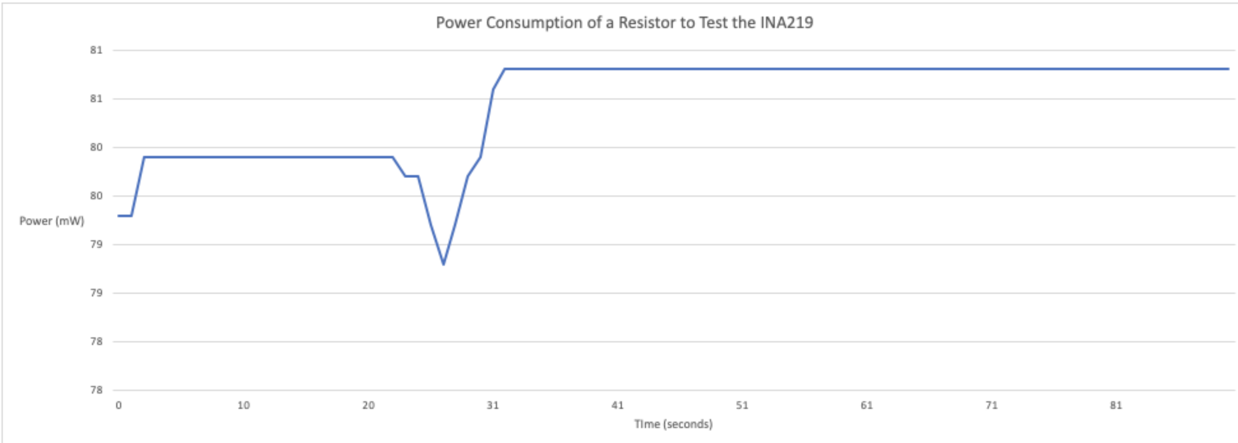
- Determining the power consumption of each sensor
- Determining how frequently we ought to transmit data based on the amount of voltage coming out of the battery
- Translate the output of the battery to the concept of battery charge. We can measure the voltage output of the battery but how does this translate to the power remaining inside of the battery?
- The physical setup of the system including the solar panel and other harnessing measures necessary



This chart shows the trial were we collected the power consumption of RPI-S through the INA219 that is connected to the RPI-C. We noticed that the data that we collected has a similar pattern to the data that we collected in the past as there are spikes every minute that agree with the collection of data from the sensors. However, there is an underlying sinusoidal behaviour on top of the fact that our voltage readings were around 0.8 volts when they should be around 5 volts. We finished this at the end of our session and will come on tuesday looking for errors in our set up.

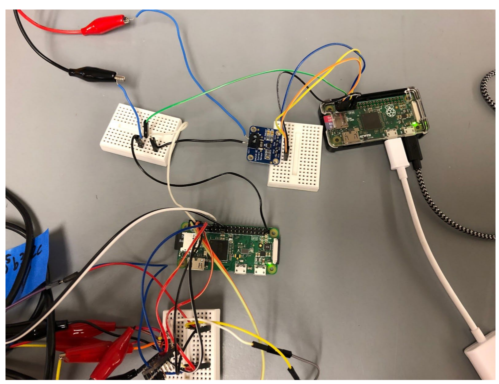
Tuesday, May 14

After plotting the data that we collected for the power consumption of the RPI featuring sensors we realised that the graph depicted some sinusoidal behavior. We want to investigate if this is due to the RPI consuming power with a specific frequency or if this as a result of the INA219 sensor collecting data with some frequency. To do this we will measure the power consumption of a simple resistor of equal resistance and observe if the power consumption has a similar frequency or if it is steady.



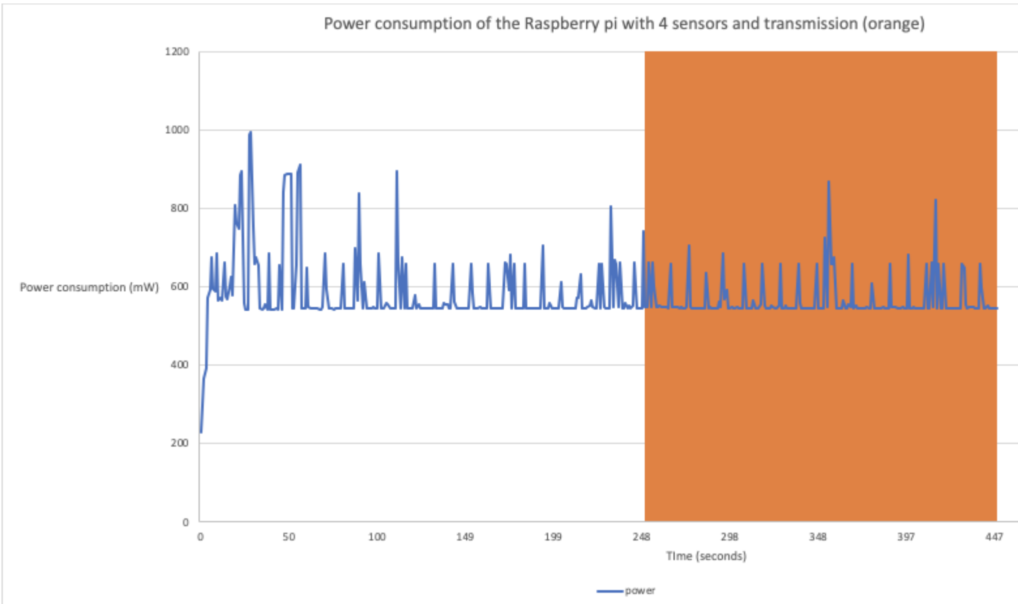
The two bumps in the chart above are from when we turned the dial on the DC generator. Other than our own manipulation, the voltage stays extremely steady.

After researching on this link we discovered that in order to get steady measurements the RPI must have a common ground with the power source so that they are grounded to each other. We will still conduct a test with an equivalent resistor that we ground with the RPI and see if we observe more accurate results.



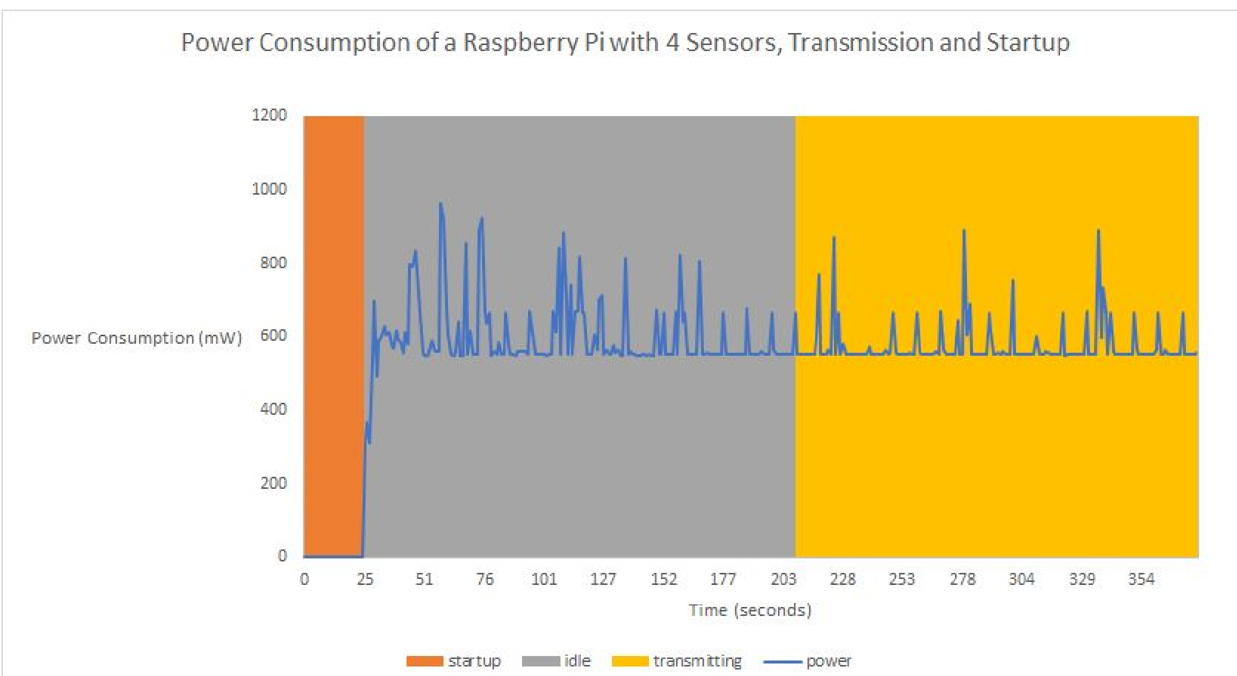
This is the set up that we used to test the power consumption of the RPI. Note that the green wire that connects the small breadboard on the top left that connects to the RPI in the top acts to ground the two to the same ground. The red and black clips in the top left connect to a DC power supply providing 5 volts.

We started by having the RPI on the top right that collected the data from the INA219 (RPI-C) turned on an running the program that reads out the data collected from the INA219. Once the data was being transmitted for about 15 seconds we then turned on the RPI in the center of the image which is connected to the sensors (RPI-S). Once RPI-S has turned on we then initiate the sensors to take measurements every minute. Then we will plot the power consumption with respect to time.

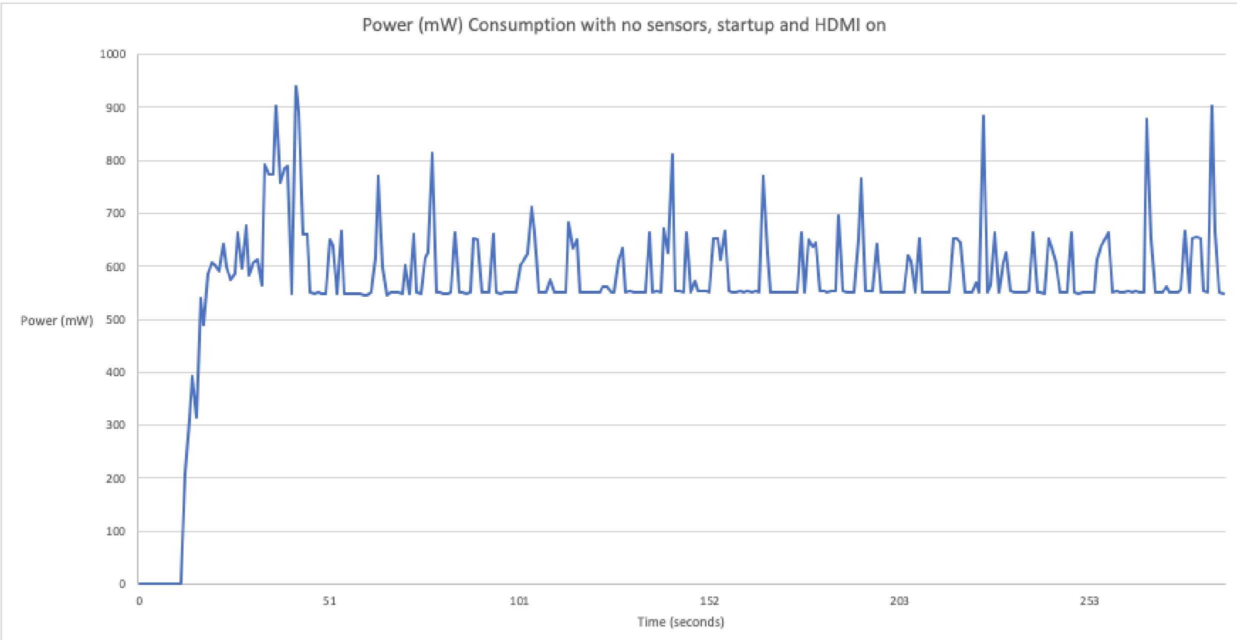


note that there is a spike every 10 seconds that we can not account for

Before performing our next trial we will disable the on board bluetooth by editing the /boot/config.txt file by adding the line `dtoverlay=pi3-disable-bt` to the bottom. We are using the same exact set up as above only that now the bluetooth on RPI-S is now turned off.

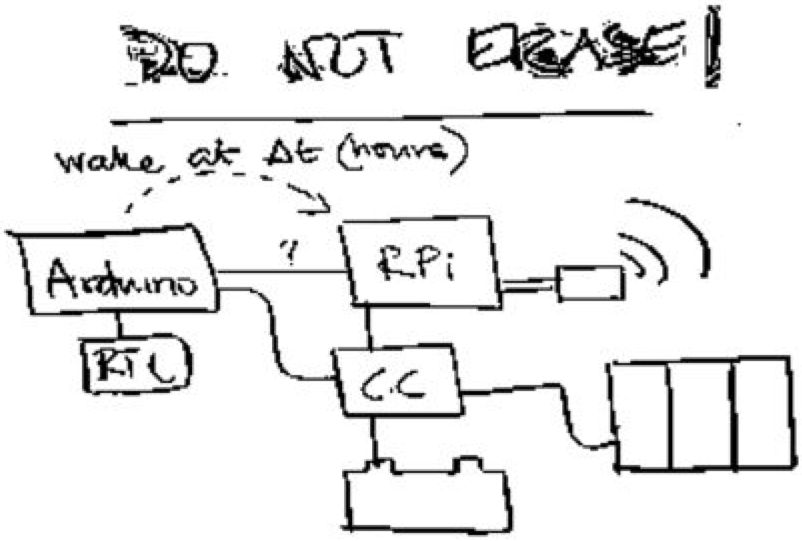


When we disconnect the sensors and we take measurements, we still continue to see the 10 second oscillations. See the graph below that shows power consumption as a function of time with no sensors.



This is a big mystery that we are trying to solve. Our next guesses are to turn off the HDMI port to see if this is causing the periodic increase in the power consumption. We plugged the sensors back in and we turned off HDMI. See the graph below to see the power consumption as a function of time with HDMI off.

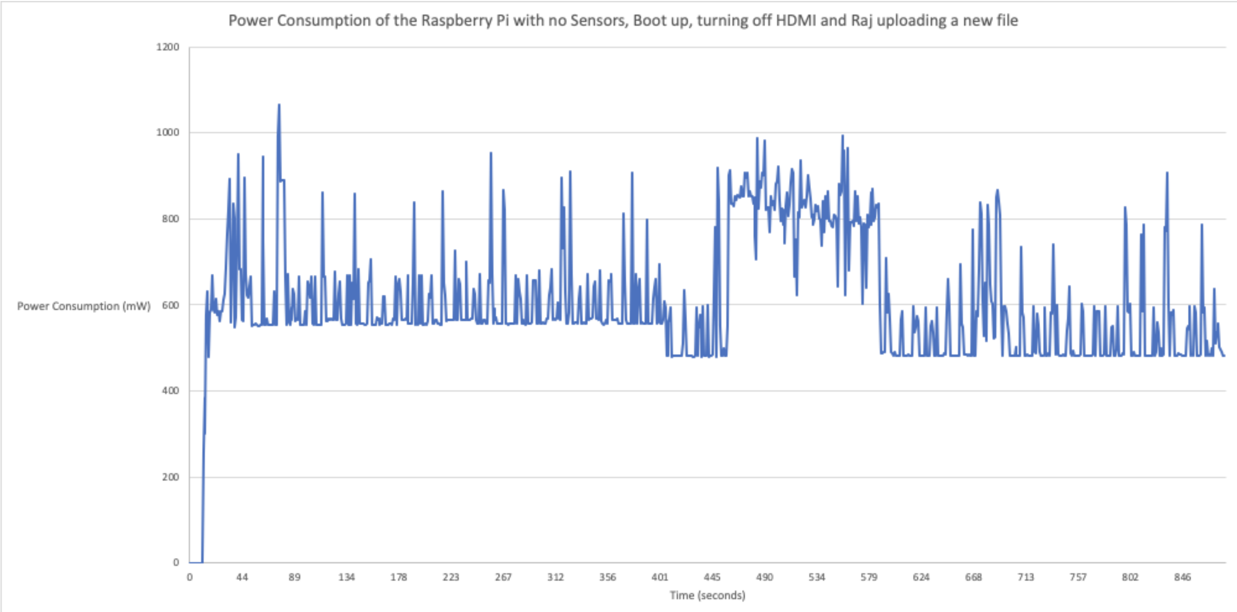
Here is the chart that we made in class today to see if we can use an Arduino to power up and power down the raspberry Pi with a real time clock. For further homework, we are going to research turning on/off a raspberry pi with an Arduino.



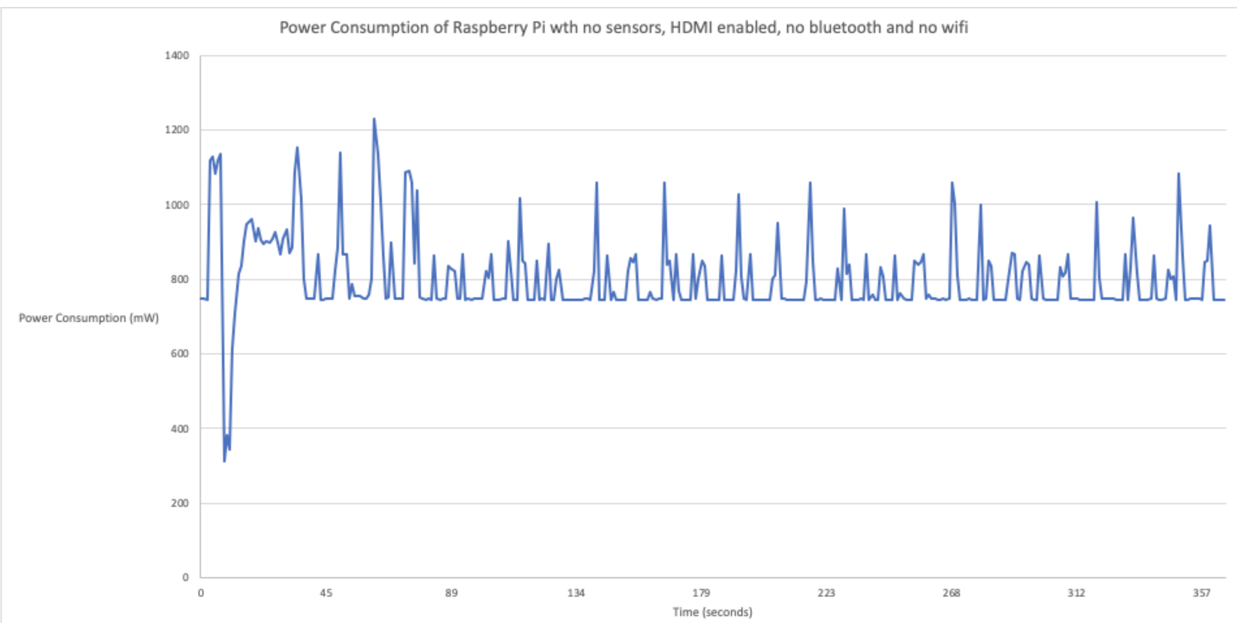
Wednesday, May 15

Today we plan to continue to investigate what causes the irregular power usage by turning off the onboard wifi and using the RPI-S through the HDMI port connected to a monitor. We also took out all the connections for the sensors to see if they play any role in turning bluetooth off.

The below graph shows power consumption over time. It shows the start up. There is a significant dip when we turn off HDMI. There is a significant increase when Raj uploads a file to the Pi. Finally, we let the Pi idle at the end. However, we still see the irregularities in the power consumption of the Pi. We still do not know why.

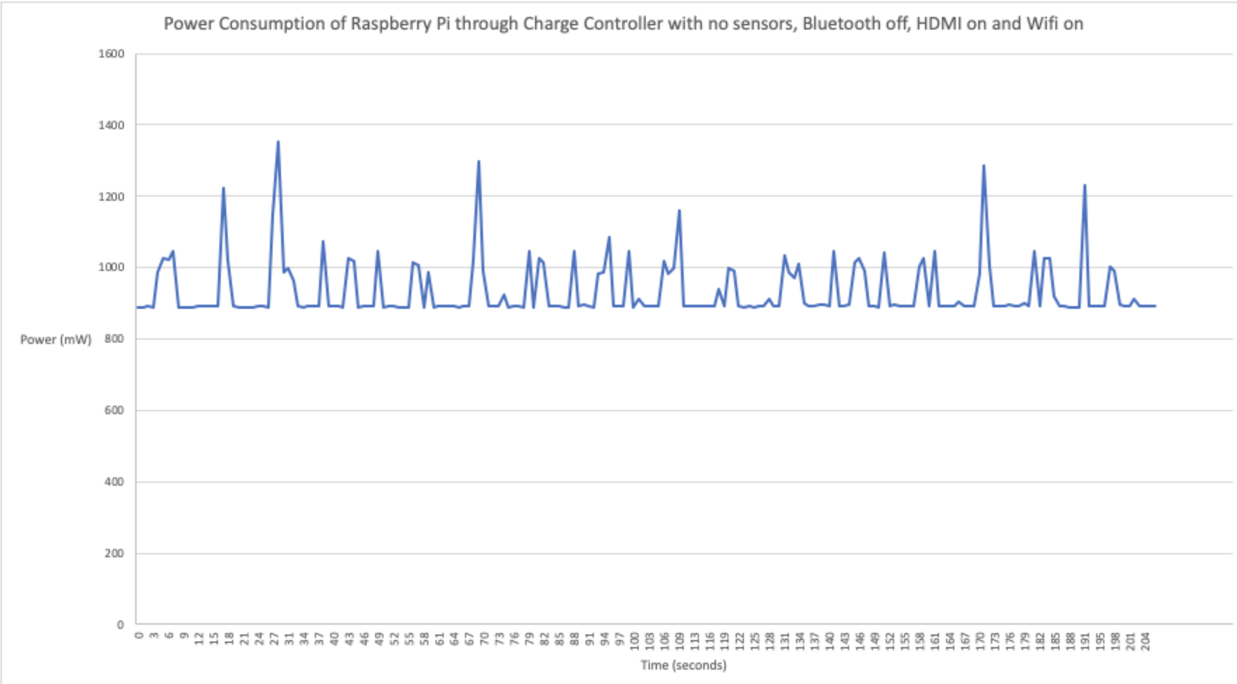


Next, we turned HDMI back on, but turned off Wifi. In both cases we still see strong irregularities in the baseline power consumption of the Pi.



This plot shows our data from when no sensors were attached to RPI-S and we were controlling the system via an HDMI connection with a monitor. The onboard wifi for RPI-S was disabled and we still observe some frequent power jumps. From this we concluded that it was neither the HDMI port, Wifi, or Bluetooth that causes these jumps.

Now, we are trying to discover charge controller efficiency. Bluetooth off, wifi on, HDMI on and no sensors.



Ultimately, we struggled to understand why the power consumption of the Raspberry Pi was so variable. Here is a summary of the tests that we completed and their average power consumptions:

Test	Sensors (in or out)	Transmitting?	Bluetooth	WIFI	HDMI	Monitor ?	Average Power Consumption
1	IN	NO	YES	YES	YES	NO	558.60 mW
2	IN	YES	YES	YES	YES	NO	601.3 mW
3	IN	NO	NO	YES	YES	NO	551.50 mW
4	IN	YES	NO	YES	YES	NO	574.61 mW
5	OUT	NO	NO	YES	YES	NO	597.43 mW
6	OUT	NO	NO	YES	NO	NO	525.02 mW
6	OUT	NO	NO	NO	YES	YES	852.95

							mW
Charge Controller	OUT	NO	NO	YES	NO	NO	934.47 mW

Now, through all of our tests, we are able to create a table to describe the energy consumption of various aspects of this project:

Item	Measurement
WIFI Transmission (frequency = 1 per minute)	32.91 mW
Idle Pi	Unknown for now
Bluetooth	16.90 mW
HDMI	72.41 mW
WIFI	Unknown for now
4 Sensors	45.93
Efficiency of Charge Controller	System with the charge controller consumes 77.98% more energy than the system alone

Inputs:
Times turning on the PI in a day
Sensors in the PI
Frequency of Transmission
Darkness Time
Quality of batteries (Ah)
Estimate for cellular transmission

Output:
Number of Batteries (100 Ah)

Thursday, May 16

Today Raj told us that he talked to the sales representative at the solar company and was told that the efficiency of our charge controller was as good as it was going to get. This is extremely unfortunately considering that the charge controller is extremely inefficient.

We also made an excel file that will tell us the number of batteries that we need to power our station if we use an Arduino to send signals to the Raspberry Pi. We also included a high energy consumption case, a low energy consumption case and a base case. Below are pictures from the interactive Excel model.

High energy case:

Times turning the Pi on per day	200
Cellular transmissions per day	1.00
Number of weeks spent in darkness	22
Amphour rating of the batteries	100
Baseline power consumption from Arduino in mW (~ 100 to 500 mW)*	500
Estimate for power consumption of the cellular transmission in mW (~100 mW to 1000 mW or larger)*	1000
Length of cellular transmission (minutes)	4
Efficency loss from charge controller (currently measured at 0.7798)**	0.9
Number of Batteries You Need to Survive Winter	3.019808102

Low energy case:

Times turning the Pi on per day	40
Cellular transmissions per day	0.14
Number of weeks spent in darkness	12
Amphour rating of the batteries	100
Baseline power consumption from Arduino in mW (~ 100 to 500 mW)*	180
Estimate for power consumption of the cellular transmission in mW (~100 mW to 1000 mW or larger)*	200
Length of cellular transmission (minutes)	0.5
Efficency loss from charge controller (currently measured at 0.7798)**	0.5
Number of Batteries You Need to Survive Winter	0.461621875

Base case:

Times turning the Pi on per day	60
Cellular transmissions per day	0.50
Number of weeks spent in darkness	18
Amphour rating of the batteries	100
Baseline power consumption from Arduino in mW (~ 100 to 500 mW)*	300
Estimate for power consumption of the cellular transmission in mW (~100 mW to 1000 mW or larger)*	1000
Length of cellular transmission (minutes)	2
Efficency loss from charge controller (currently measured at 0.7798)**	0.8
Number of Batteries You Need to Survive Winter	1.3825875

As you can see, the system is sensitive to parameterization. We still need to test the power consumption of a cellular transmission and we need to test the baseline power consumption of the Arduino. After we complete those power consumption measurements, we are then going to do further research regarding the setup of a Raspberry Pi controlled by an Arduino and further research regarding the software that will transmit the data through the cellular transmission. This includes the codes that are required to run data collection and the codes that are required to determine when and what data to send.

We had some trouble with the shunt resistor and expected current parts of the INA219 code when measuring the power consumption and duration of the cellular device. All in all, the INA219 had some trouble measuring current and power. At a certain point, the numbers would just seem to double and then never came back to normal. We tried multiple tests. The results of the tests are in the table below.

Number of Characters	Time to send message
50	16 seconds
100	14 seconds
1	17 seconds, 14 seconds

Beyond the above results, we determined that the cellular modem consumes approximately 400 mW during its transmission. We also determined that turning off the USB decreased the power consumption of the raspberry pi significantly.

Now, we are going to research how to use the Arduino to power on and off a Raspberry Pi. This will occupy the remaining portion of our class time. We are also going to begin researching a GitHub page for our final project. The goal of the GitHub page is to illustrate our DIY project to the world so it can be easily recreated.

Link	Reason
https://www.raspberrypi.org/forums/viewtopic.php?t=188798	Chain discussing how to build an arduino that powers on and off the RPI
https://www.raspberrypi.org/forums/viewtopic.php?p=497325#p497325	Chain debating where to place the controller
https://forum.arduino.cc/index.php?topic=518600.0	Chain discussing how to build own switch
http://www.allspectrum.com/mopower/	Pre-built along the same lines

Arduino controller things to consider

- The total resistance of the controller and the pi together will decrease the current and drain more power
- If you put the controller before or after the pi in the circuit (seems like it should be in front)
- A relay switch that acts as a transistor may be necessary