ECE 3334 Group 4
Week 3 Presentation

Solar Panel Powered Microgrid and Monitoring Station

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Computer Engineer

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Computer Engineer

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Electrical Engineer

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Electrical Engineer – Team Lead

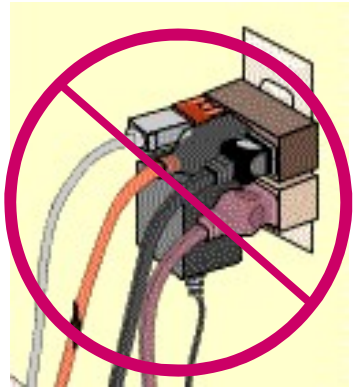
February 7, 2018

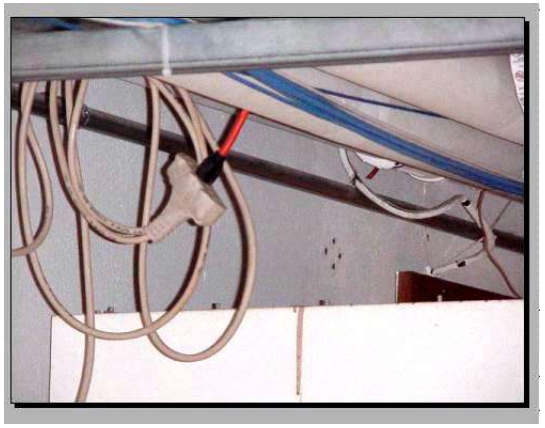
System Description

- The microgrid will use a solar panel to charge a battery while the different sections of the grid are monitored using sensors.
- Data is set via Wi-Fi to a base station built using a Raspberry Pi where data about the system is displayed on a touchscreen.

Safety

- Be sure to have safety certificates for Lab Bench
- Check for frayed or worn wires
- Be sure not to daisy chain wires
- Be sure not to overload a powerstrip





Division of Labor

Base Station Software and UI: Kenneth

Micro-grid Sensors and Communication: Justin

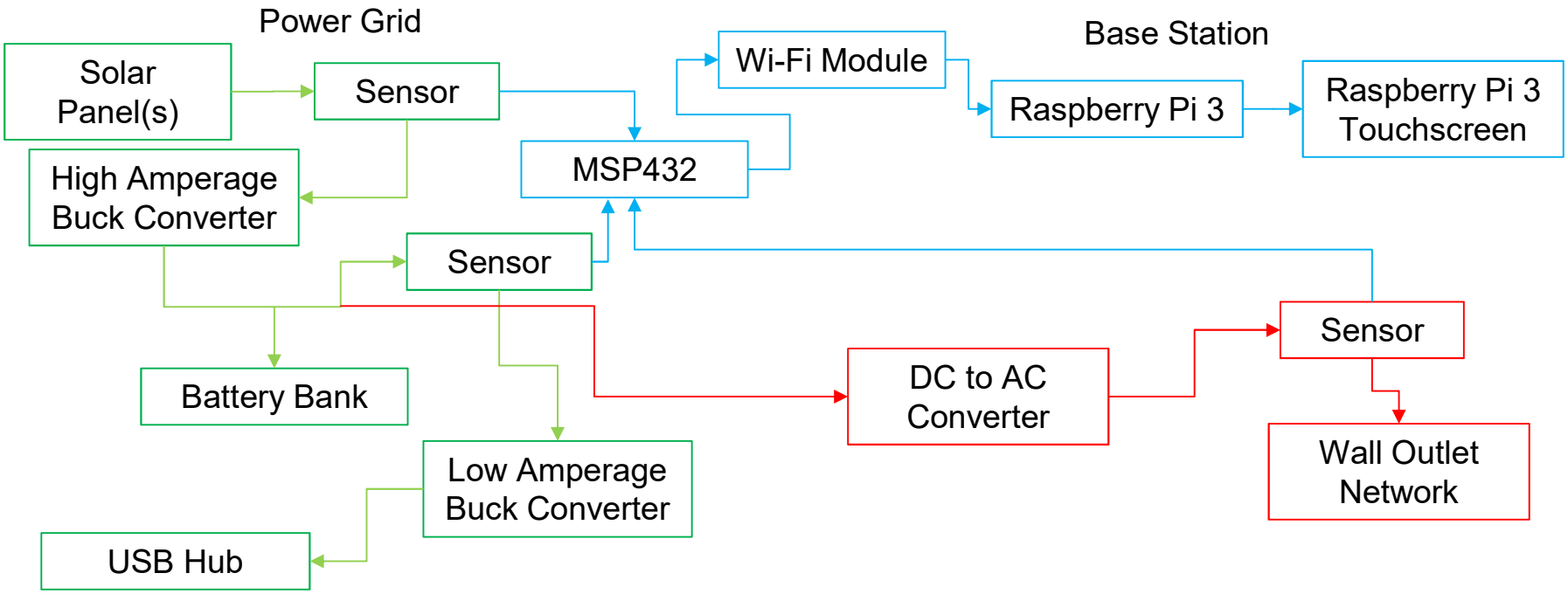
Battery and Power: Juan

Power Conversion and Grid Construction: Jared

Deliverables for Previous Week

- Get lab bench - Completed
- Research monitoring sensors
- Research base station hardware - Completed
- Research microgrid hardware
- Research Batteries - Completed
- Acquire Raspberry Pi - Completed

Hardware Flowchart



Jared Tulio

Grape Solar 100W Panel

Model	GS-STAR-100W
Maximum Power P_{max}	100 W* (0%, +6%)
Voltage at Maximum Power Point V_{mpp}	18.0 V
Current at Maximum Power Point I_{mpp}	5.56 A
Open Circuit Voltage V_{oc}	21.9 V
Short Circuit Current I_{sc}	6.13 A
Module Efficiency (%)	14.63%
Temperature Coefficient of V_{oc}	-0.32% /ºC
Temperature Coefficient of I_{sc}	+0.04% /ºC
Temperature Coefficient of P_{max}	-0.45% /ºC
Weight	8.9 kg (19.66 lbs)
Module Dimension (L x W x T)	1020mm x 670mm x 35mm (40.16” x 26.37” x 1.38”)

Other Performance Data

Power Tolerance	Operating Temperature	Max Series Fuse Rating	NOCT*
0%, +6%	-40 ºC to +85 ºC	10A	45 +/-2ºC

[14]

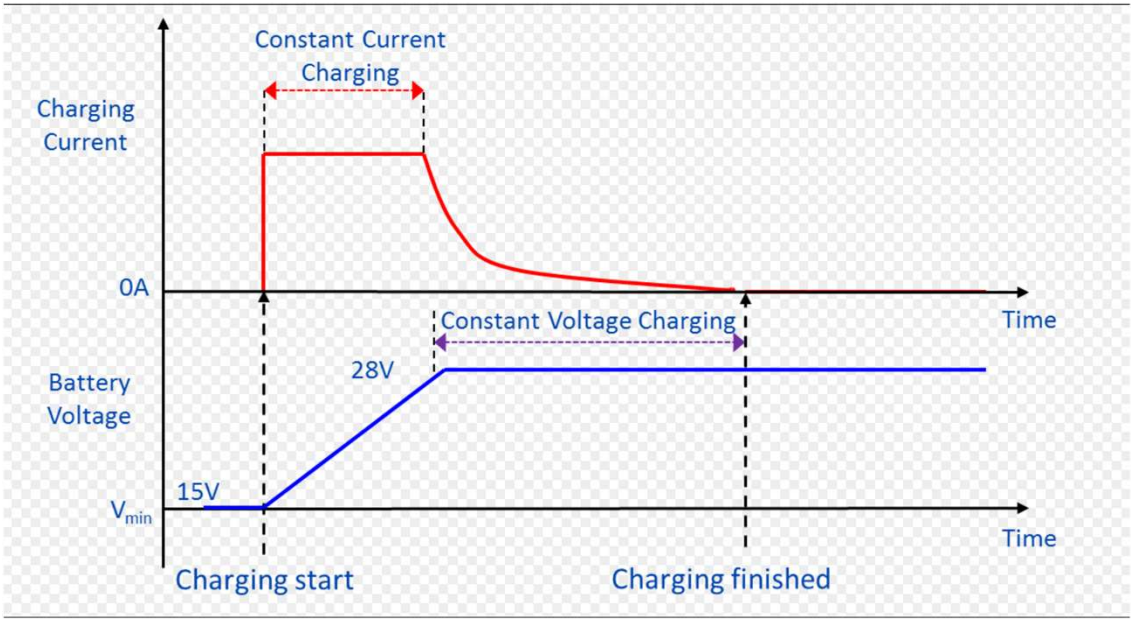
Buck Converter – High Amperage

SMAKN® DC-DC High Power 20A Buck

*Input voltage: DC10V-40V 10V enter below the undervoltage protection
*Output voltage: 0.8V-13V (onboard potentiometer adjustable)
*Cooling: natural cooling
*Rated power: 150W (natural cooling)
*Rated power: 250W (plus fan forced cooling)
*Current Rating: 20A
*Peak current: 30A ≥35A enter overcurrent
*Efficiency: 96% (24V switch 12V / 10A measured)
*Output Ripple: 200-300mV and input-output differential and power-related
*Operating frequency: 100KHz
*Load regulation ≤1% (0-30A output drop of about 50mV)
*Short circuit protection: There can be a long short re-power recovery
*Reverse protection: reverse current is 0
*Over-temperature protection: There reaches a certain temperature automatically shut down output
Dimensions and wiring instructions:
*Dimensions: 64 * 61.5 * 32mm including heat sink, fan-free
*Fixation: four M3 screws
*Wiring: high-current-free solder terminals
Vin +, Vin- input positive and negative
OUT +, OUT- output positive and negative
*Work instructions: blue for the output voltage is normal.
*Scope: 12V turn 5V, 3.3V, 24V switch 12V, 9V, 5V, 3.3V, 36V switch 12V, other voltage conversion deration is required.

[15]

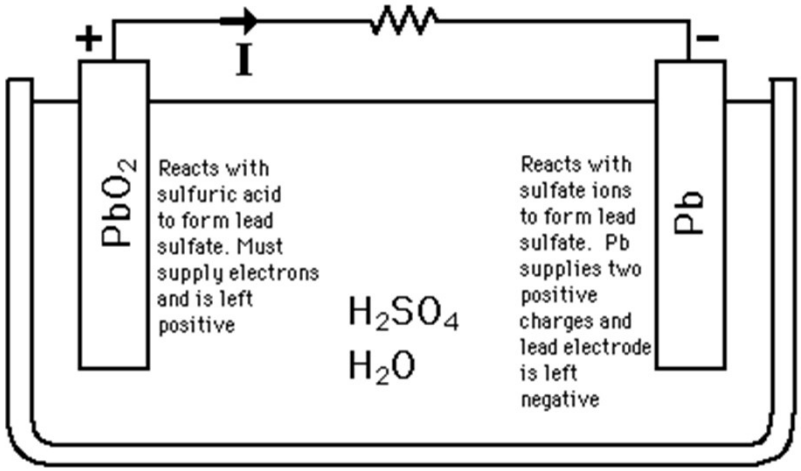
Buck Converter



[16]

Lead-Acid Battery

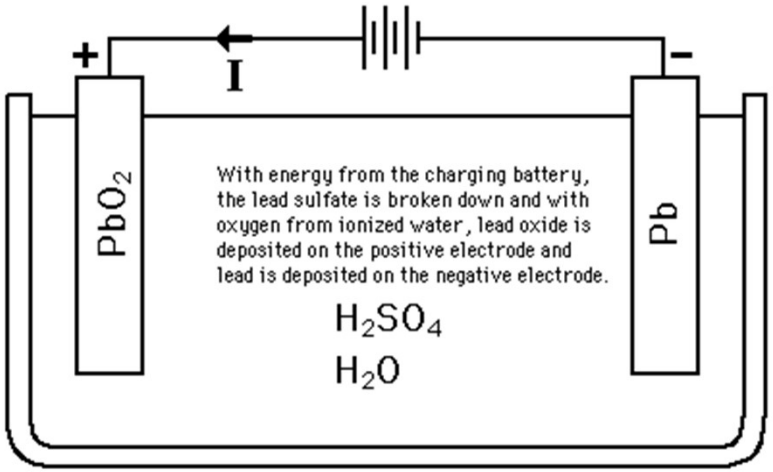
A battery works by the reaction of lead and lead oxide with sulfuric acid electrolyte which then produces a voltage. The supplying energy to external loads discharges the battery.



[1]

Lead-Acid Battery

The battery can be recharged by applying a voltage from a charging source which in our case will be the solar panels



[2]

Lead-Acid Battery

Battery is needed in order to store energy that is generated by the solar panel. The batteries in our project should have a high Amp Hour in order to store as much energy as possible

Lead-Acid Battery

One battery we will be using is the UB12350 Battery

Brand Name	Universal Power Group
EAN	0082045880427
Item Weight	23.15 pounds
Model Number	4330199522
Part Number	4330199522
Voltage	12v
Amp Hours	35Ah

[3]

Lead-Acid Battery

The other batteries we will be using is the UltraTech 12V 7Ah
Sealed Lead Acid (SLA) Rechargeable Battery UT-1270-2 pack

Brand Name	UltraTech
Item Weight	10 pounds
Model Number	PK1270X2rfvv
Part Number	1270
Voltage	12v
Amp Hours	7Ah

[4]

Lead-Acid Battery

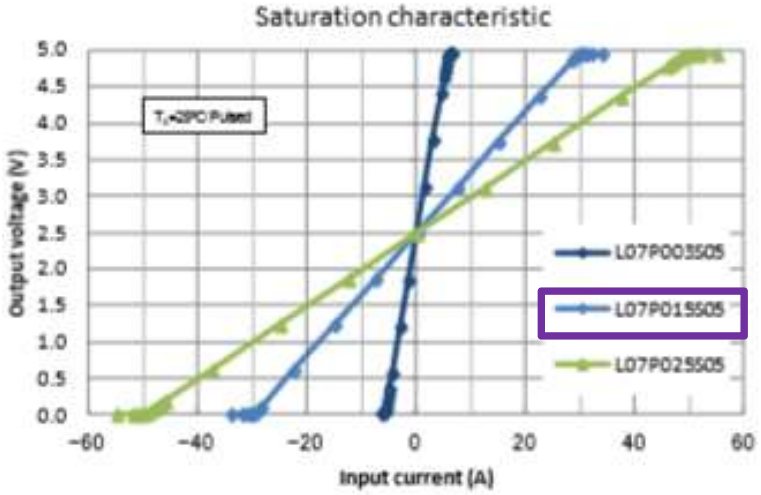
To calculate battery percentage we reference this chart the lower voltage the lower the charge.

STATE OF CHARGE					
	V open circuit	V open circuit	V open circuit	V open circuit	specific gravity
charge	6-V battery	12-V battery	24-V bank	48-V bank	per cell
100%	6.37	12.73	25.46	50.92	1.277
90%	6.31	12.62	25.24	50.48	1.258
80%	6.25	12.50	25.00	50.00	1.238
70%	6.19	12.37	24.74	49.48	1.217
60%	6.12	12.24	24.48	48.96	1.195
50%	6.05	12.10	24.20	48.40	1.172
40%	5.98	11.96	23.92	47.84	1.148
30%	5.91	11.81	23.62	47.24	1.124
20%	5.83	11.66	23.32	46.64	1.098
10%	5.75	11.51	23.02	46.04	1.073

[5]

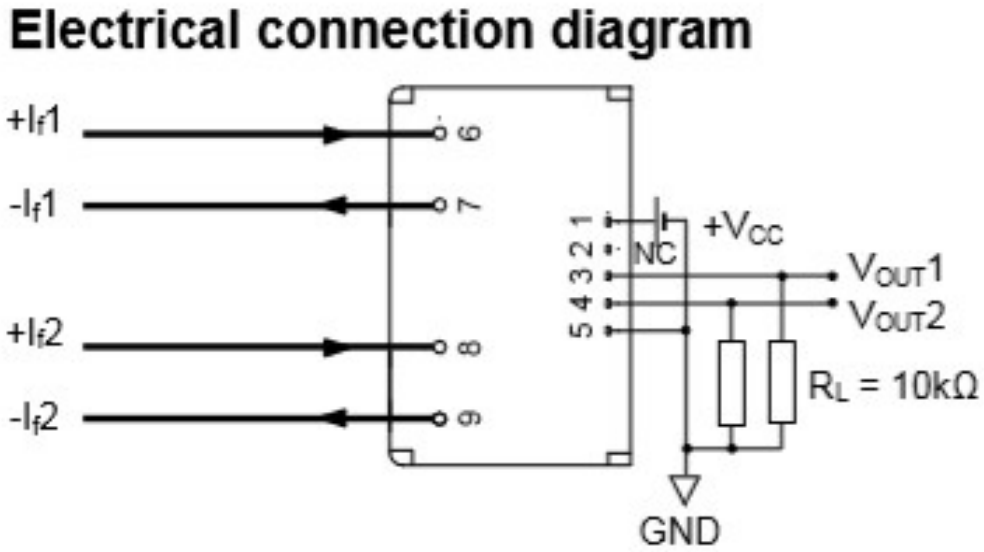
L07P010S05 Current Sensor

Parameters	Symbol	L07P003S05	L07P005S05	L07P010S05	L07P015S05	L07P020S05	L07P025S05	L07P030S05
Primary nominal current	I_r	3A	5A	10A	15A	20A	25A	30A
Saturation current	I_{fmax}	≥ ± I_r x 1.5						
Rated output voltage	V_o	V_{of} + 1.250V ± 0.040V (at If)						
Offset Voltage[1]	V_{of}	Vref [1] ± 0.040V (at If = 0A)						
Output Linearity[2](0A~If)	ε_L	≤ ±1% (at If)						
Power supply voltage	V_{CC}	+ 5V ± 5%						



- Using the 10A module (green square)
- Vref = Vcc/2 (From datasheet)
- Output voltage range from 0 to 3.5V with input current from 0 to 10A (purple square)

L07P010S05 Pinout

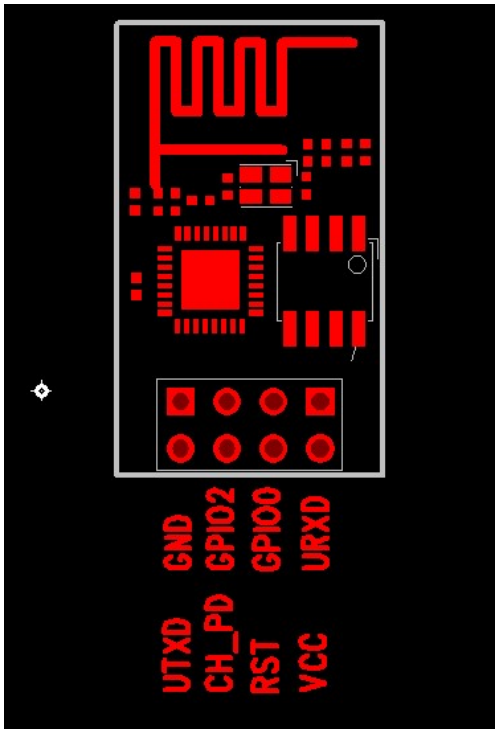


[6]

Terminal	Function
1	$+V_{CC}$(+5V)
2	NC
3	$V_{OUT}1$
4	$V_{OUT}2$
5	GND
6	Primary input current1 (+)
7	Primary input current1 (-)
8	Primary input current2 (+)
9	Primary input current2 (-)

[6]

ESP8266 WIFI Module



[7]

- Supports 2.4Ghz 802.11 b/g/n
- VCC of 3.3V
- Chip Enable (CH_PD) active high
- Communicated using UART
- Default 115200 baud rate, 1 stop bit, no start bit, 8 message bits
- Configured using AT commands

Relevant AT Commands

Commands[8]:

- AT ---> Put into AT command mode
- AT+RST ---> Reset module
- AT+CWMODE ---> Set if in client, access point, or both
- AT+CWJAP=<ssid>,<pwd> ---> Connect to a network or access point
- AT+CIFSR ---> Retrieve assigned IP address

Base Station: Hardware

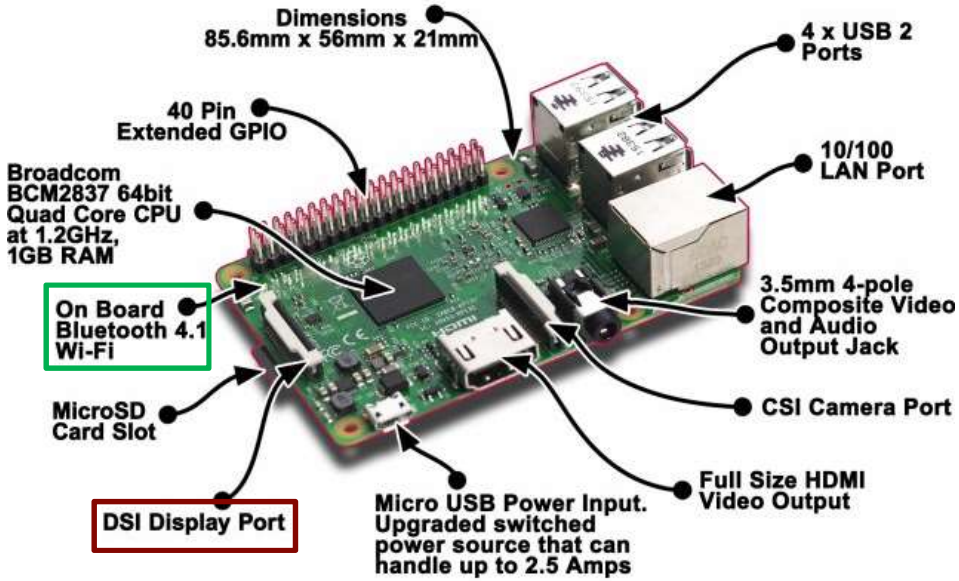
Raspberry Pi 3 Model B

Specifications[1]:

SoC: Broadcom BCM2837
CPU: 4× ARM Cortex-A53, 1.2GHz
GPU: Broadcom VideoCore IV
RAM: 1GB LPDDR2 (900 MHz)
Networking: 10/100 Ethernet, 2.4GHz 802.11n wireless
Bluetooth: Bluetooth 4.1 Classic, Bluetooth Low Energy
Storage: microSD
GPIO: 40-pin header, populated
Ports: HDMI, 3.5mm analogue audio-video jack, 4× USB 2.0, Ethernet, Camera Serial Interface (CSI), Display Serial Interface (DSI)
Power: 5V, 2A power supply necessary to power the Raspberry Pi and the attached touchscreen

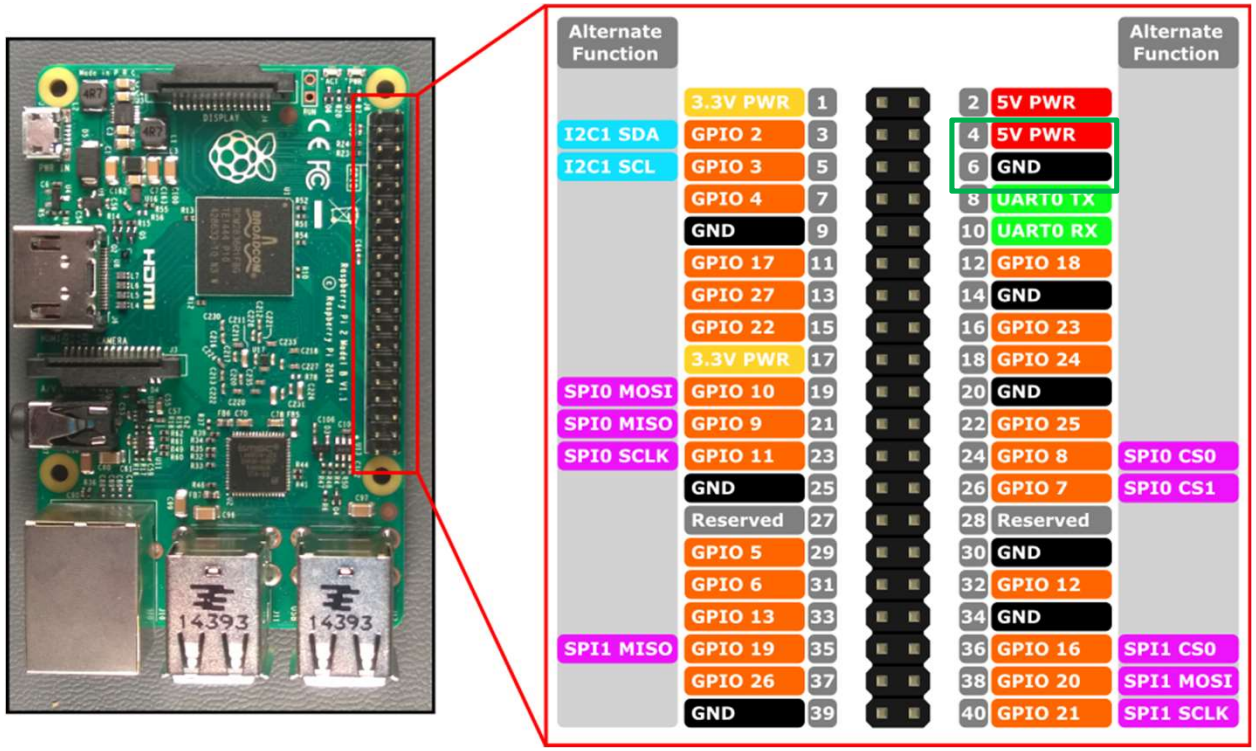
Raspberry Pi 3 Model B[9]

Base Station: Raspberry Pi 3 Ports



Raspberry Pi Ports [10]

Base Station: Raspberry Pi 3 Pinout



Raspberry Pi 3 Model B Pinout[11]

Base Station: Raspberry Pi 3 Software

Raspbian OS v4.9 is the operating system used on the Raspberry Pi 3 Model B. This supports the setup for both the on board Wi-Fi antenna and the drivers for the touchscreen.

Base Station: Raspberry Pi 3 7” Touchscreen

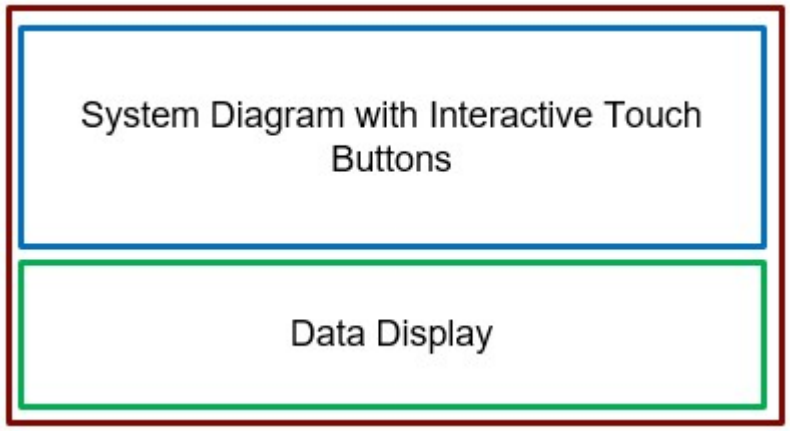
Features & Benefits of the Pi LCD Touch Screen[4]:

- Multi-touch capacitive touch
- 7 inch display
- 800 x 480 pixel resolution at 60 frames per second (fps)
- No electronic interference
- Full Raspbian OS functionality without a keyboard
- Kivy touch screen development software available
- Connects to the Raspberry Pi board using the DSI port
- Adapter board is used to power the display
- Will require the latest version of Raspbian OS to operate

Raspberry Pi 7” Touchscreen[12]

Base Station: GUI

The GUI displayed on the touchscreen will allow users to select any section of the microgrid to access detailed information about the specific section. The GUI will also display basic information by default without any buttons being pressed.



Raspberry Pi Touchscreen Display

Base Station: GUI Software

"Open source Python library for rapid development of applications that make use of innovative user interfaces, such as multi-touch apps."[13]

Kivy allows for touchscreen compatible GUI development on the Raspberry Pi 3.

Raspberry Pi	KivyPie - Image for Raspberry Pi containing Kivy	Installation for Raspberry Pi	532 Mb

Total Budget

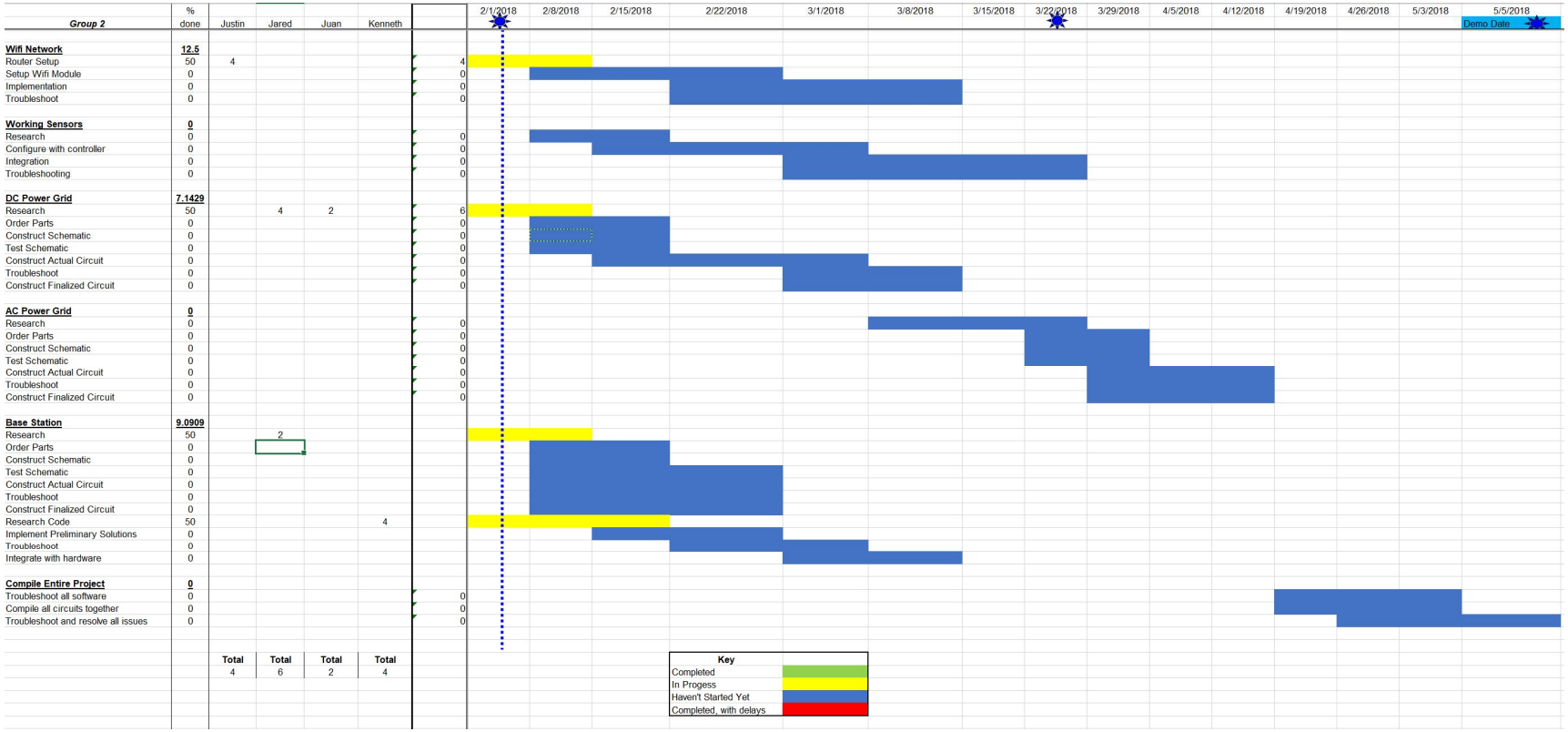
Lab 1 - Group 2	Running Total			Total Estimate			Start Date	2/1/2018
Direct Labor:							Today	2/7/2018
Category or individual:	*Rate/Hr*	*Hrs*		*Rate/Hr*	*Hrs*			
Kenneth	18	8	$144.00	18	215	$3,870.00	End Date	5/5/2018
Jared	18	8	$144.00	18	215	$3,870.00	Days Past	6
Justin	18	8	$144.00	18	215	$3,870.00	Total Days	93
Juan	18	8	$144.00	18	215	$3,870.00	Days Left	87
DL Subtotal (DL)		Subtotal:	$576.00		Subtotal:	$15,480.00		
Labor Overhead	*rate:*	100%	$576.00	*rate:*	100%	$15,480.00		
Total Direct Labor (TDL)			$1,152.00			$30,960.00		
Contract Labor:								
Lab 1 Help	$15	0	$0.00	$15	0	$0.00		
Lab 2 Help	$18	0	$0.00	$18	0	$0.00		
Lab 3 Help	$18	0	$0.00	$18	10	$180.00		
Lab 4 Help	$18	0	$0.00	$18	15	$270.00		
Lab 5 Help	$25	0	$0.00	$25	10	$250.00		
Tutors	$40	0	$0.00	$40	15	$600.00		
Lab Assistants	$40	0	$0.00	$40	15	$600.00		
Woodcock	$100	0	$0.00	$100	5	$500.00		
Prof. Ray	$200	0	$0.00	$200	20	$4,000.00		
Total Contract Labor (TCL)			$0.00			$6,400.00		
Direct Material Costs:			$0.00			$650.00		
(from Material Cost worksheet)								
Total Direct Material Costs: (TDM)			$0.00			$650.00		
Equipment Rental Costs:	Value	Rental Rate		Value	Rental Rate		Date begin	Date end (or today)
Oscilloscope	$5,300.00	0.20%	$63.60	$5,300.00	0.20%	$985.80	2/1/2018	5/5/2018
Function Generator	$500.00	0.20%	$6.00	$500.00	0.20%	$93.00	2/1/2018	5/5/2018
DMM	$958.00	0.20%	$11.50	$958.00	0.20%	$178.19	2/1/2018	5/5/2018
Power Supply	$1,700.00	0.20%	$20.40	$1,700.00	0.20%	$316.20	2/1/2018	5/5/2018
Soldering Station	$100	0.20%	$1.20	$100.00	0.20%	$18.60	2/1/2018	5/5/2018
Total Rental Costs: (TRM)			$101.50			$1,573.19		
Total TDL+TCL+TDM+TRM			$1,253.50			$39,583.19		
Business overhead		100%	$1,253.50		100%	$39,583.19		
Total Cost:		**Current**	$2,506.99		**Estimate**	$79,166.38		

Jared Tulio

Total Budget Cont'd

Name	Cost	Quantity	Website	Notes	Purchase Date	Total		TOTAL
ESP8266 WiFi Module	$6.95	2	SparkFun	NA		$13.90		$538.38
100W-Solar Panel - Grape Solar	$97.00	1	Home Depot	NA		$97.00		
35Ah 12V Lead Acid Battery	$64.99	1	Amazon	NA		$64.99		
7Ah 12V Lead Acid Battery	$28.49	1	Amazon	Pack of 2		$28.49		
Buck Converter - High Amperage	$26.00	2	Amazon	NA		$52.00		
Buck Converter - Low Amperage	$8.00	4	Amazon	NA		$32.00		
Rasberry Pi 3	$35.00	1	Allied Electronics	NA		$35.00		
Rasberry Pi Touch Screen	$70.00	1	Allied Electronics	NA		$70.00		
Rechargeable Battery	$15.00	1	Amazon	NA		$15.00		
Current Sensor	$20.00	3	Mouser	NA		$60.00		
Power Inverter	$70.00	1	Amazon	NA		$70.00		

Gantt Chart



Group 2	% done	Justin	Jared	Juan	Kenneth	
Wifi Network	**12.5**					
Router Setup	50	4				4
Setup Wifi Module	0					0
Implementation	0					0
Troubleshoot	0					0
Working Sensors	**0**					
Research	0					0
Configure with controller	0					0
Integration	0					0
Troubleshooting	0					0
DC Power Grid	**7.1429**					
Research	50		4	2		6
Order Parts	0					0
Construct Schematic	0					0
Test Schematic	0					0
Construct Actual Circuit	0					0
Troubleshoot	0					0
Construct Finalized Circuit	0					0
AC Power Grid	**0**					
Research	0					0
Order Parts	0					0
Construct Schematic	0					0
Test Schematic	0					0
Construct Actual Circuit	0					0
Troubleshoot	0					0
Construct Finalized Circuit	0					0
Base Station	**9.0909**					
Research	50		2			
Order Parts	0					
Construct Schematic	0					
Test Schematic	0					
Construct Actual Circuit	0					
Troubleshoot	0					
Construct Finalized Circuit	0					
Research Code	50				4	
Implement Preliminary Solutions	0					
Troubleshoot	0					
Integrate with hardware	0					
Compile Entire Project	**0**					
Troubleshoot all software	0					0
Compile all circuits together	0					0
Troubleshoot and resolve all issues	0					0
		Total	**Total**	**Total**	**Total**	
		4	6	2	4	

References

[1] http://hyperphysics.phy-astr.gsu.edu/hbase/electric/leadacid.html

[2] https://powerwerx.com/ub12350-12v-35ah-battery-group-u1

[3] https://www.amazon.com/UB12350-WKDC12-35J-U1HR1500S-0120935-6FM33U1/dp/B00IL0PVL4/ref=cm_wl_huc_item

[4]https://www.amazon.com/dp/B007ROV36W/_encoding=UTF8?coliid=I1ZROGN1XTDKII&colid=3DVKL0V7S8W7F&psc=0

[5] https://modernsurvivalblog.com/alternative-energy/battery-state-of-charge-chart/

[6] https://www.mouser.com/ds/2/397/L07PXXXS05-467715.pdf

[7] https://github.com/esp8266/esp8266-wiki/wiki

[8] https://cdn.sparkfun.com/datasheets/Wireless/WiFi/Command%20Doc.pdf

[9] https://www.raspberrypi.org/products/raspberry-pi-3-model-b/

[10] https://www.jameco.com/Jameco/workshop/circuitnotes/raspberry_pi_circuit_note_fig2.jpg

[11] https://docs.microsoft.com/en-us/windows/iot-core/learn-about-hardware/pinmappings/pinmappingsrpi

[12] https://www.alliedelec.com/raspberry-pi-raspberry-pi-7-touchscreen/

[13] https://kivy.org/#home

[14] https://www.homedepot.com/catalog/pdfImages/1d/1d1b46a0-4979-46fa-b5d2-73cc1f950f30.pdf

[15] https://www.amazon.com/SMAKN%C2%AE-Adjustable-Converter-10-40V-0-8-13V/dp/B00VY1CYL2

[16] https://en.wikipedia.org/wiki/Buck_converter

Questions?