FunBox Classic (FBC)

Group 14

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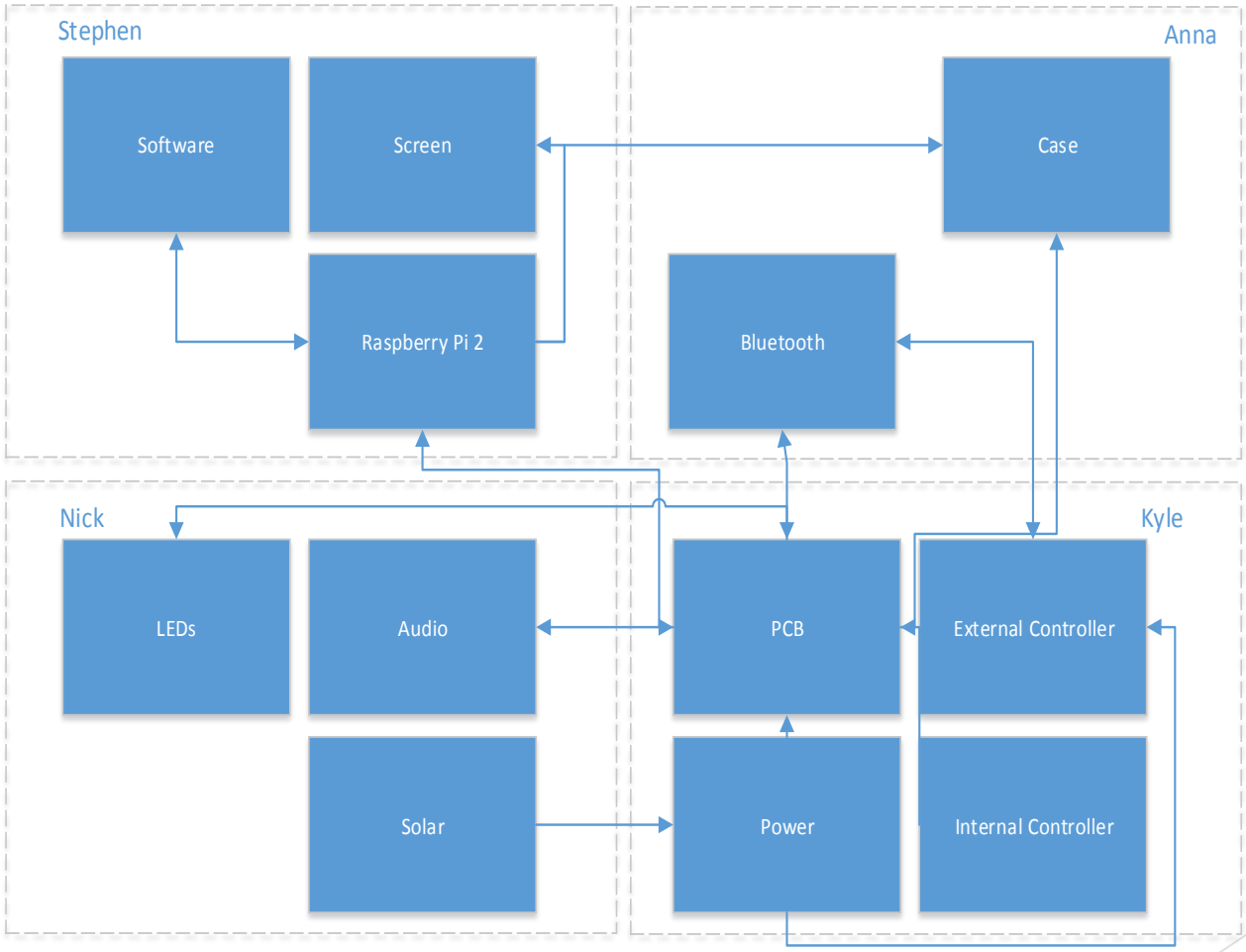
Goals and Objectives

- Accurately simulate old consoles
- Rechargeable battery from USB
- Emulate GB, GBC, GBA, NES, and SNES at native speed
- Games upload through USB
- Audio through speakers or headphones
- Controller feels like a SNES controller
- Sturdy housing
- Built-in Bluetooth
- Solar Charging
- Battery Life Indicator

Specifications

Component	Parameter	Design Specification
Screen	Size	Between 3.5" and 6"
Screen	Refresh Rate	50Hz (PAL)
Bluetooth	Version	4.0 LE or higher
Storage	Type	MicroSD
	Size	Minimum 16 GB
Headphones	Connector	3.5mm jack
Speakers	Power	1W
	Impedance	Minimum 8 ohms
Power	Max Current Draw	700 mA
	Solar Charge Current	Minimum 100 mA
Battery	Charging Voltage	5V
	Capacity	Minimum 2100 mAh
	Discharge Time	Minimum 2 hours

Project Block Diagram



Constraints

- Economic constraints
  - Financing/shipping from ordering many individual components
- Manufacturing constraints
  - Acquisition of needed parts and manufacturing supplies
- Size constraints
  - Surface mounted components and case design parameters
- Sustainable energy constraints
  - Power supply and battery charging challenges

Standards

Identification Number	Standard Description
SMPTE-170M-1990	Standard for analog television system color bar test system
IEEE 802.15.1	Standard for Bluetooth development (currently under BSIG jurisdiction)
IEC 62680-1:2013	Standard for Universal Serial Bus (USB) interfaces for data and power (revision 2.0)
IEC 62680-2:2013	Standard for micro-USB cables and connectors specifications
IEEE 928-1986	Standard for general performance standards of photovoltaic power systems
IEEE 1625-2008	Standard for rechargeable batteries for multi-cell mobile computing devices

Research On Case-Design

Display:

Dual Single




Centered Above Control Buttons



Buttons:

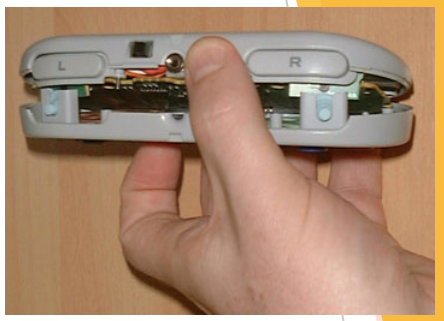

Obstacle - hard to deal with custom made buttons

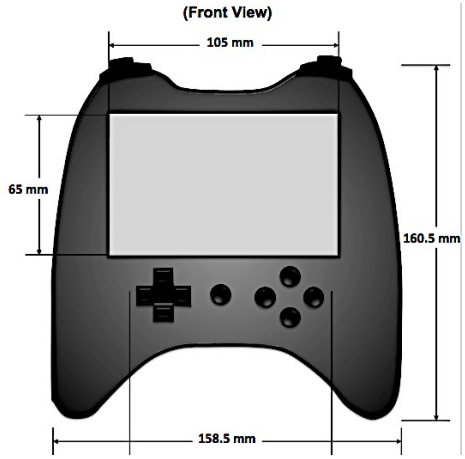
Solution – use circuit board with buttons from Nintendo controller

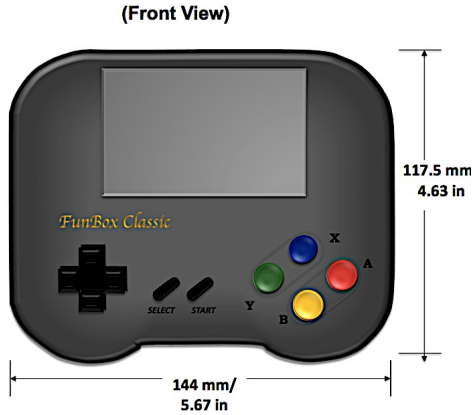
Design Decisions

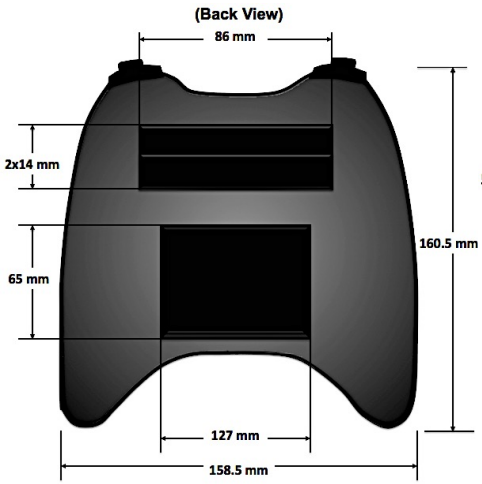
- Single display located above control buttons
- Use circuit board with buttons from original Nintendo controller
- L and R buttons locate on the back side of the controller

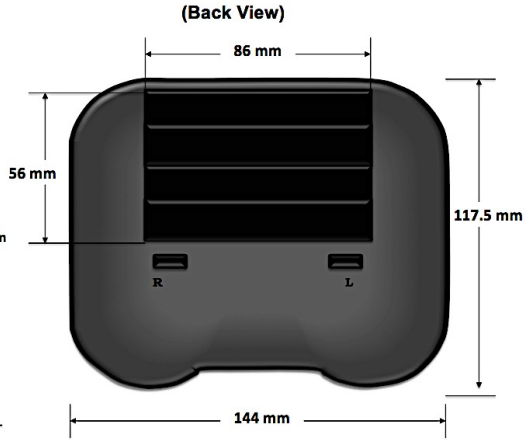
Initial & Current Designs





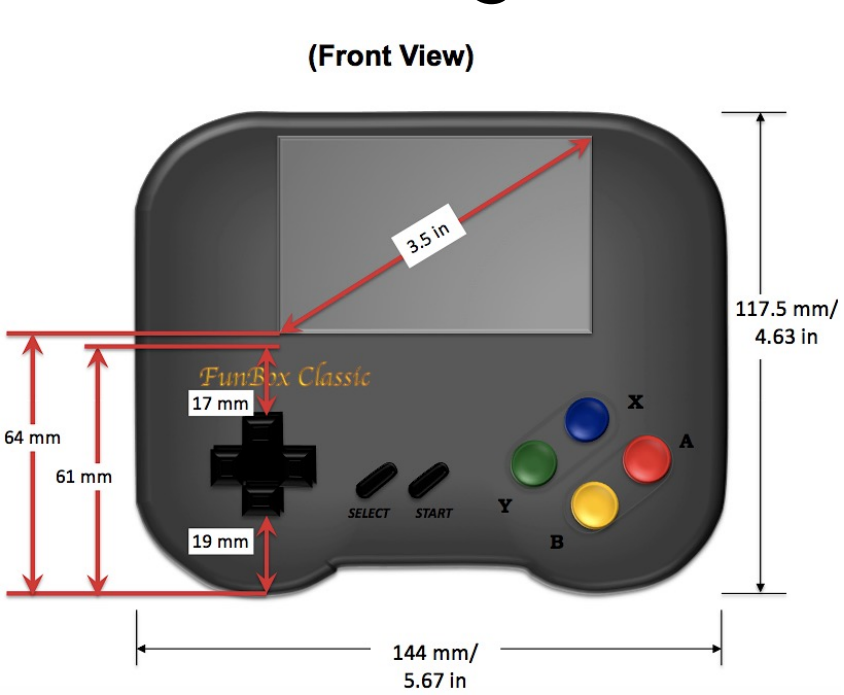


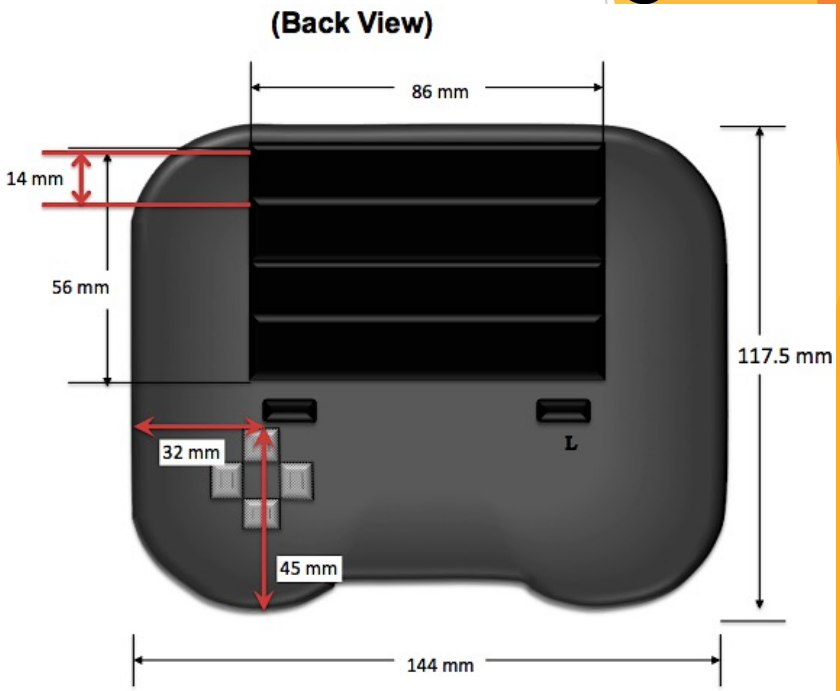


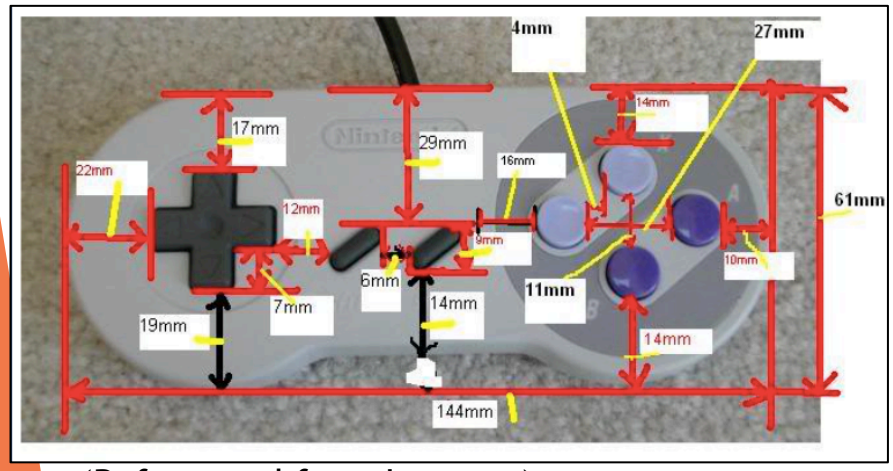


3D PRINT		
Category	**Type**	**Comments**
Software	SolidWorks	OpenSCAD.org
Design	Custom	Thingiverse.com
Size	4.63x5.67x2 in	Up to 10x10x12 in
Cost	Free	Free up to 15 in^3
Color	Grey or combination of two colors	Red, Blue, Yellow, Green, Grey, Black

Design Dimensions and 3D Printing







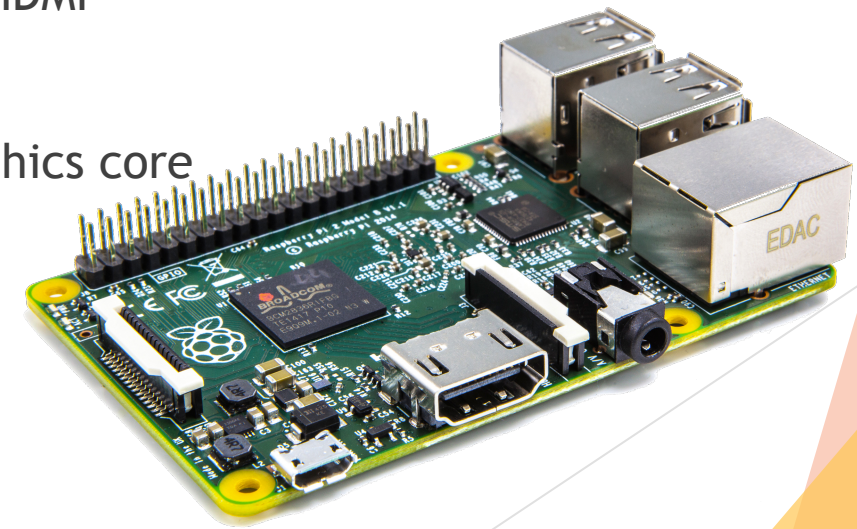
(Referenced from Internet)

Have Objectives Been Met

- ✓ Small
- ✓ Light Weight
- ✓ 3.5 in Display

Raspberry Pi 2

- Input: 5V Micro USB
- Current Draw: <= 1A
- 900 MHz quad-core ARM Cortex-A7 CPU
- 1GB RAM
- 40 GPIO pins
- Composite Video or HDMI
- 2 USB headers
- VideoCore IV 3D graphics core



Screen

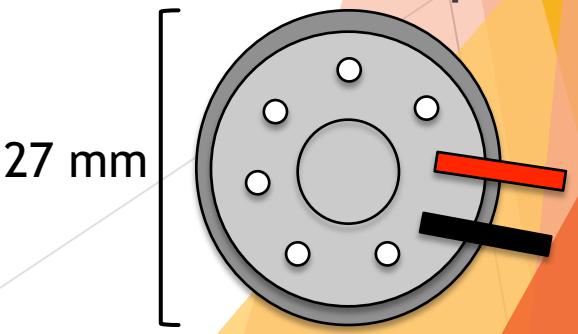
- 3.5” Diagonal
- 480x320 Resolution
- Composite Connection
- Backlit

Audio

- Outputs audio via external stereo speakers and 3.5mm jack
- Closed circuit audio port toggles between speakers and auxiliary headphones

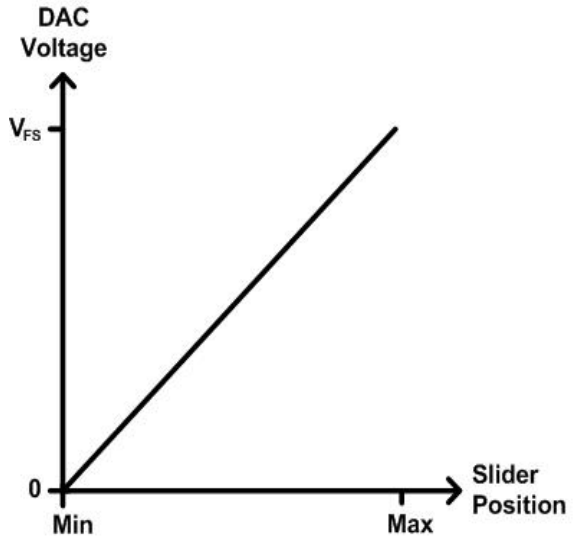
Model	Supply Current	Power Output	Cost
TDA2822M	6 mA	300 mW	$1.33
TS4984	7.4 mA	1 W	$1.89
LM4880	3.6 mA	250 mW	$1.26

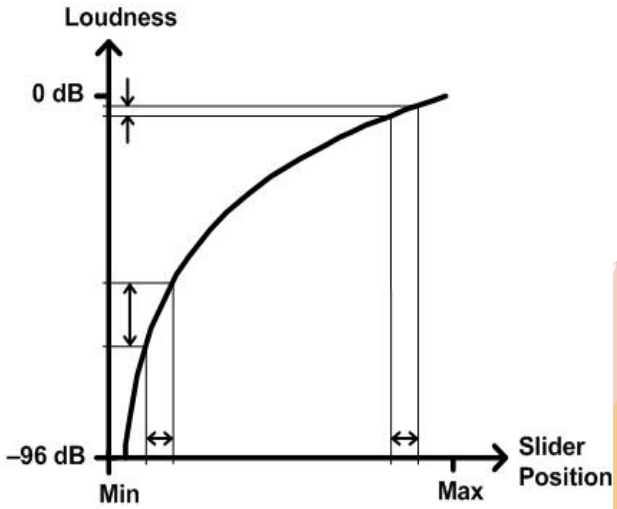
- Choose 2 LM4880 8-pin audio amplifiers used to output audio from Raspberry Pi 2
- 2 102-1554-ND speakers
  1) Frequency range of 530 Hz – 20 KHz
  2) 27 mm diameter



Volume Control

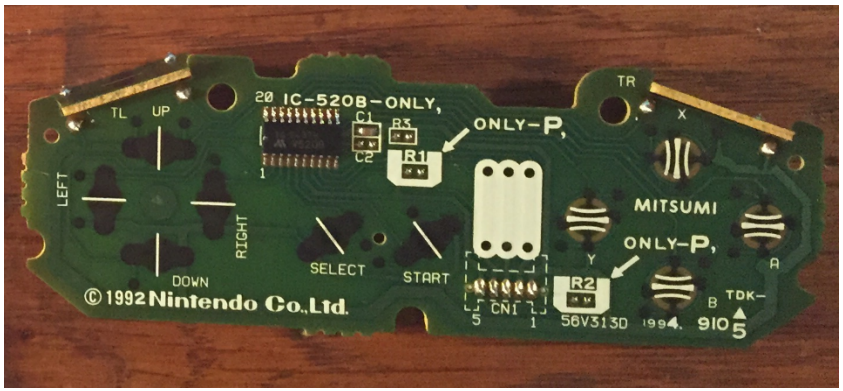
- Use Bourns 3352T-103LF-ND thumbwheel potentiometer
- Logarithmic volume control
- 270° rotation angle
- Maximum 10 kilo-ohm resistance to “mute” audio output





Internal Controller

- We will connect a SNES controller circuit board to the RP2 GPIO pins
- SNES Controller has 5 connections:
  - Power
  - Clock
  - Latch
  - Data
  - Ground



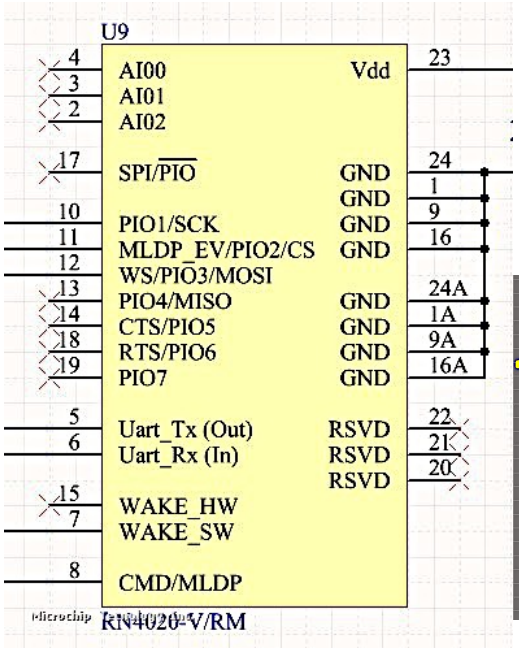
- Raspberry Pi 2 code will interpret data from SNES controller
  - SNESDev

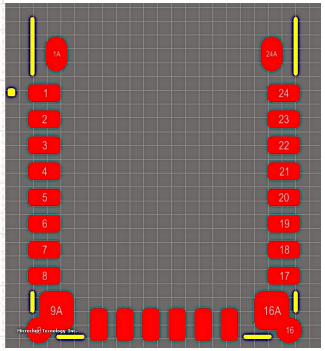
Bluetooth Chip RN4020

Why RN4020:

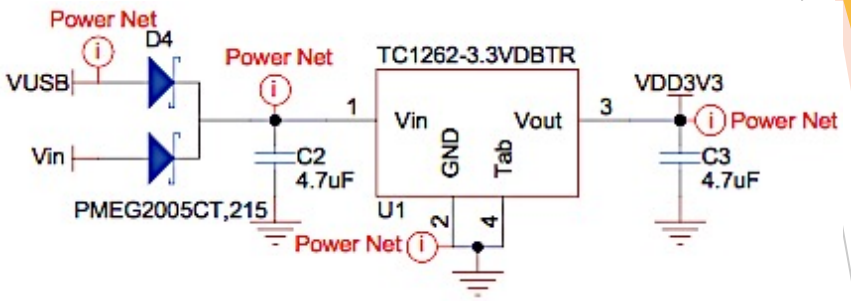
- Newest Bluetooth Version 4.1
- Comfortable Size 11.5 x 19.5 x 2.5mm
- Best Cost for one chip $10.61
- Long Range Performance over 100 m or 300 ft
- Low Power Consumption

PCB Layout for Custom Made Board:

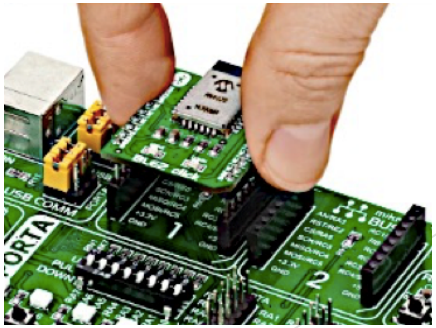




(Suggested PCB Design from Internet)



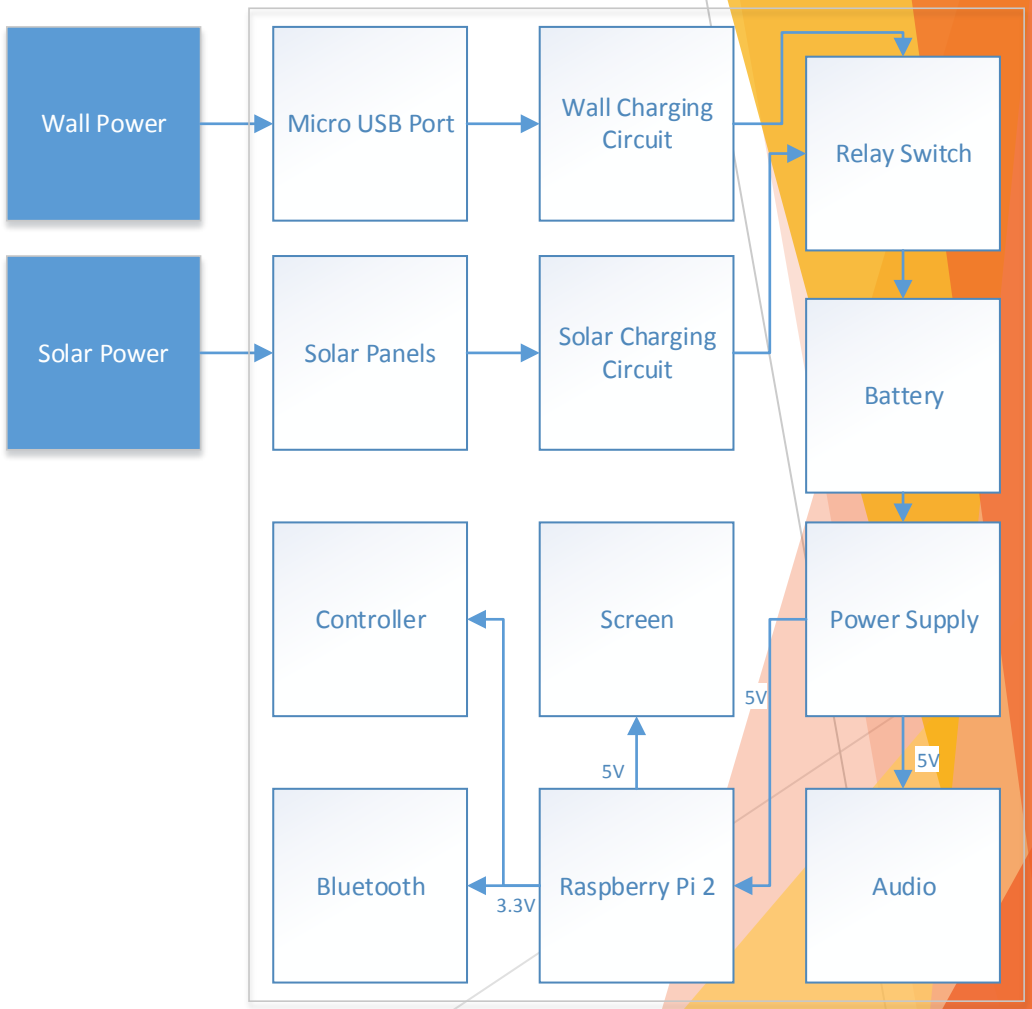
Referenced from Microchip



(Image from MkroElectronica)

Power System

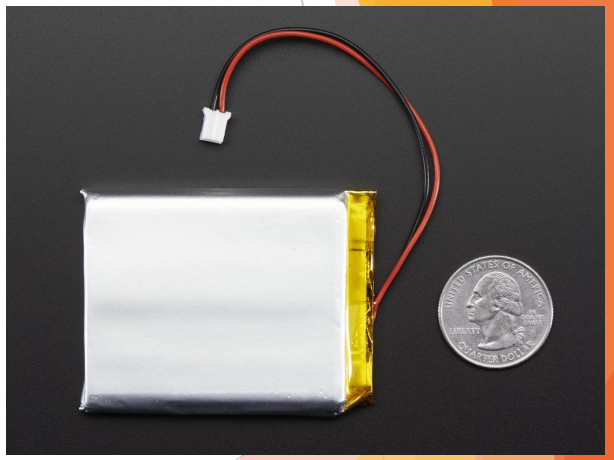
- The power system is responsible for supplying the power for the operation of the device
- The power system consists of five main components:
  - Battery
  - Wall Charging Circuit
  - Solar Charging Circuit
  - Relay
  - Power Supply



Battery

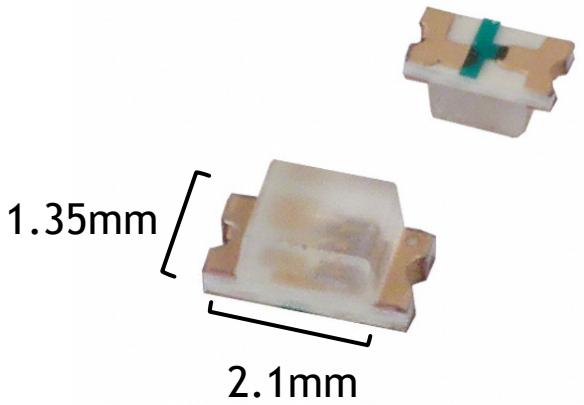
- We compared a few different types of batteries
- We settled on using either a Li-ion battery or LiPo battery for the FBC

	Tenergy Li-Ion 18650 Battery Module 5200	Tenergy Li-Ion 18650 Battery Module 2200	Adafruit Lithium Ion Polymer Battery
Capacity (mAh)	5200	2200	2500
Size (mm)	66 x 37 x 19	69 x 19	65 x 51 x 8
Weight (g)	96	54	52
Protection Circuit	Yes	Yes	Yes
Shape	Rectangular	Cylindrical	Rectangular
Price	$19.99	$10.99	$14.95



Battery Status Indicator LEDs

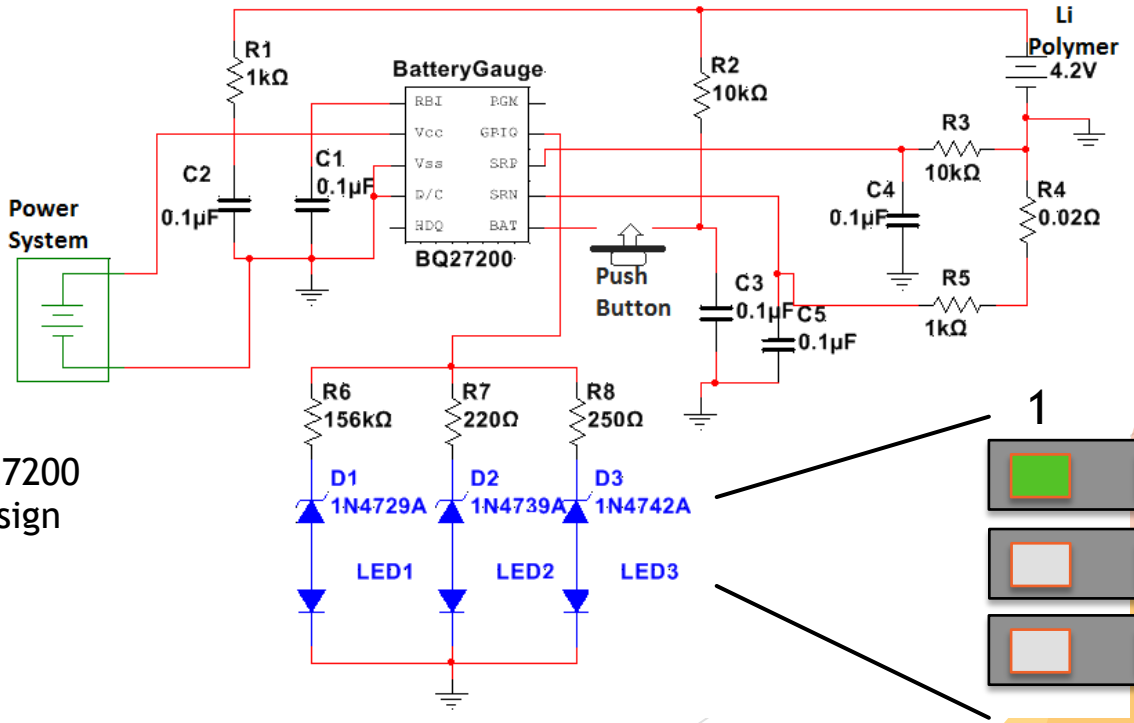
- Surface mount LEDs (SMD LEDs) used for size and viewing angle advantages
  - 20 mA forward current
  - 2.2 V forward voltage
  - 2.1 mm x 1.35 mm
  - 160° viewing angle
  - Cost: $0.28



- 3 green SMD LEDs will display the remaining charge of the source battery upon push-button initiation
  - 3 SMD LEDs “ON” @ battery charge of 100% to 70%
  - 2 SMD LEDs “ON” @ battery charge of 70% to 40%
  - 1 SMD LED “ON” @ battery charge below 40%

Battery Status Indicator LEDs

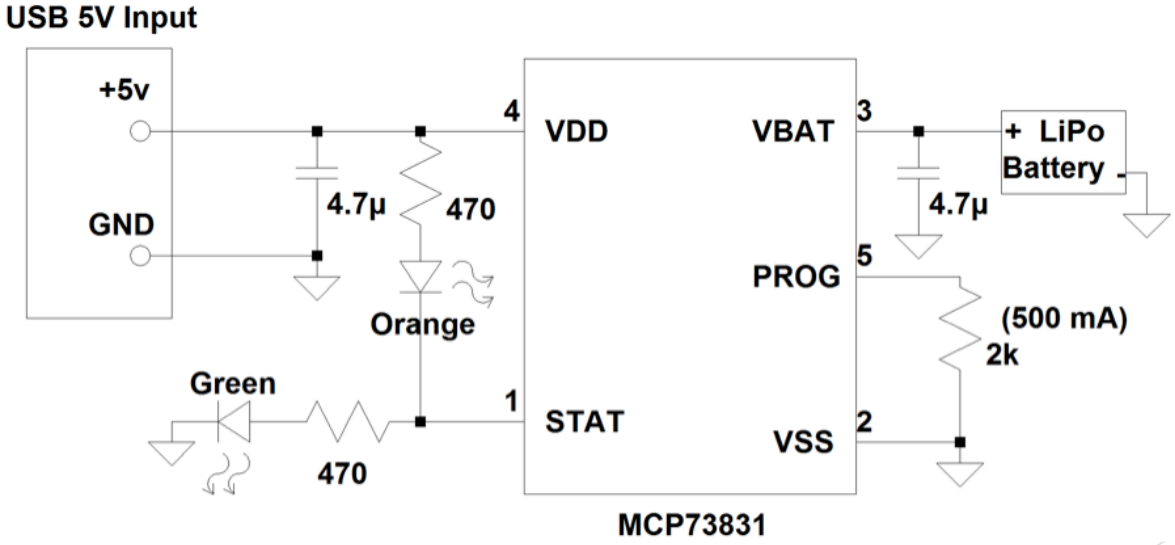
- Push button command sends signal of source battery to the battery status LED circuit
- Uses the bq27200 battery gauge to ensure the SMD LED indicators stay lit 5 seconds after push button is initiated

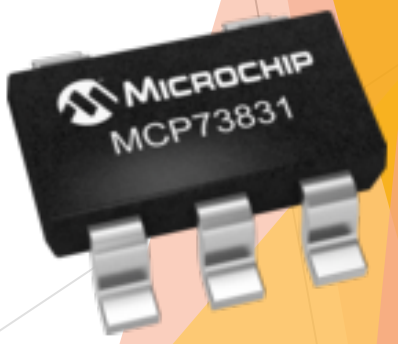


Based on bq27200 reference design

Wall Charging Circuit

- Charging LiPo batteries can be dangerous so we had to make sure that we were safely charging the device
- We needed to find a charging IC that would first charge the FBC with a constant current and then a constant voltage
- We chose the MCP73831 as our charging IC
- The MCP73831 costs $0.67





Based on reference design from MCP73831 datasheet

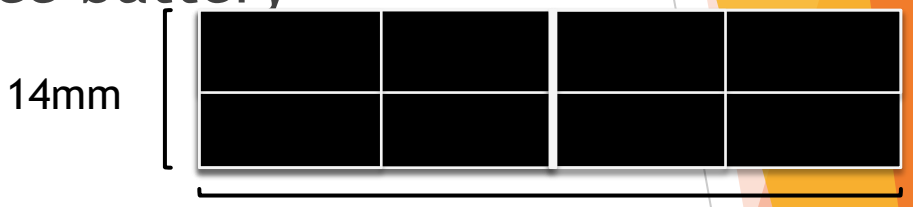
Solar Cell Selection

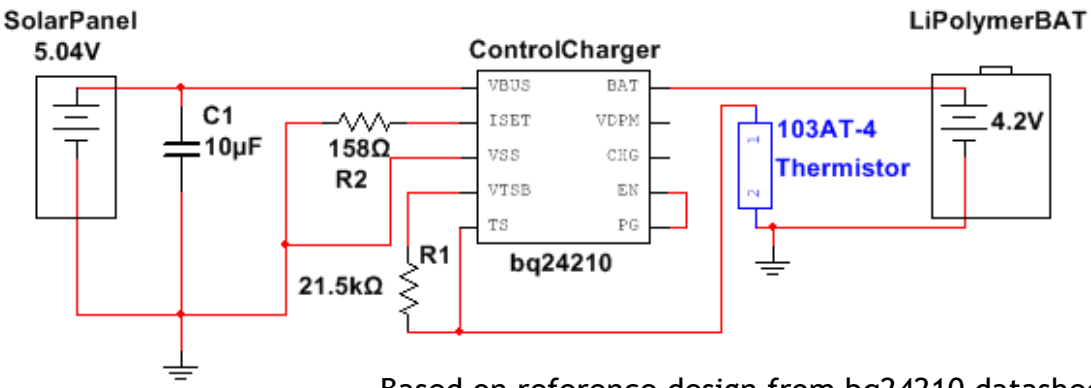
- Desired panel dimensions: 85 mm x 56 mm
- Multi cell panel preferred over single cell

	Monocrystalline	Polycrystalline	Thin Film
Efficiency			
Durability			
Exposure Performance			
Flexibility			
Cost			

Solar Battery Charger

- Auxiliary battery charger on the exterior case
- 4 monocrystalline solar cells in parallel output maximum 200mA to source battery
- Cost: $10.23
- 22% Efficiency rating
- Operational in indirect sunlight
- Use the bq24210 charging circuit to charge the source battery

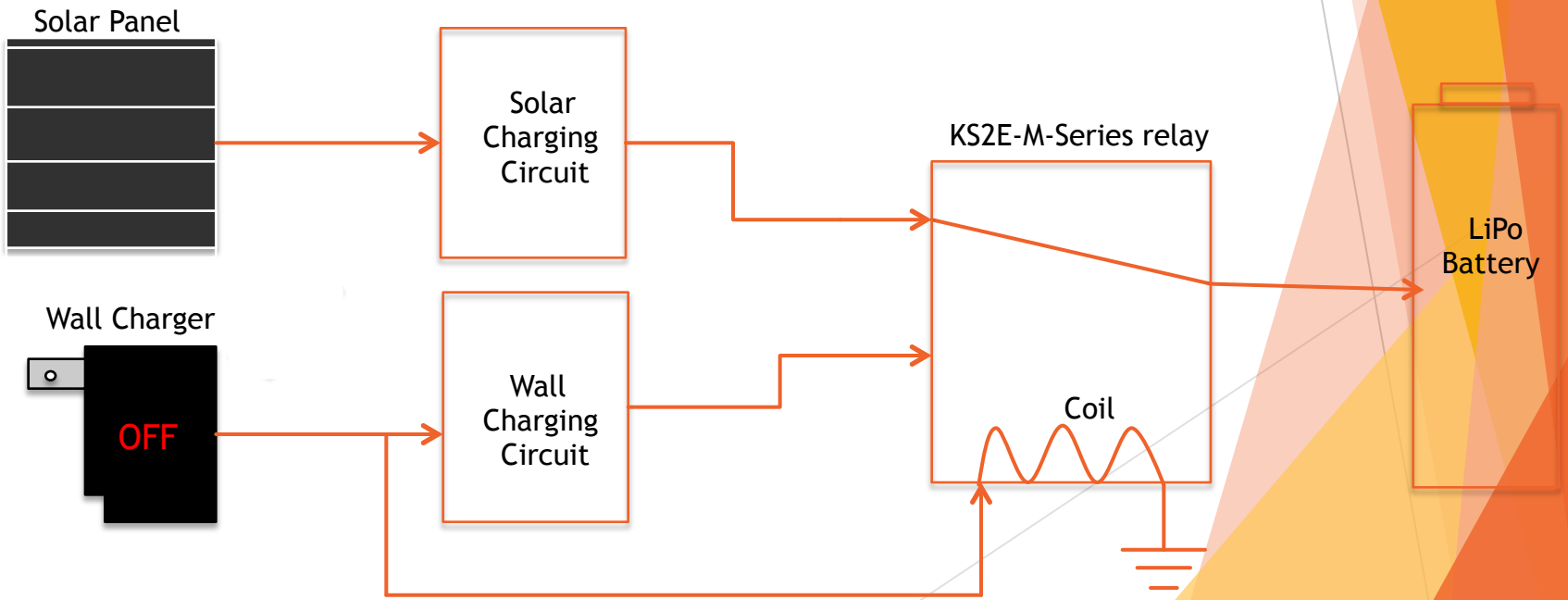




Based on reference design from bq24210 datasheet

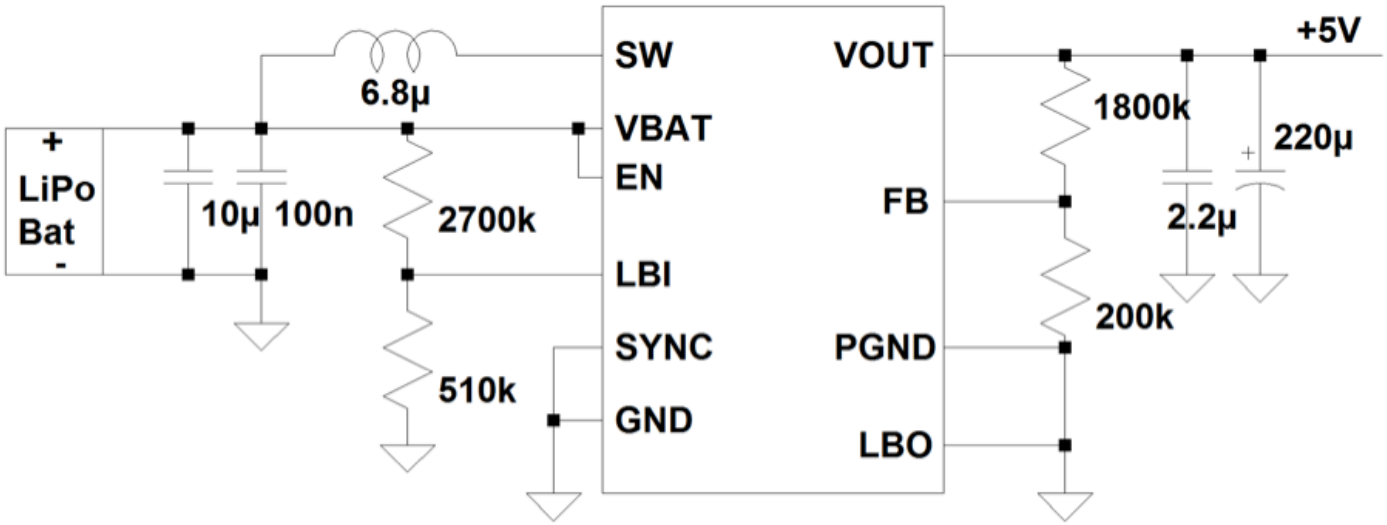
Solar and Wall Charger Relationship

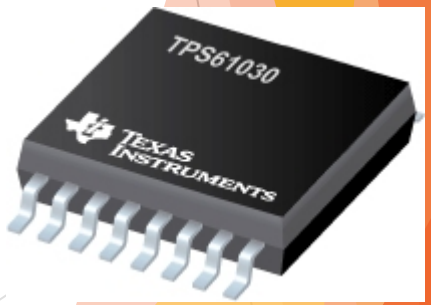
- To prevent simultaneous charging, KS2E-M-Series relay alternates the two power sources
- Without wall charger present, relay connects solar charge circuit to source battery
- When 5V wall charger is introduced, the internal relay switch disconnects the solar circuit, and connects the wall charger to the source battery



Power Supply

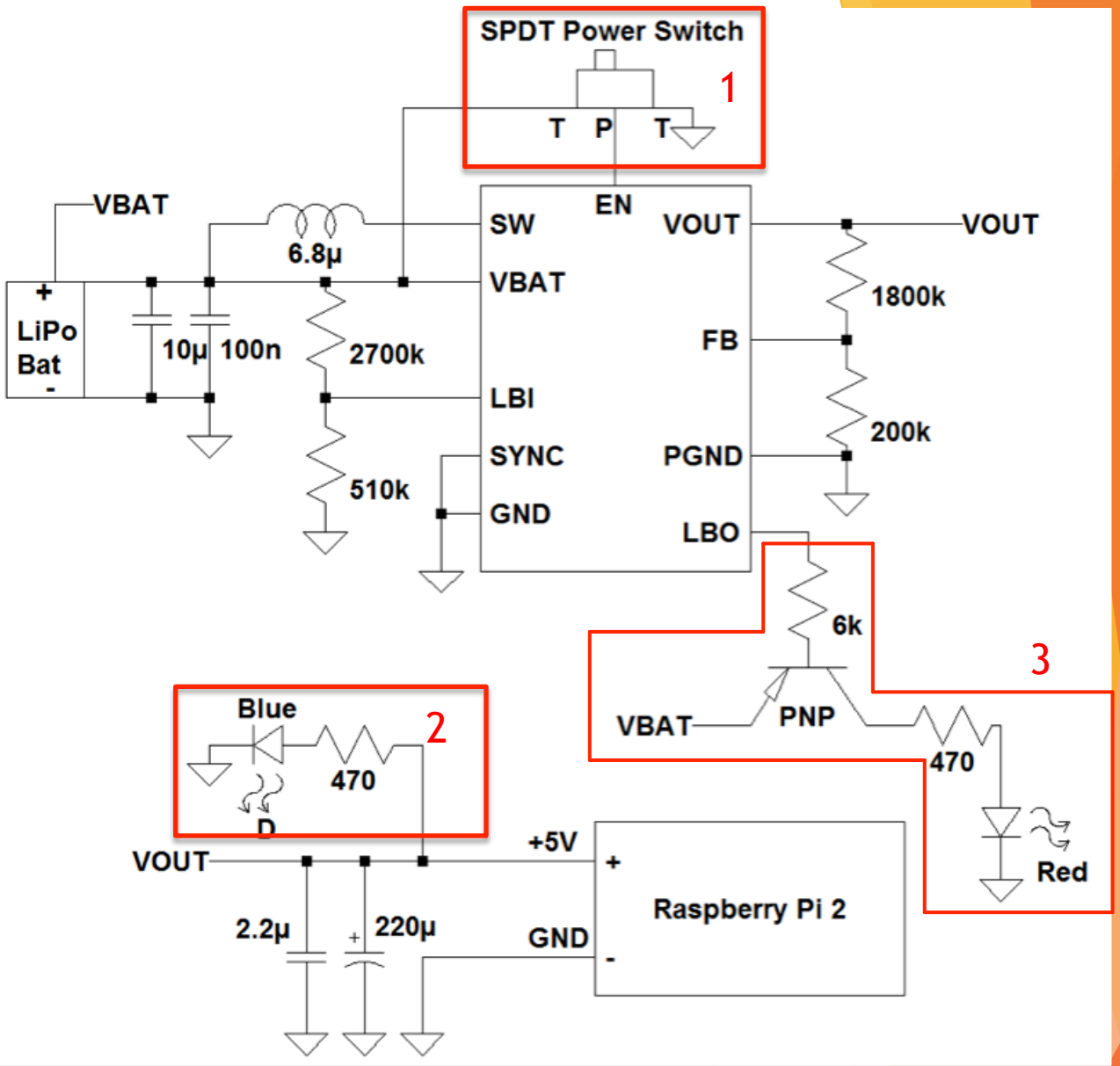
- There were a couple of restrictions that played a factor in design of the power supply
  - The battery will output between 2.5 and 4.2 volts at any given time
  - The Raspberry Pi 2 runs off of 5 volts
- These restrictions led to the selection of TPS61030
- The TPS61030 costs $3.78





Based on reference design from TPS61030 datasheet.

1. Power Switch
2. Power LED
3. Low Bat



Based on reference design from TPS61030 datasheet.

Software

- Debian Kernel
- EmulationStation Frontend
- FCEUX, PiSNES, Gambatte, gpSP
- Disabled Power-Intensive Software Features

Budget

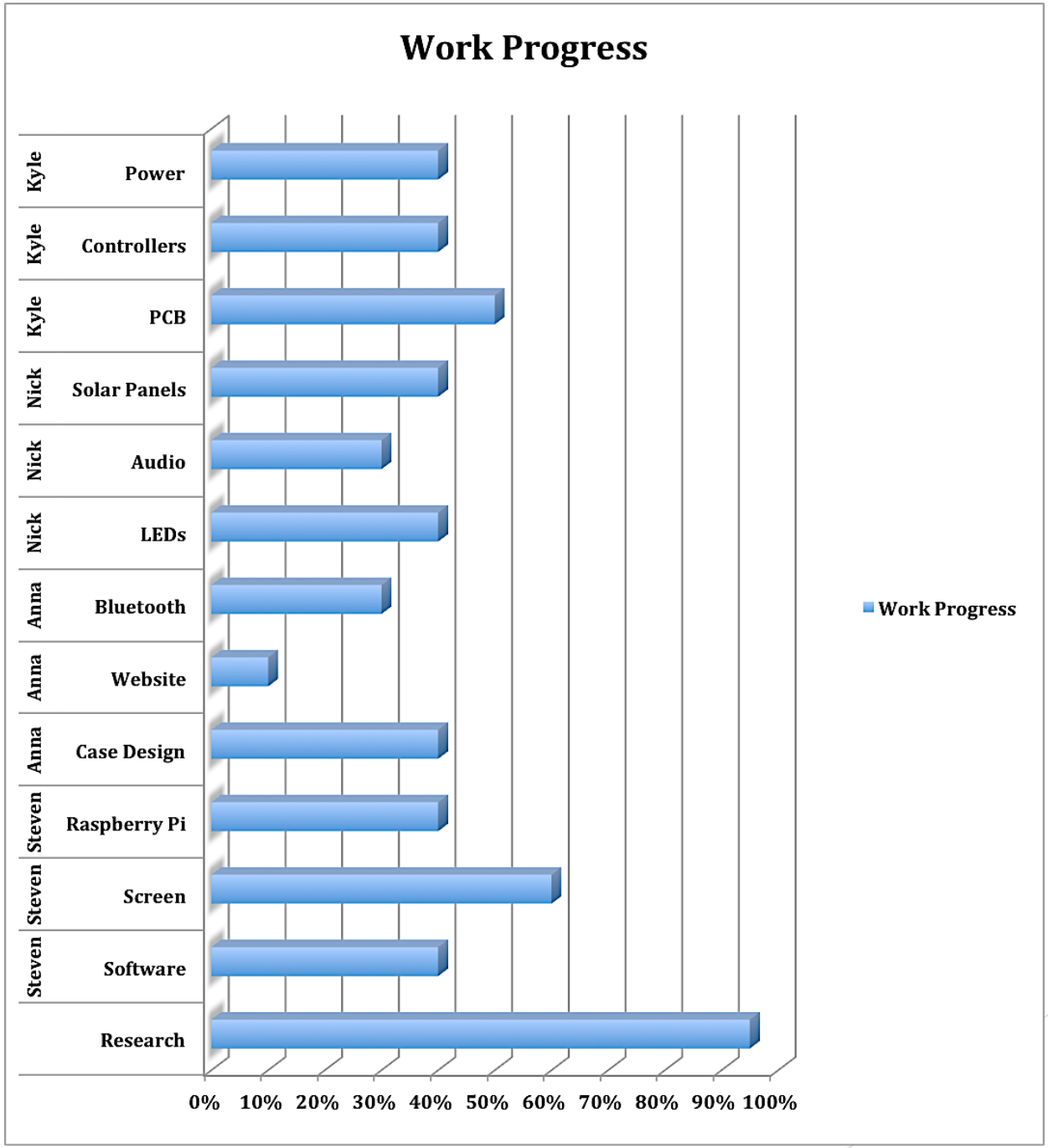
Index	Item	Supplier	Part Number	Quantity	Unit Price	Total Price & Shipping
1	LEDS	DigiKey	475-1410-1-ND	6	$0.080	$0.48
2	BATTERY "GAS GAUGE"	DigiKey	296-17521-1-ND	3	$4.280	$12.84
7	SPEAKERS	DigiKey	102-1554-ND	3	$4.150	$12.45
8	.1 MICROF CAPS	DigiKey	478-1244-1-ND	20	$0.280	$5.60
9	.33 MICROF CAPS	DigiKey	478-5902-1-ND	6	$0.260	$1.56
10	100 MICROF CAP	DigiKey	478-4091-1-ND	3	$1.750	$5.25
11	20K RES	DigiKey	P20.0KHCT-ND	50	$0.011	$0.57
12	1K RES	DigiKey	P1.0KJCT-ND	50	$0.011	$0.53
13	10 UF CAP	DigiKey	478-1575-1-ND	7	$0.770	$5.39
14	21.5K RES	DigiKey	P21.5KHCT-ND	3	$0.100	$0.30
15	158 RES	DigiKey	P158HCT-ND	3	$0.100	$0.30
16	.02 RES	DigiKey	1276-6157-1-ND	3	$0.480	$1.44
17	10K RES	DigiKey	RHM10.0KCDCT-ND	10	$0.013	$0.13
18	330 RES	DigiKey	RHM330CFCT-ND	10	$0.011	$0.11
19	470 RES	DigiKey	RHM470CDCT-ND	10	$0.013	$0.13
20	2K RES	DigiKey	RHM2.00KCFCT-ND	10	$0.011	$0.11
21	6.04K RES	DigiKey	541-6.04HHCT-ND	10	$0.081	$0.81
22	200K RES	DigiKey	RHM200KCFCT-ND	10	$0.011	$0.11
23	1.8M RES	DigiKey	1276-4292-1-ND	25	$0.005	$0.12
24	2.7M RES	DigiKey	1276-4457-1-ND	10	$0.013	$0.13
25	510K RES	DigiKey	RHM510KCFCT-ND	10	$0.011	$0.11
26	100NF CAPS	DigiKey	587-1227-1-ND	10	$0.012	$0.12
27	2.2 UF CAPS	DigiKey	1276-1469-1-ND	3	$0.120	$0.36
28	220 UF CAPS	DigiKey	1276-3375-1-ND	3	$1.650	$4.95
29	4.7 UF CAP	DigiKey	1276-2087-1-ND	4	$0.100	$0.40
30	PNP TRANS	DigiKey	MMBT2907A-TPMSCT-ND	3	$0.140	$0.42
31	MICRO USB HEADER	DigiKey	609-4616-1-ND	3	$0.460	$1.38
32	AUDIO JACK	DigiKey	CP-3523SJCT-ND	3	$1.340	$4.02
33	IC REG BOOST SYNC	DigiKey	296-14416-1-ND	3	$3.150	$9.45
34	IC CONTROLLER	DigiKey	MCP73831T-2ACI/OTCT-ND	3	$0.670	$2.01
35	SMT RGB 5050 LED	Adafruit	ID:619	10	$0.495	$4.95
36	Lithium Ion Polymer Battery	Adafruit	ID:328	1	$14.950	$14.95
37	Breadboard Slide Switch	Adafruit	ID:805	3	$0.950	$2.85
38	Bluetooth RN4020	Microchip	RN4020-V/RM	1	$17.590	$17.59
39	Relay	Jameco	KS2E-M-DC5	2	$11.000	$13.71
40	Solar Panels	Jameco	IXYS SLMD121H8L	4	$10.23	$40.92
	Screen		B0045IIZKU	1	$17.57	$17.57
	Raspberry Pi			1	$39.99	$39.99
40	United Parcel Service	Adafruit	N/A	1	$11.620	$11.62
41	SD1 Document Print	Staples	N/A	1	$90.00	$90.00
Total Due Date						**$325.73**

Financial Plan

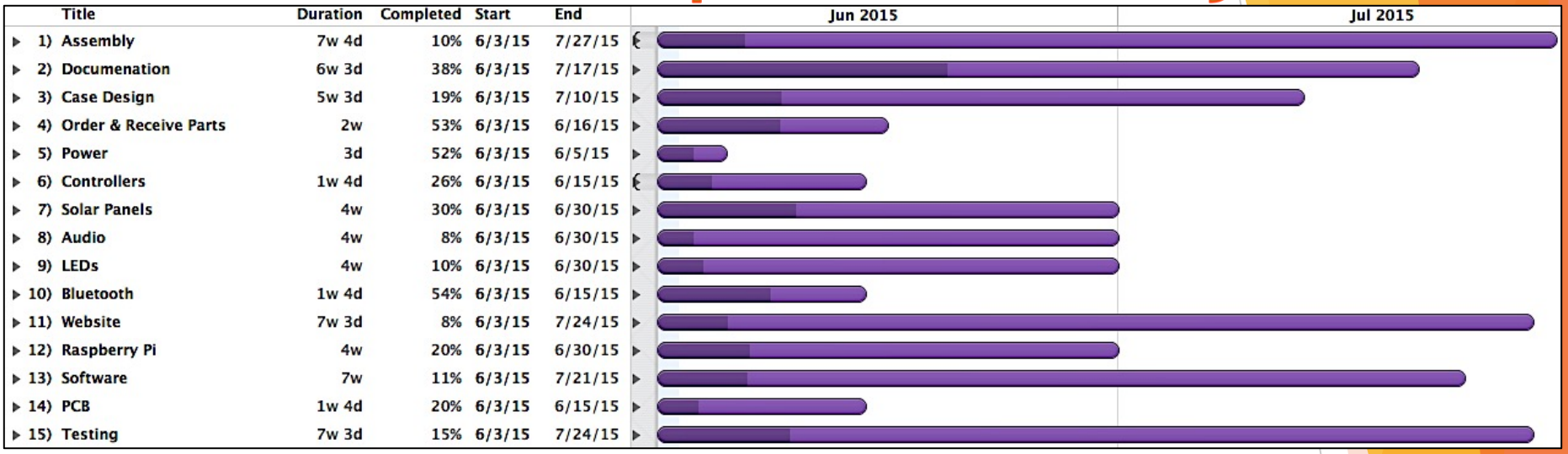
- Self-Sponsored Project
- Planned to Spend Up to $400
- Total Expenses: $325.73
- Positive Balance Left: $74.27

Future Expenses:

Index	Item	Cost
1	3D Printing	$0.00
2	Extra Parts	$50.00
Total		**$50.00**


Work Progress
Kyle
Power
Kyle
Controllers
Kyle
PCB
Nick
Solar Panels
Nick
Audio
Nick
LEDs
Anna
Bluetooth
Anna
Website
Anna
Case Design
Steven
Raspberry Pi
Steven
Screen
Steven
Software
Research
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Work Progress

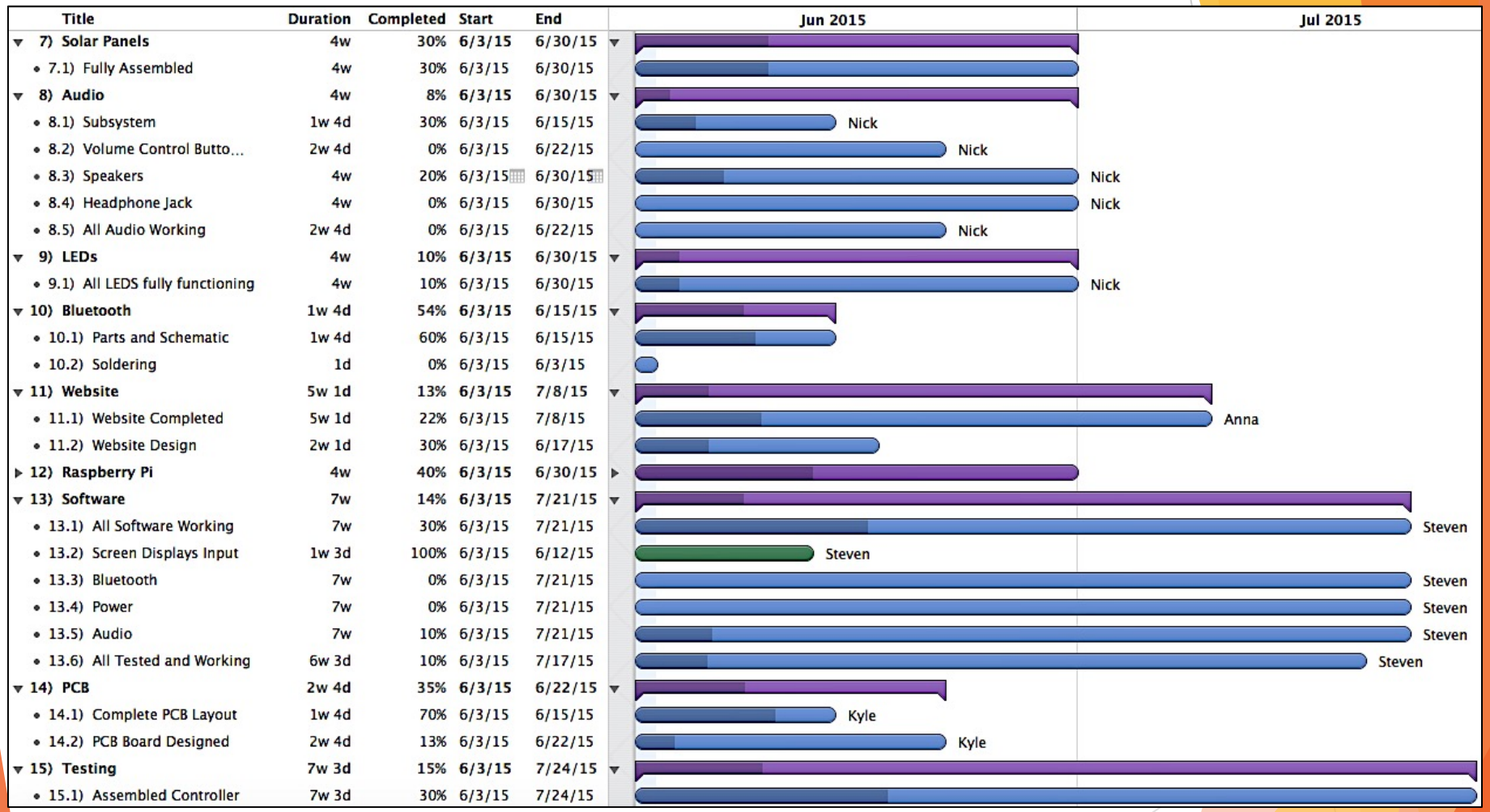
Successful Completion of the Project



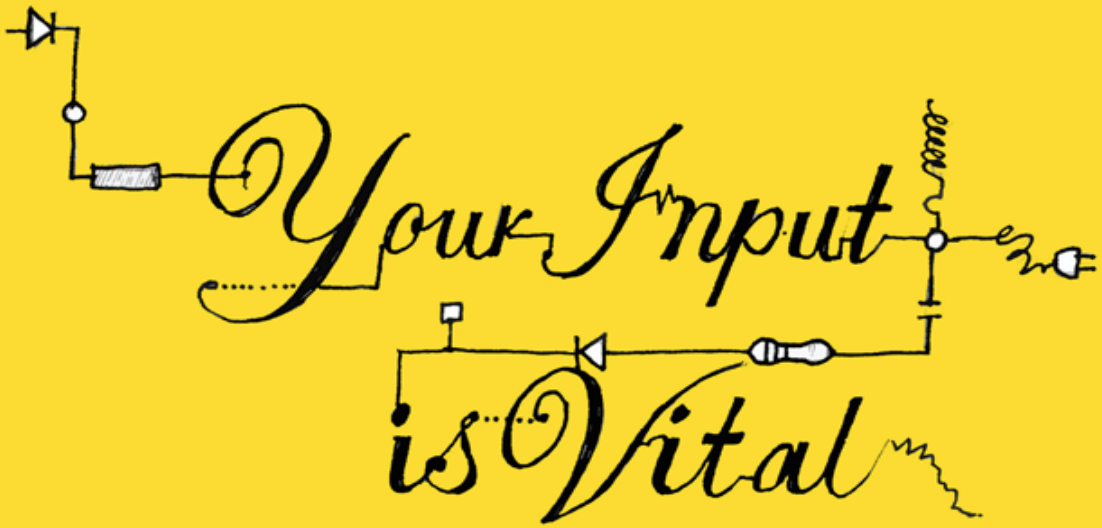
1)	Assembly	7w 4d	10%	6/3/15	7/27/15
2)	Documenation	6w 3d	38%	6/3/15	7/17/15
3)	Case Design	5w 3d	19%	6/3/15	7/10/15
4)	Order & Receive Parts	2w	53%	6/3/15	6/16/15
5)	Power	3d	52%	6/3/15	6/5/15
6)	Controllers	1w 4d	26%	6/3/15	6/15/15
7)	Solar Panels	4w	30%	6/3/15	6/30/15
8)	Audio	4w	8%	6/3/15	6/30/15
9)	LEDs	4w	10%	6/3/15	6/30/15
10)	Bluetooth	1w 4d	54%	6/3/15	6/15/15
11)	Website	7w 3d	8%	6/3/15	7/24/15
12)	Raspberry Pi	4w	20%	6/3/15	6/30/15
13)	Software	7w	11%	6/3/15	7/21/15
14)	PCB	1w 4d	20%	6/3/15	6/15/15
15)	Testing	7w 3d	15%	6/3/15	7/24/15

Tracking Project Progress

Tracking Project Progress



Title	Duration	Completed	Start	End	Jun 2015 / Jul 2015
7) Solar Panels	4w	30%	6/3/15	6/30/15	
• 7.1) Fully Assembled	4w	30%	6/3/15	6/30/15	
8) Audio	4w	8%	6/3/15	6/30/15	
• 8.1) Subsystem	1w 4d	30%	6/3/15	6/15/15	Nick
• 8.2) Volume Control Butto...	2w 4d	0%	6/3/15	6/22/15	Nick
• 8.3) Speakers	4w	20%	6/3/15	6/30/15	Nick
• 8.4) Headphone Jack	4w	0%	6/3/15	6/30/15	Nick
• 8.5) All Audio Working	2w 4d	0%	6/3/15	6/22/15	Nick
9) LEDs	4w	10%	6/3/15	6/30/15	
• 9.1) All LEDS fully functioning	4w	10%	6/3/15	6/30/15	Nick
10) Bluetooth	1w 4d	54%	6/3/15	6/15/15	
• 10.1) Parts and Schematic	1w 4d	60%	6/3/15	6/15/15	
• 10.2) Soldering	1d	0%	6/3/15	6/3/15	
11) Website	5w 1d	13%	6/3/15	7/8/15	
• 11.1) Website Completed	5w 1d	22%	6/3/15	7/8/15	Anna
• 11.2) Website Design	2w 1d	30%	6/3/15	6/17/15	
12) Raspberry Pi	4w	40%	6/3/15	6/30/15	
13) Software	7w	14%	6/3/15	7/21/15	
• 13.1) All Software Working	7w	30%	6/3/15	7/21/15	Steven
• 13.2) Screen Displays Input	1w 3d	100%	6/3/15	6/12/15	Steven
• 13.3) Bluetooth	7w	0%	6/3/15	7/21/15	Steven
• 13.4) Power	7w	0%	6/3/15	7/21/15	Steven
• 13.5) Audio	7w	10%	6/3/15	7/21/15	Steven
• 13.6) All Tested and Working	6w 3d	10%	6/3/15	7/17/15	Steven
14) PCB	2w 4d	35%	6/3/15	6/22/15	
• 14.1) Complete PCB Layout	1w 4d	70%	6/3/15	6/15/15	Kyle
• 14.2) PCB Board Designed	2w 4d	13%	6/3/15	6/22/15	Kyle
15) Testing	7w 3d	15%	6/3/15	7/24/15	
• 15.1) Assembled Controller	7w 3d	30%	6/3/15	7/24/15	



Questions & Concerns?