FunBox Classic (FBC)

Group 14

Stephen Caskey (EE & CS)

Anna Iskender (EE)

Nick Johnson (EE)

Kyle McCleary (EE & CS)

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

Work Distribution

Group Member	Case	Raspberry Pi	PCB	Bluetooth	Solar Battery	Power	Audio	Website
Stephen		Primary	Secondary	Secondary		Secondary		
Kyle		Secondary	Primary		Secondary	Primary		
Nick					Primary		Primary	
Anna	Primary			Primary				Primary

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

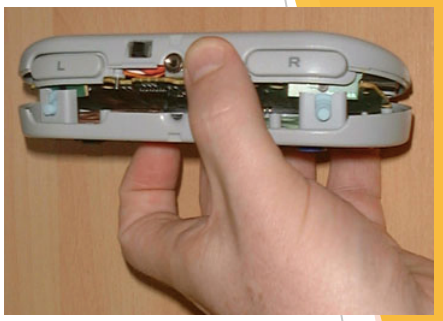
Standards

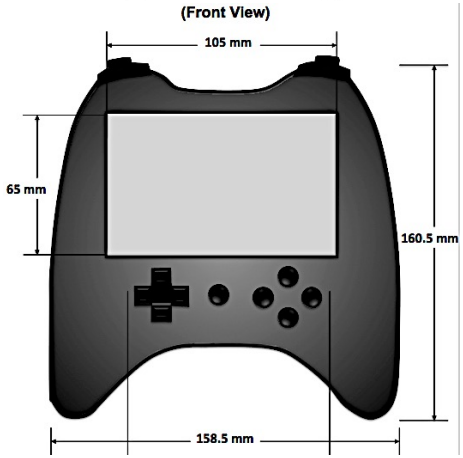
Identification Number	Standard Description
SMPTE-170M-1990	Standard for analog television system color bar test system
IEEE 802.15.1	Standard for Bluetooth development (currently under BSIG jurisdiction)
IEC 62680-1:2013	Standard for Universal Serial Bus (USB) interfaces for data and power (revision 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

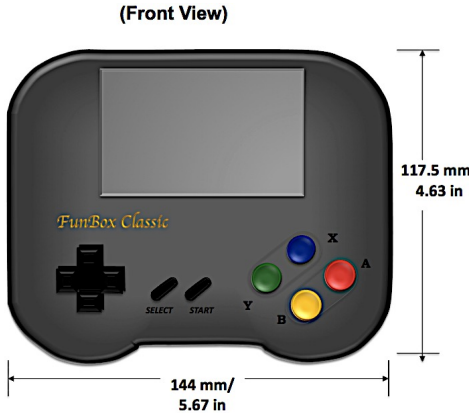
Research on The Case Design

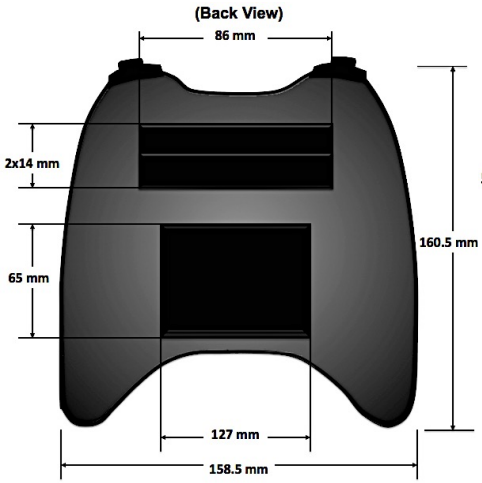
Inspiration

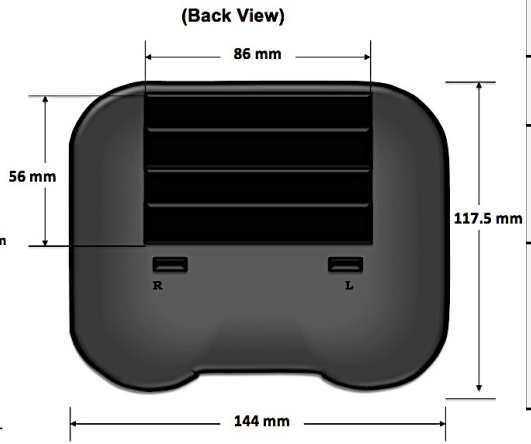
Initial Designs





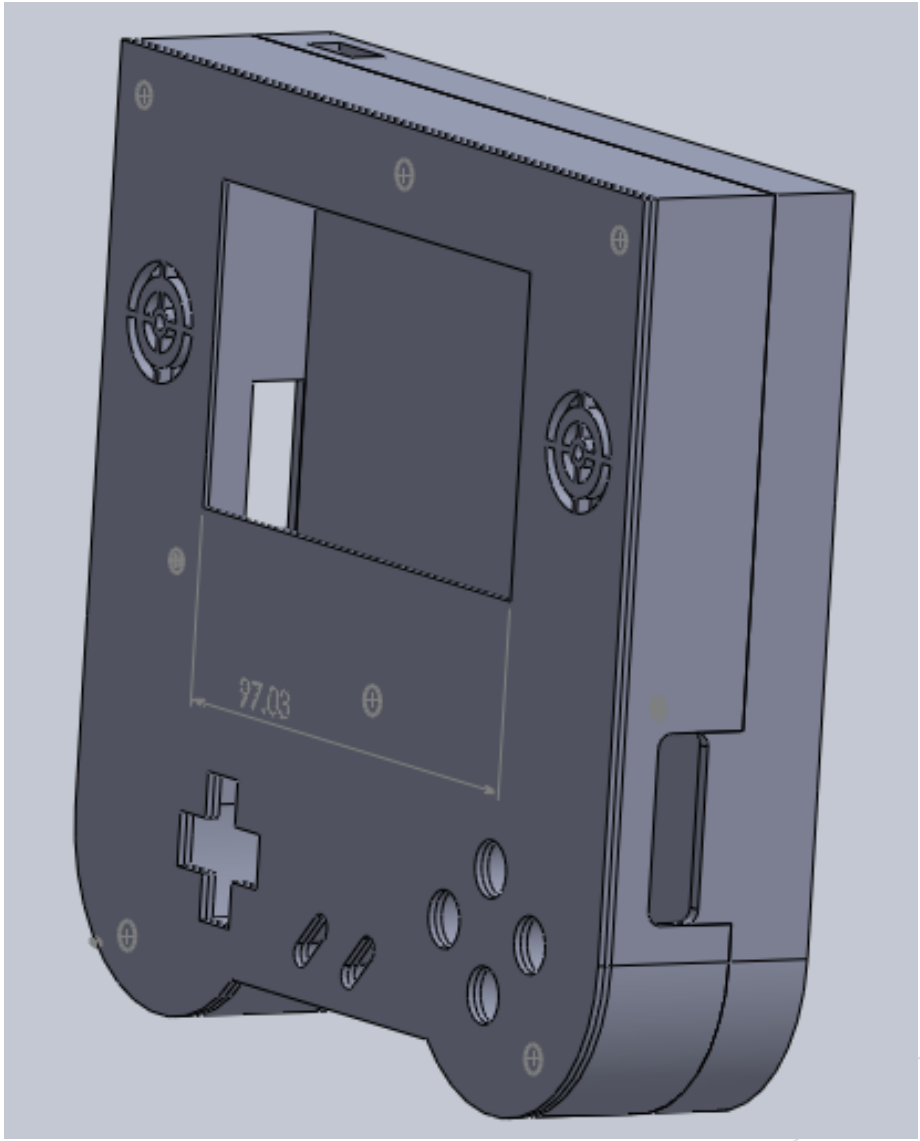




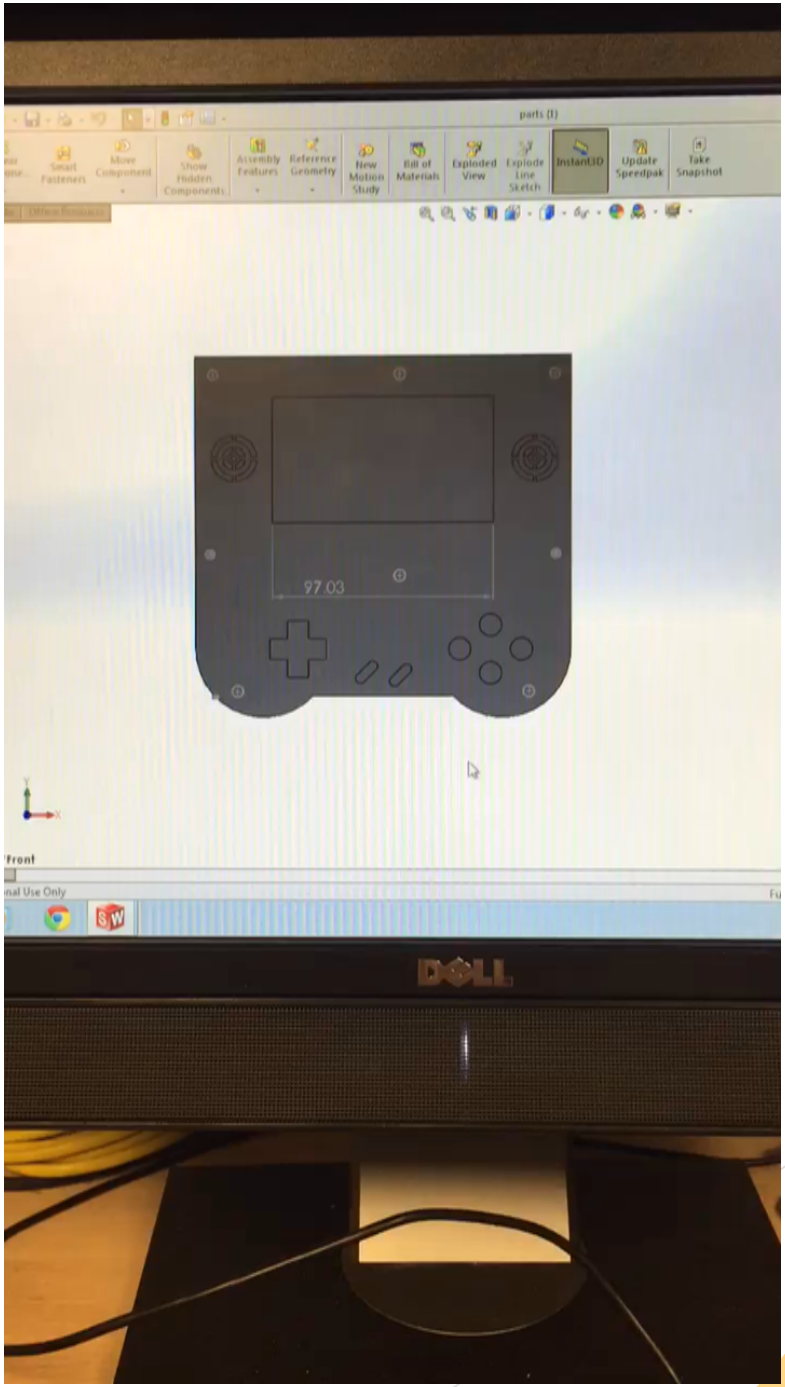


3D PRINT		
Category	**Type**	**Comments**
Software	SolidWorks	Vs. OpenSCAD.org
Design	Custom	Thingiverse.com
Cost	Free	Up to 10 – 15 in^3
Size	4.63x5.67x2 in	Up to 10x10x12 in
Color	Grey or Mix	Red, Blue, Yellow, Green, Grey, Black

Design Dimensions and 3D Printing

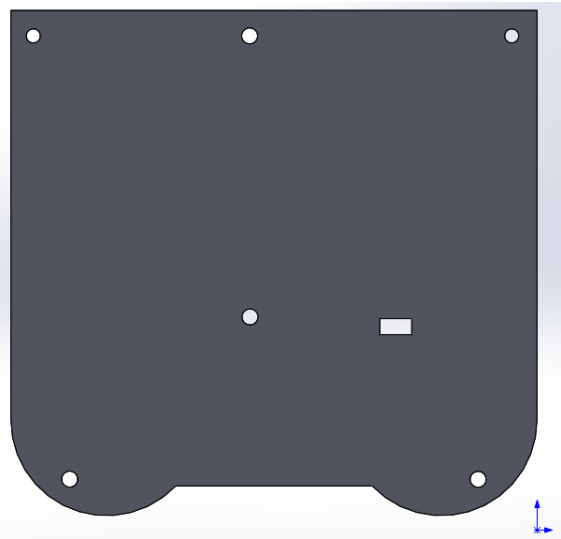


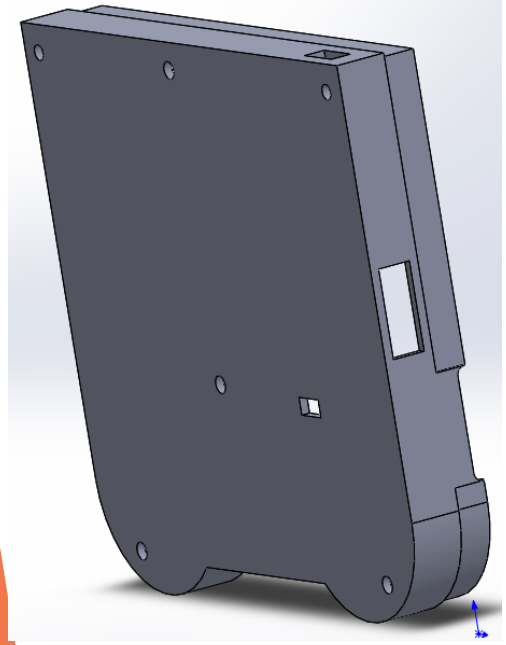
Case Design in SolidWorks

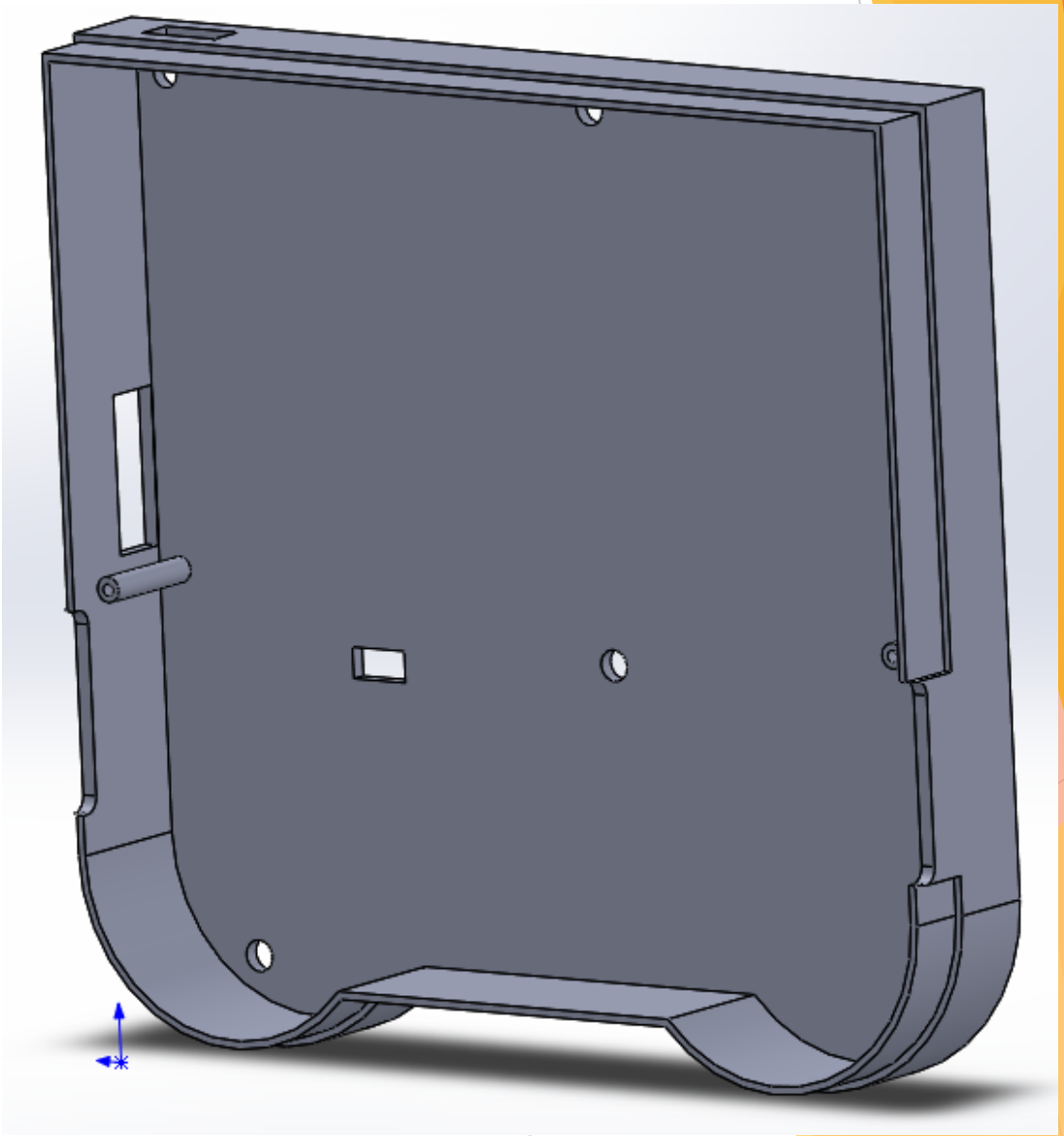


Front Side Design

Back Side Design

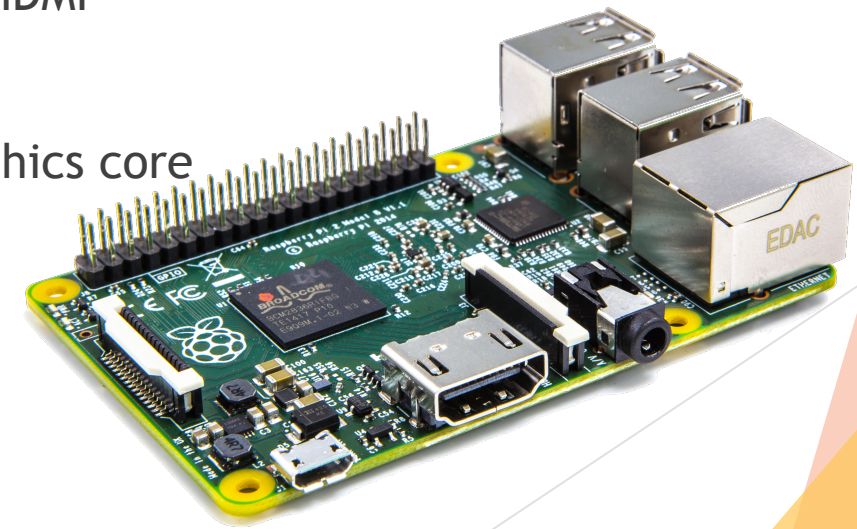






Raspberry Pi 2

- 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

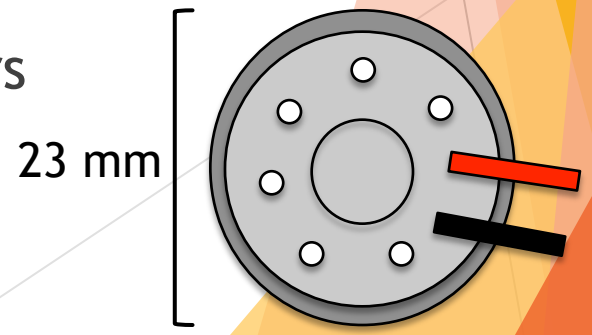
- 4.3” Diagonal
- 480x272 Resolution
- Composite Connection
- Backlit

Audio

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

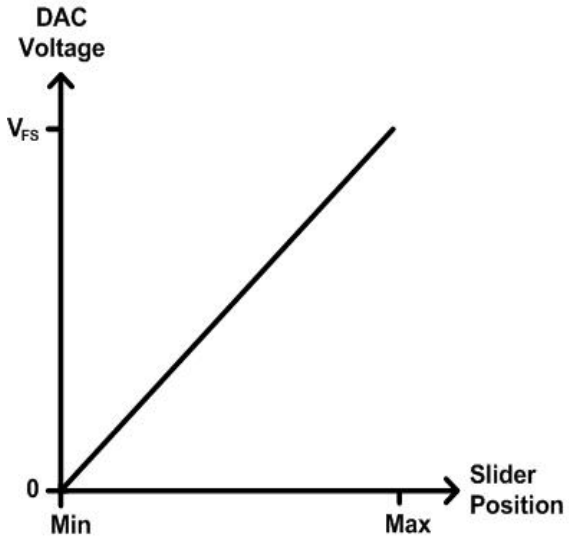
Model	Supply Current	Power Output	Cost
TDA2822M	6 mA	300 mW	$1.33
TS4984	7.4 mA	1 W	$1.89
LM4880	3.6 mA	250 mW	$1.26

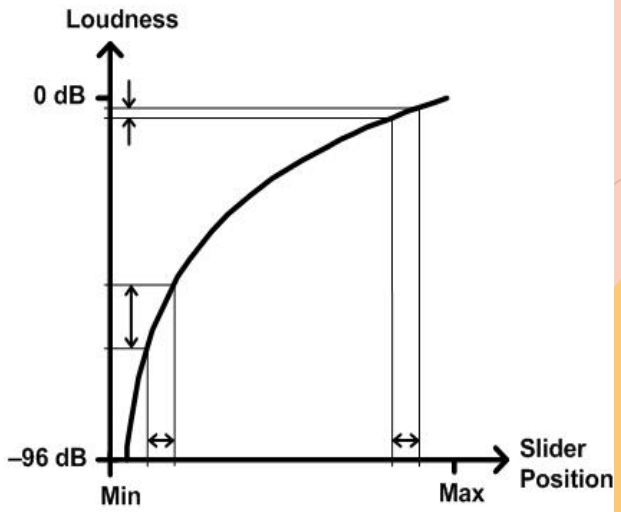
- Chose LM4880 audio amplifier used to output audio from Raspberry Pi 2 to audio jack
- Chose 2 LM4861 audio amplifier used to output audio to left and right speakers
- 2 CLS0231-L152 speakers
  1) Frequency range of 650 Hz – 18 KHz
  2) 23 mm diameter



Volume Control

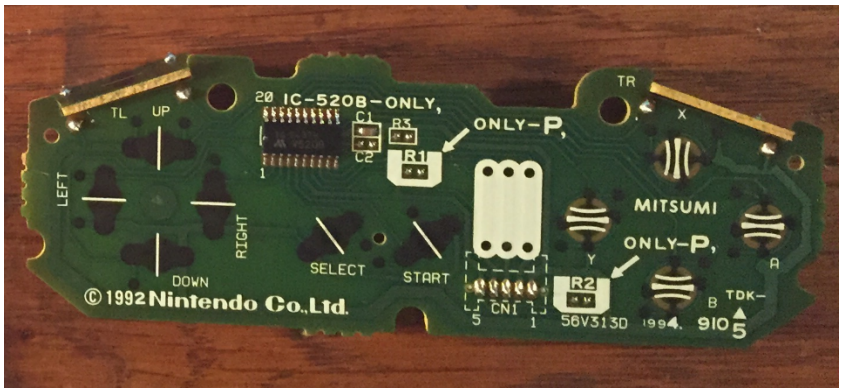
- Use 5-pin thumbwheel potentiometer to simultaneously control both speakers
- Logarithmic volume control
- 270° rotation angle
- Maximum 10 kilo-ohm resistance to “mute” audio output





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

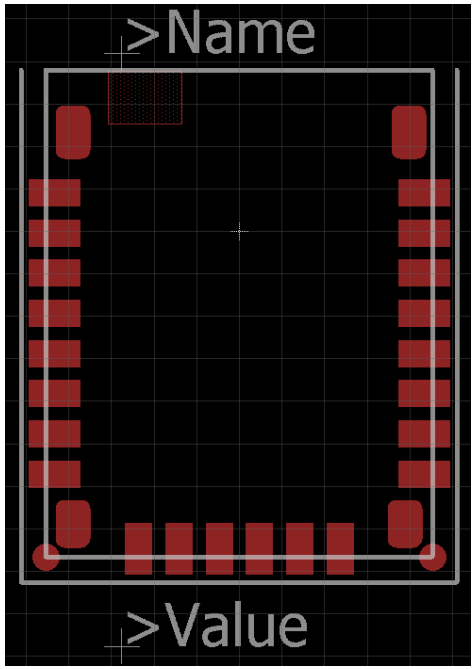
Bluetooth Chip RN4020

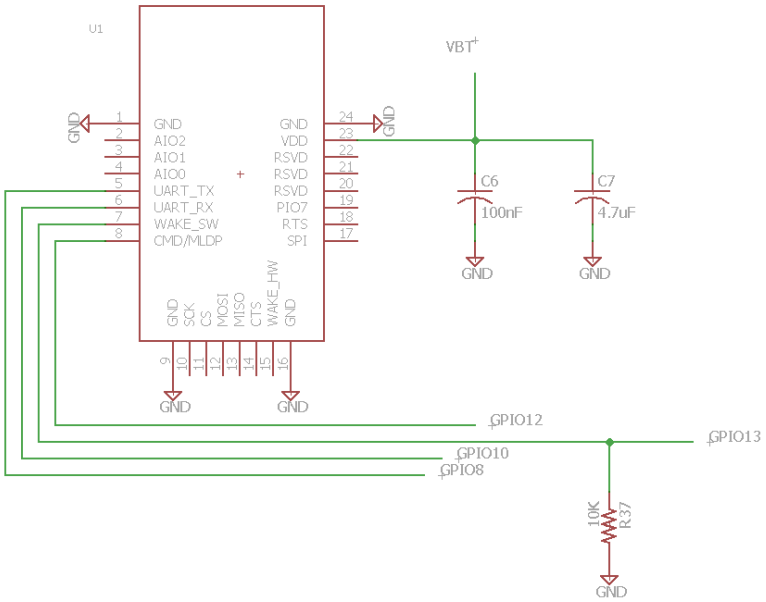
Why RN4020:

- 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

Major Con:

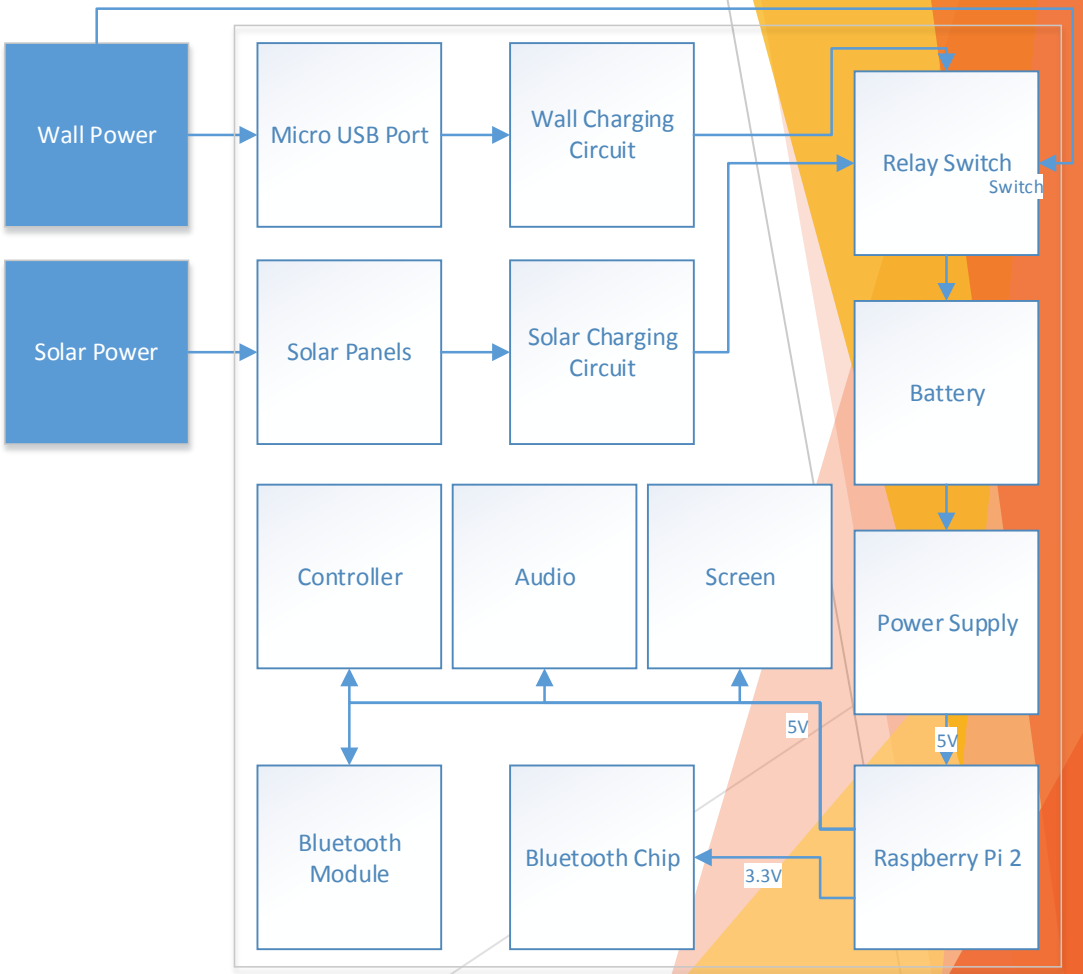
- BTLE ONLY – Single Mode Chip.





Power System

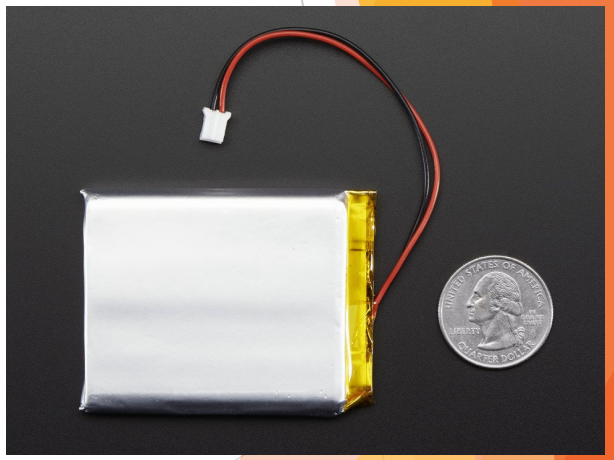
- The power system is responsible for supplying the power for the operation of the device
- The power system consists of five main components:
  - Battery
  - Wall Charging Circuit
  - Solar Charging Circuit
  - Relay
  - Power Supply



Battery

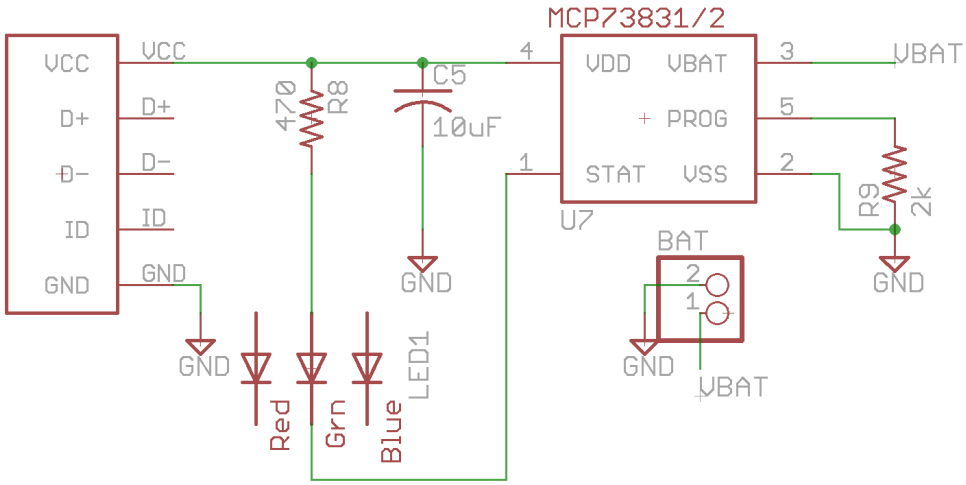
- We compared a few different types of batteries
- We settled on using either a Li-ion battery or LiPo battery for the FBC

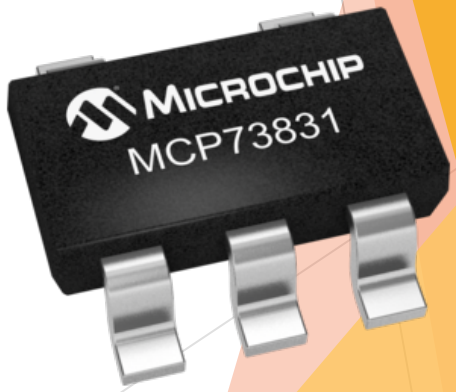
	Tenergy Li-Ion 18650 Battery Module 5200	Tenergy Li-Ion 18650 Battery Module 2200	Adafruit Lithium Ion Polymer Battery
Capacity (mAh)	5200	2200	2500
Size (mm)	66 x 37 x 19	69 x 19	65 x 51 x 8
Weight (g)	96	54	52
Protection Circuit	Yes	Yes	Yes
Shape	Rectangular	Cylindrical	Rectangular
Price	$19.99	$10.99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



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 from DigiKey





Based on reference design from MCP73831 datasheet

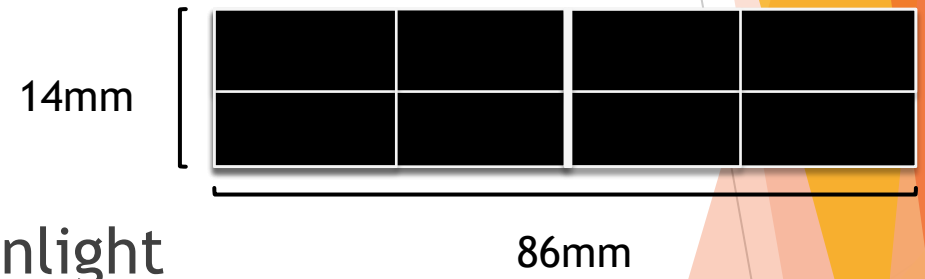
Solar Cell Selection

- 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			

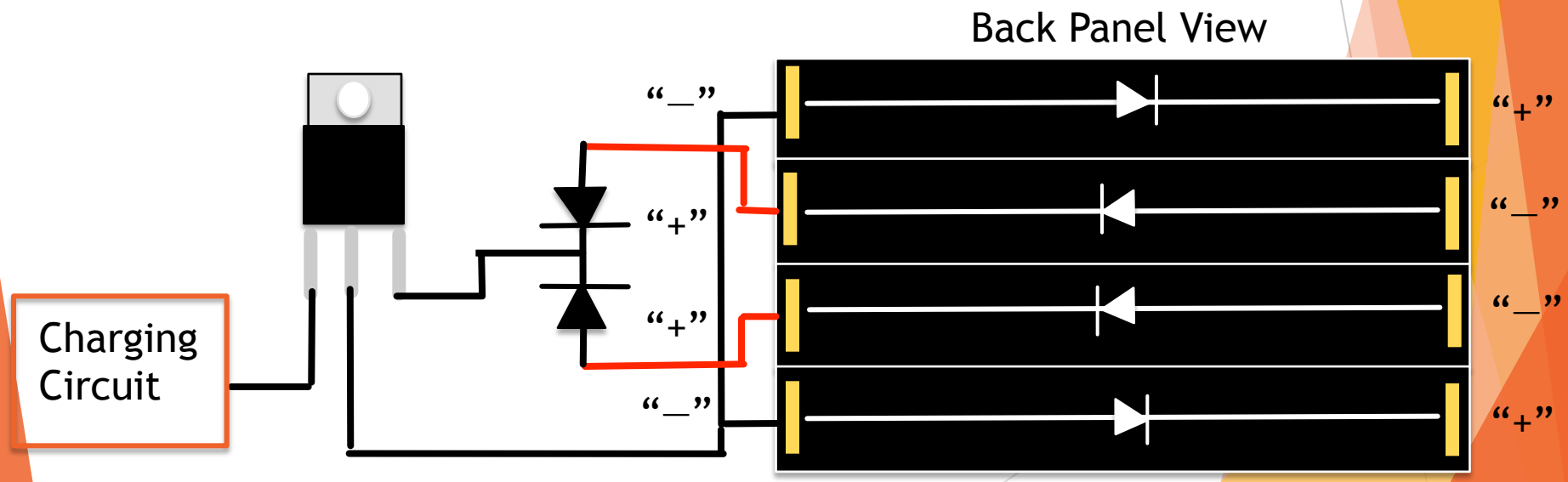
Solar Battery Charger

- Auxiliary battery charger on the exterior case
- 4 monocrystalline solar cells targeted output maximum 100mA to source battery
- Cost: $10.23
- 22% Efficiency rating
- Operational in indirect sunlight
- Use the bq24210 charging circuit to charge the source battery



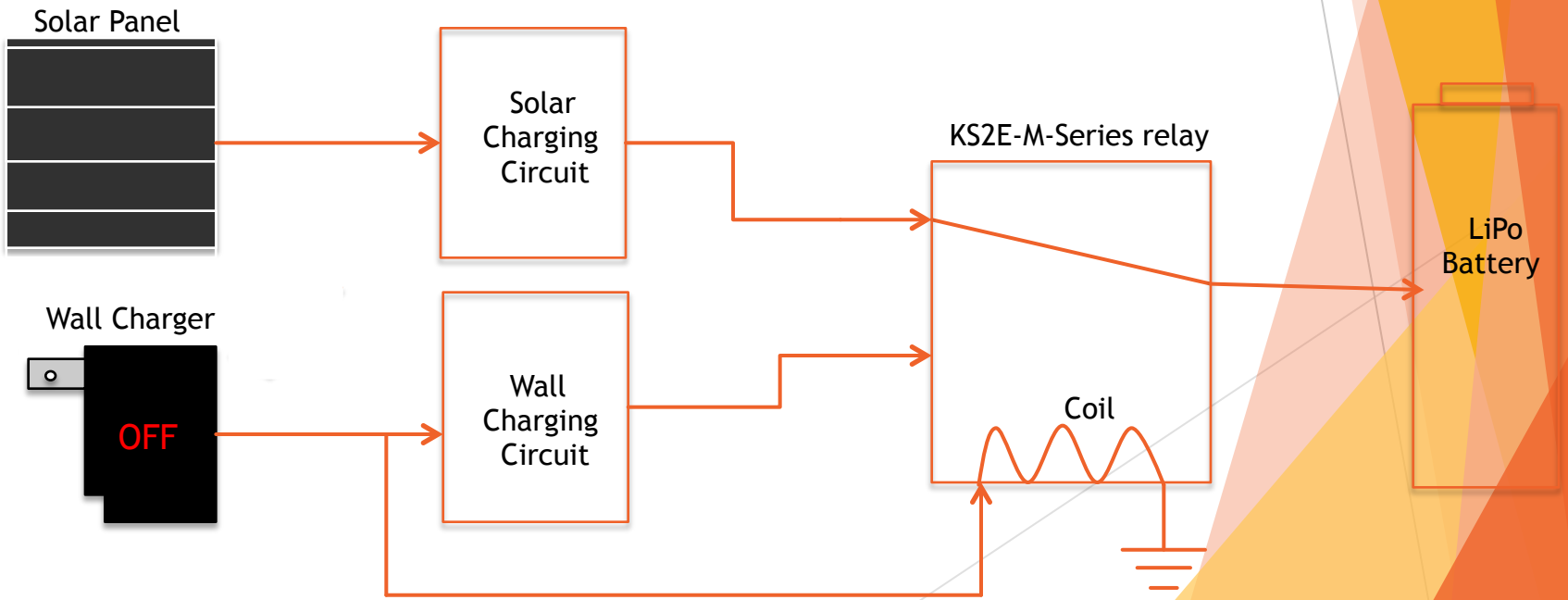
Solar Panel Connectivity

- Panel consists of series and parallel cell connections
- Bypass IN4001 diodes connected for each cell
- LM7805C 5VDC voltage regulator to step down panel output voltage



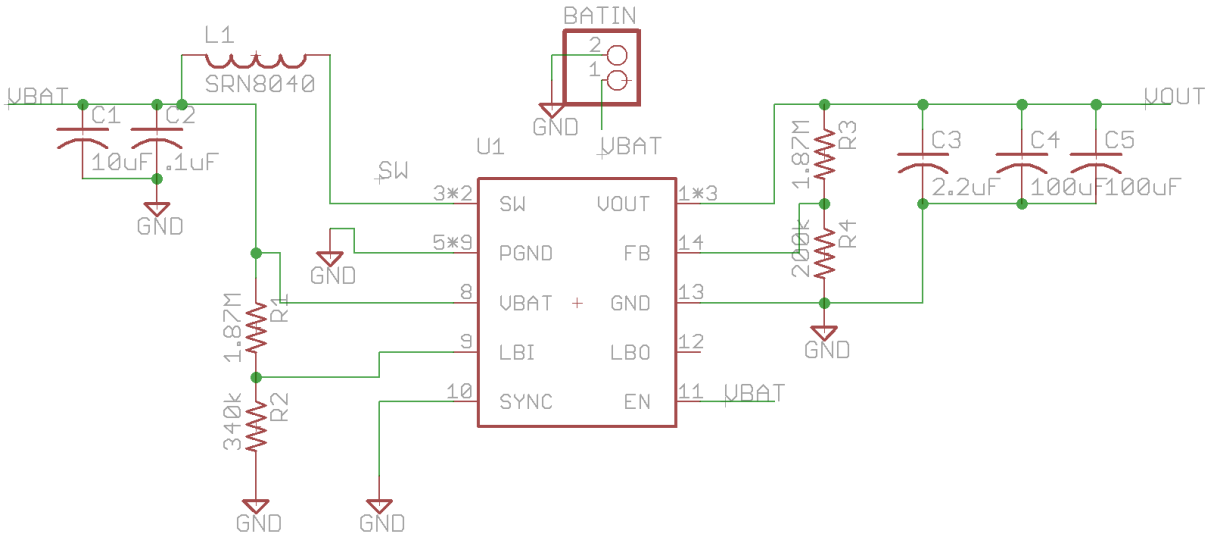
Solar and Wall Charger Relationship

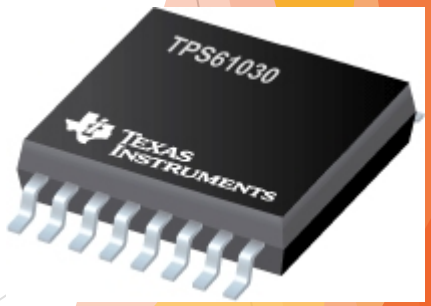
- To prevent simultaneous charging, KS2E-M-Series relay alternates the two power sources
- Without wall charger present, relay connects solar charge circuit to source battery
- When 5V wall charger is introduced, the internal relay switch disconnects the solar circuit, and connects the wall charger to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



Power Supply

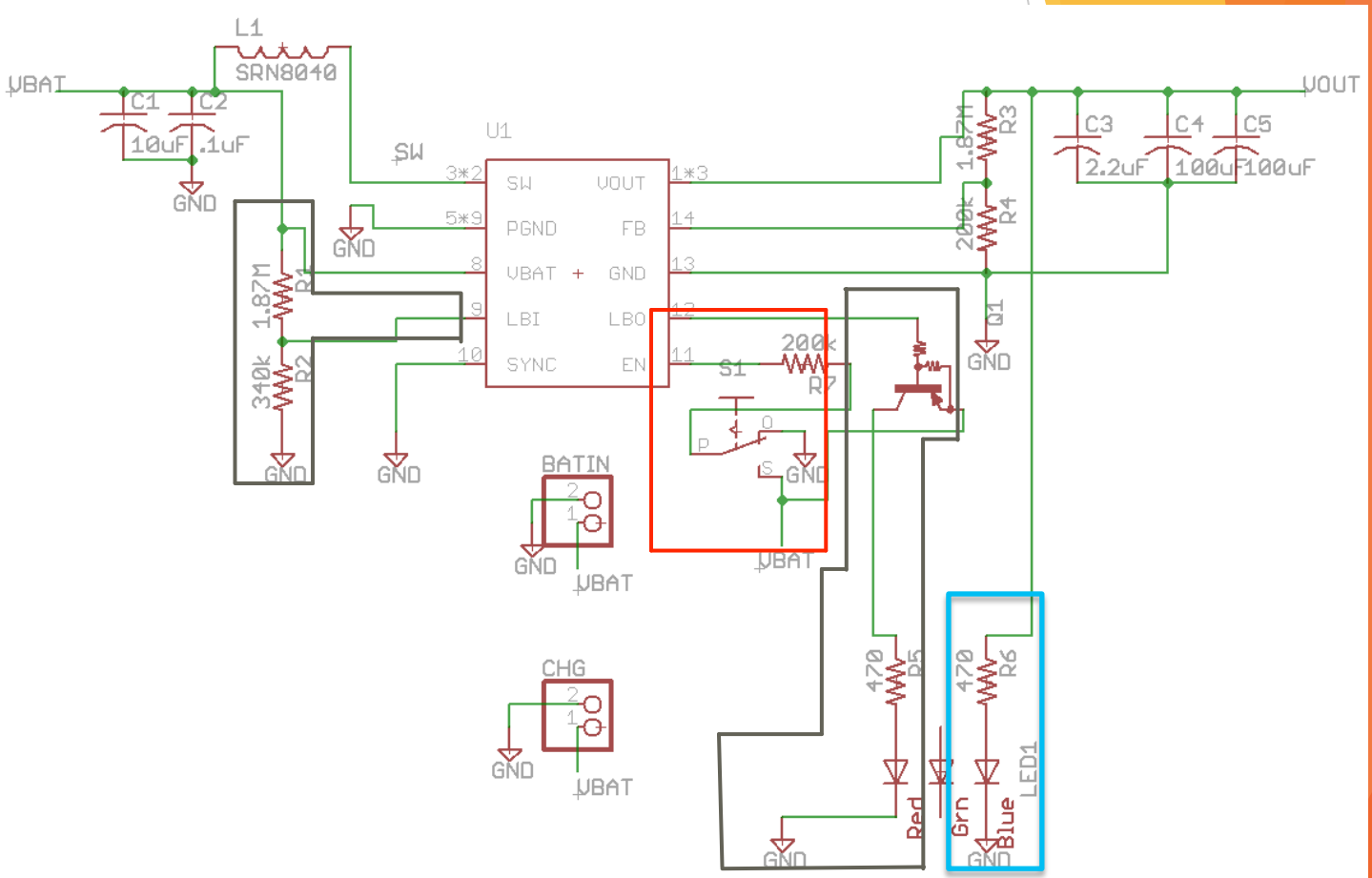
- There were a couple of restrictions that played a factor in design of the power supply
  - The battery will output between 3 and 4.2 volts at any given time
  - The Raspberry Pi 2 runs off of around 5 volts
- These restrictions led to the selection of TPS61030, a DC/DC boost converter
- The TPS61030 costs $3.15 from DigiKey





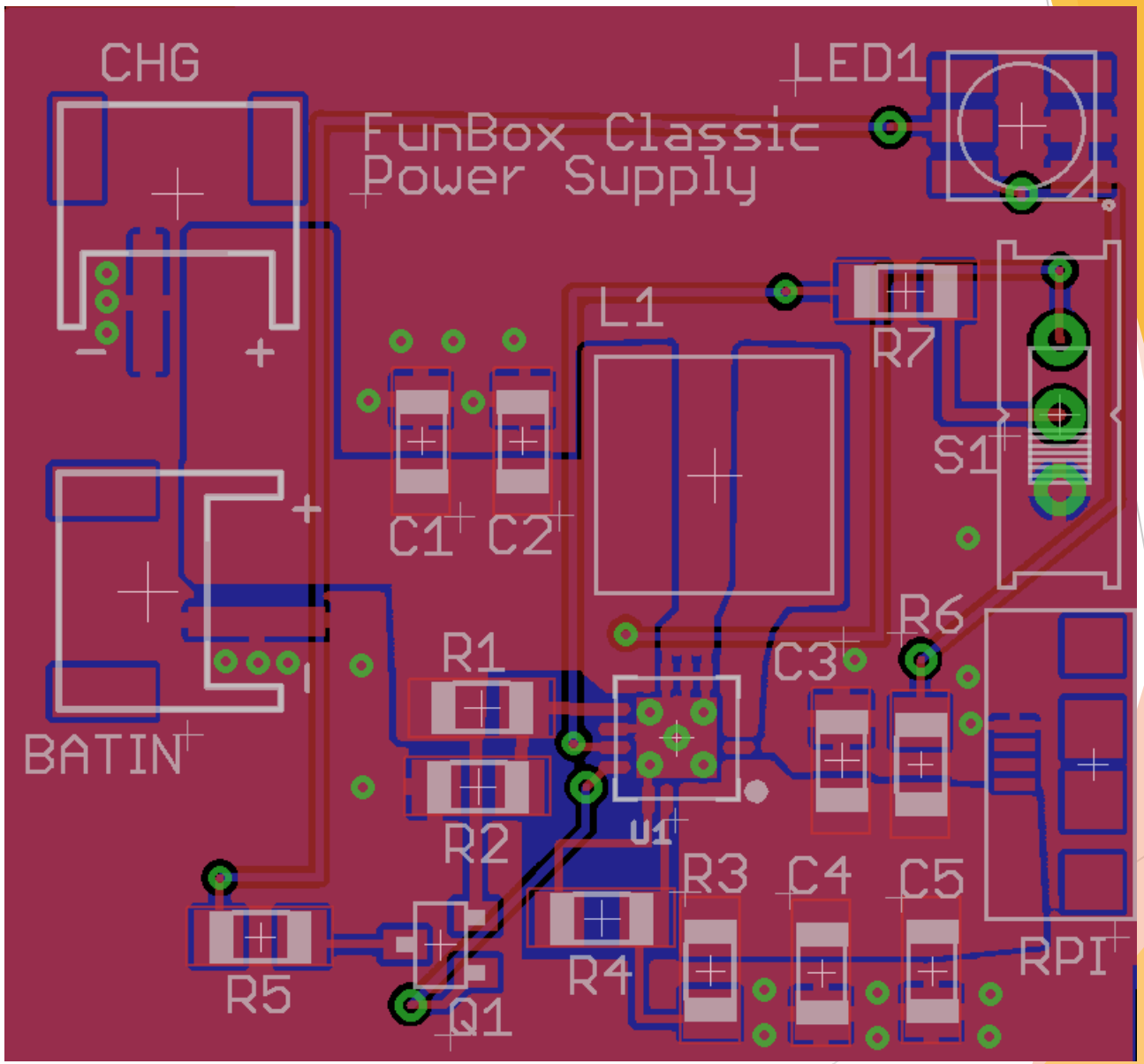
Based on reference design from TPS61030 datasheet

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



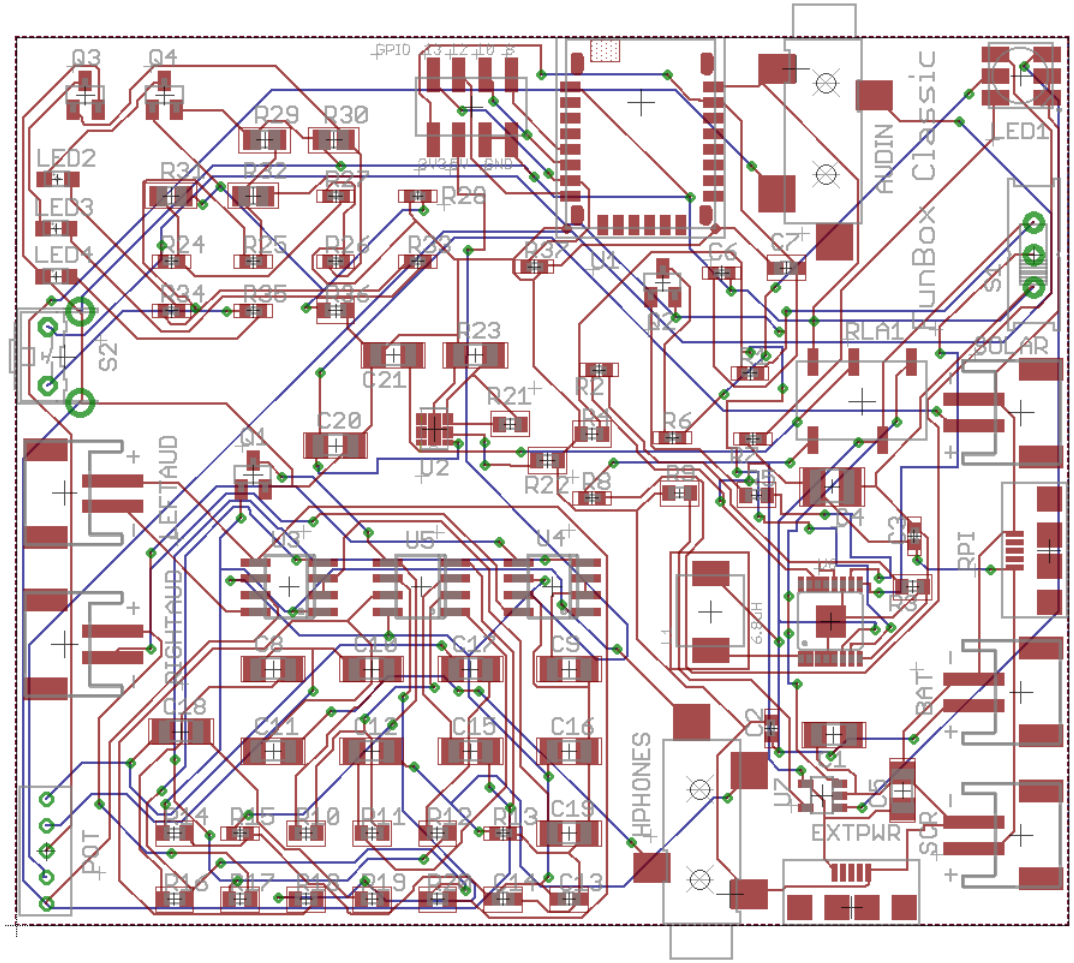
Power Supply Problems/ Solutions

- Preface: TPS61030 is a very fickle chip
- Traces burning out
  - Wire replacements/fixed virtual shorts
  - Eventually made wider traces on a new power only board
- Chip overheating and turning off
  - Better heat dissipation design on the new board
- Component short
  - Short was detected and fixed
- Ceramic vs Tantalum Capacitors
  - Turned out not to be an issue
  - TI rep very adamant about Tantalum output caps due to ESR
- Output port traces ripped off board
  - Wired output cable directly to board


CHG
LED1
FunBox Classic
Power Supply
L1
R7
S1
C1
C2
R6
R1
C3
BATIN
U1
R2
R3
C4
C5
RPI
R5
R4
Q1


LED1
FunBox Classic
Power Supply
L1
R7
S1
C1
C2
R6
R1
C3
R2
U1
R3
C4
C5
R5
J1

PCB


Q3
Q4
LED2
LED3
LED4
R29
R30
R31
R32
R33
R24
R25
R26
R27
R28
R34
R35
R36
S2
C21
R23
R21
C20
Q1
D2
R22
R8
R2
R6
U5
U4
C8
C10
C14
C9
C18
C11
C12
C15
C16
C19
R4
R5
R10
R11
R12
R3
R13
R7
R18
R19
R20
C13
POT
LEFTAUD
RIGHTAUD
HPHONES
AUDIN
SunBox Classic
LED1
S1
RLA1
SOLAR
RPI
BAT
SGR
EXTPWR
U7

Software

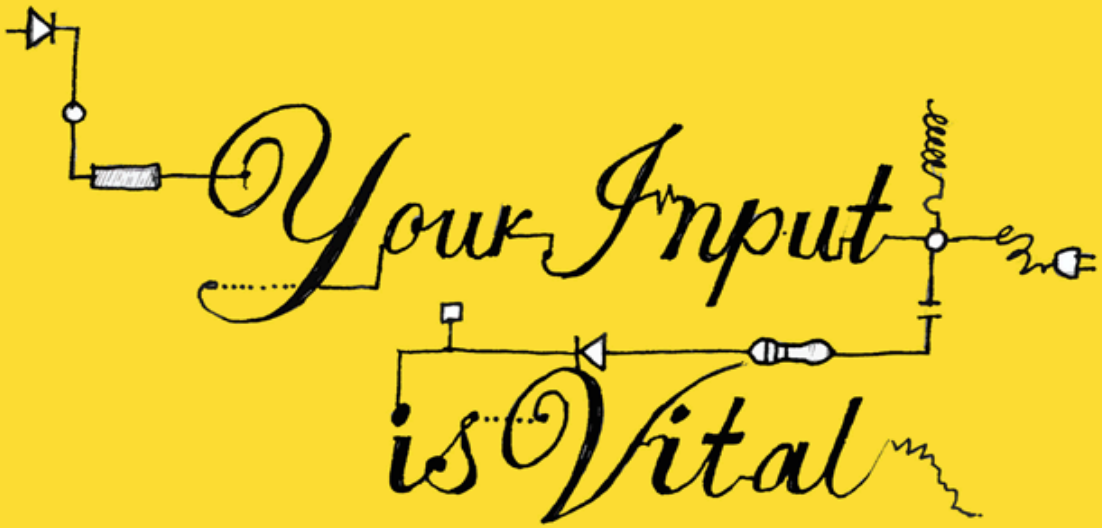
- Debian Kernel
- EmulationStation Frontend
- FCEUX, PiSNES, Gambatte, gpSP
- Disabled Power-Intensive Software Features

Expenses

Digikey	$255.85
Shipping	$79.15
Adafruit	$71.61
Shipping	$46.80
Jameco	$11.00
Shipping	$2.71
Sparkfun	$9.00
Shipping	$16.04
Mouser	$10.60
Shipping	$6.99
Oshpark	$43.20
Shipping	$5.00
Sunstone	$139.15
Shipping	$76.00
4PCB	$33.00
Shipping	$83.78
RP2	$35.00
Shipping	$9.99
Amazon	$229.84
Shipping	$3.99
Radioshack	$197.57
Home Depot	$23.38
Shipping Total	**$353.83**
Parts Total	**$1,035.82**
Total	**$1,389.65**

Financial Plan

- Self-Sponsored Project
- Planned to Spend Up to $400
- Total Expenses: $1,389.65



Questions & Concerns?