PCB Project-1 Report (Power bank circuit)
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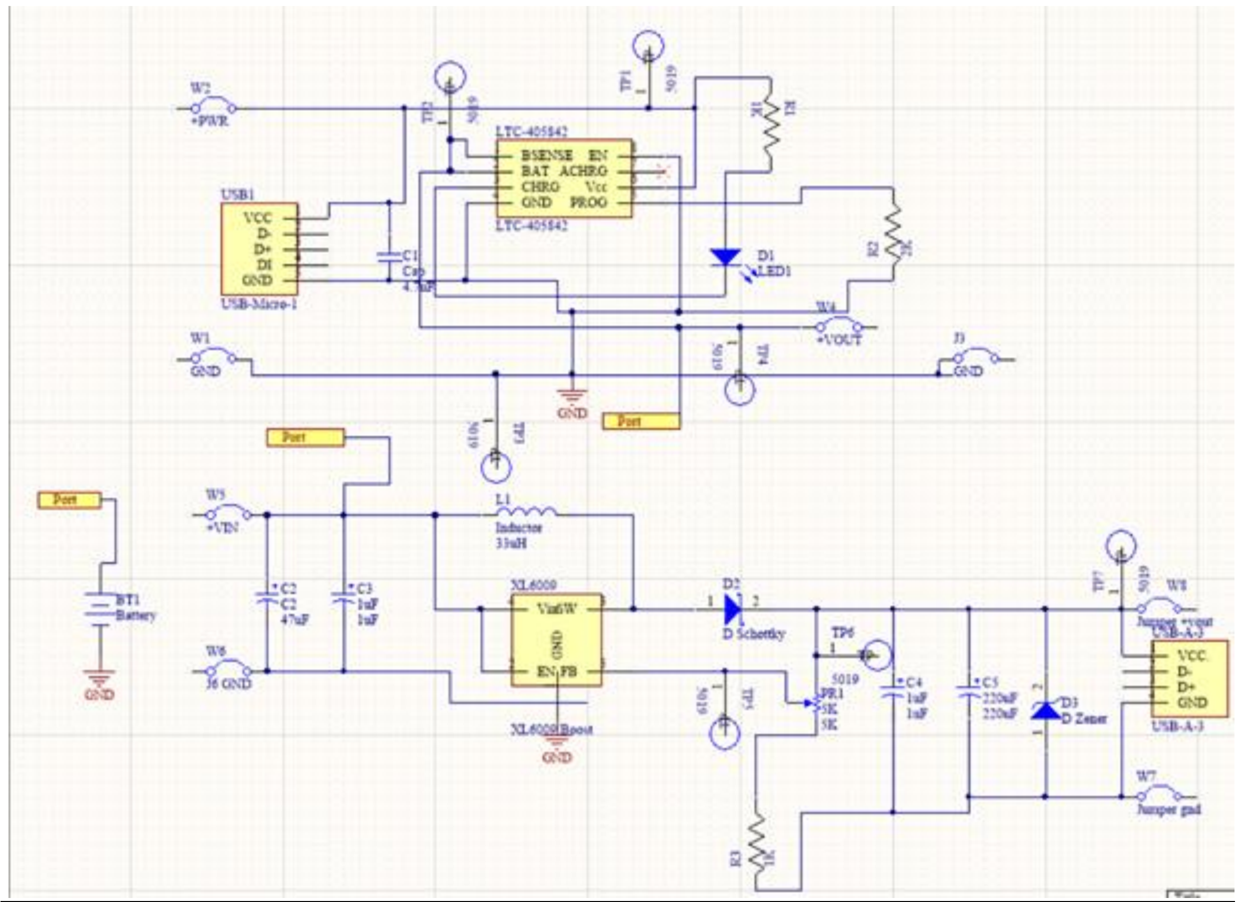
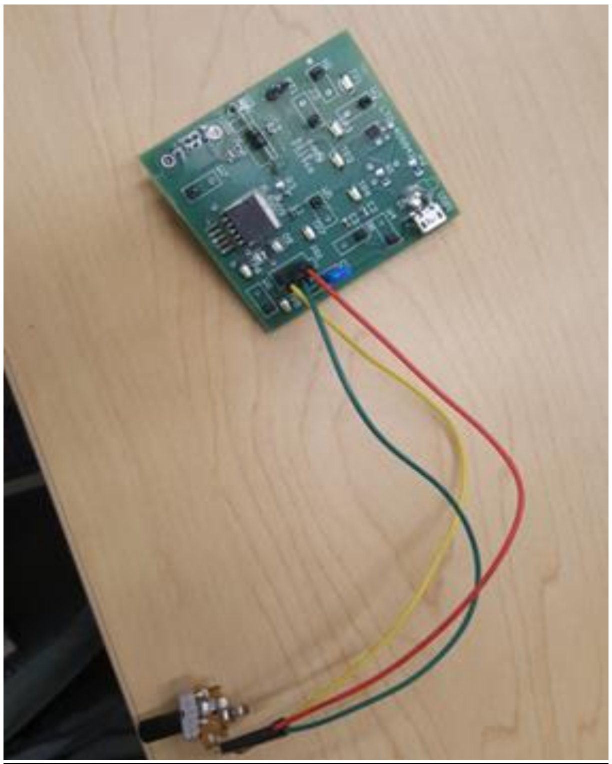
Schematic Diagram: -



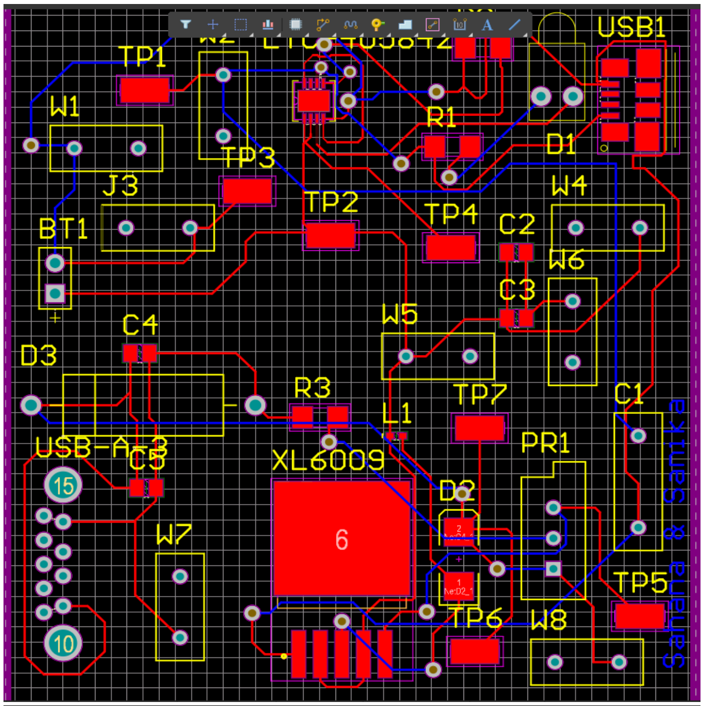
PCB Board: -

1)Top Side: -

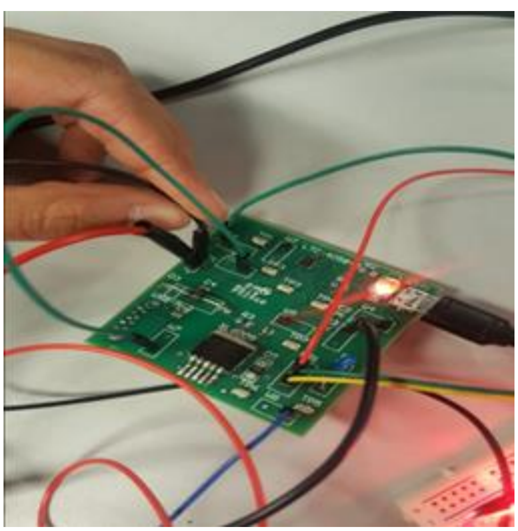


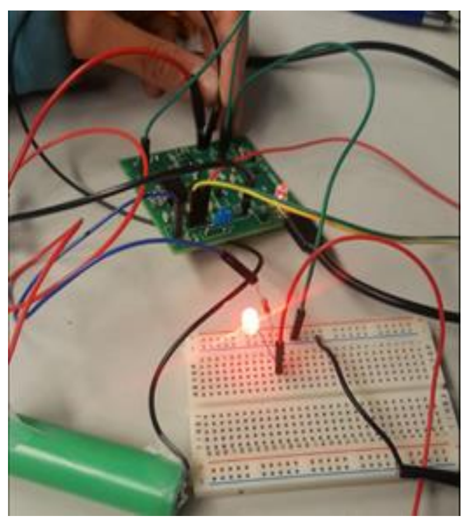
2)Bottom Side: -

PCB routing:



Circuit: -





Explanation: -

A single circuit that comprises of Boost converter module and TP4056 (constant-current /constant voltage) linear charger for a single cell lithium-ion battery. A schottky diode is used to prevent the negative charging. A chargeable battery is used to store the charge. The Boost converter is a DC-DC boost converter which gives a voltage boost from 3.7V to 5V. The circuit has 2 slots, one for charging the battery while the other for charging the phone. A Toggle switch is used to select whether the battery or the phone is being charged. Initially, the lithium battery is being charged to its full potential using the normal cell-phone charger that is connected to a port on the circuit. There is another USB port on the circuit, that is used to charge the phone using this power bank circuit.

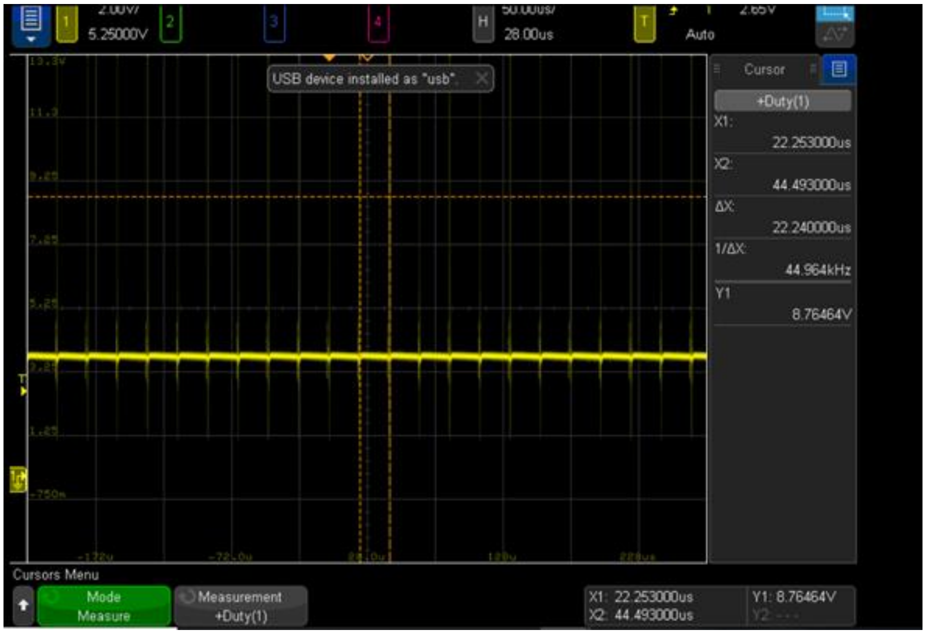
Key advantages: -

Compact, simple and cheap circuit

Testing methods: -

1. Efficiency of charging and discharging of battery.
2. The efficiency of Charging circuit (Boost circuit).
3. Charging and discharging time interval.
4. Voltage drop across various test points.
5. LEDs to indicate whether the battery or the phone is being charged.
6. Measuring the load voltage at certain intervals.
7. Checking the reliability of the output voltage, output current, input voltage and input current.
8. Checking the capacity of the circuit by testing the number of hours the power bank circuit is capable of charging (measured in Amps/Hours).

Oscilloscope Observations: -



X1 is 22.25uS. Thus, the frequency is 44.943kHz. The waveforms shows a rise and fall and thus by regulating the voltage. The voltage regulator waveforms are accurate and various minute spikes can be seen on the waveform due to ac voltage in the circuit that gets added on DC.

Testing observations: -

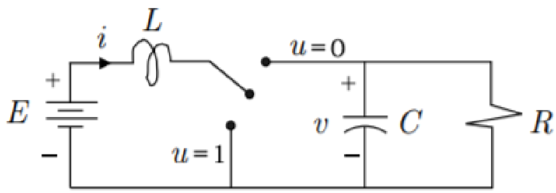
	T1-T7 are test points		
	Case: Phone charging using boost circuit		Voltage
	Test 1 : Volatge verification		
	Volateg across USBA3		6.07V
	Volatage across USB1		3.5V
	Votage across battery		3.5V
	Volatge across test points	T1	0.15v
		T2	3.5v
		T3	0v
		T4	0v
		T5	0v
		T6	4.85v
		T7	4.8v
	Voltage across zener diode	Reverse	0.001v
		Forward	-6.002v
	Volateg across schotky	Reverse	2.5v
		Forward	0.002v
	Duty Cycle		42.19
	Efficiency of Boost converter		71.32%

Testing capacitance	47uF
Charging time (from 0 to full theoretically)	5.5 hours
Charging time (from 0 to full practically)	4.37 hours
Discharging time calculated theoretically	33.3 hours
Discharging time calculated practically	39 hours
voltage across battery during charging condition	6.0v
Efficiency of charging battery - according to datasheet	99%
Efficiency of charging battery - practically tested	70%
LED glows	Yes
battery power capacity	2500mAH
20A samsung lithium cell	
Standard charge test	4.2V
Standard discharge test	3.0V
Max temperature discharge test	60C
Max temperature charge test	45C
Full charge test	6.10v

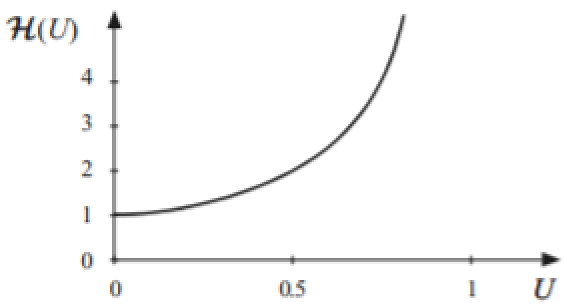
Output current	80mA
Voltage drop across load	2.92v
Thevenin's Resistance	85.06 ohms
Thevenin's voltage	6.02v

Analysis: -

Details about DC-DC boost converter: - (XL 6009)



The output ripple for dc-dc boost converter is 78mA. It boosts the input voltage from 3.7v to 6.1v (maximum) and its Quality factor is Q = R (sqrt(C/L)).



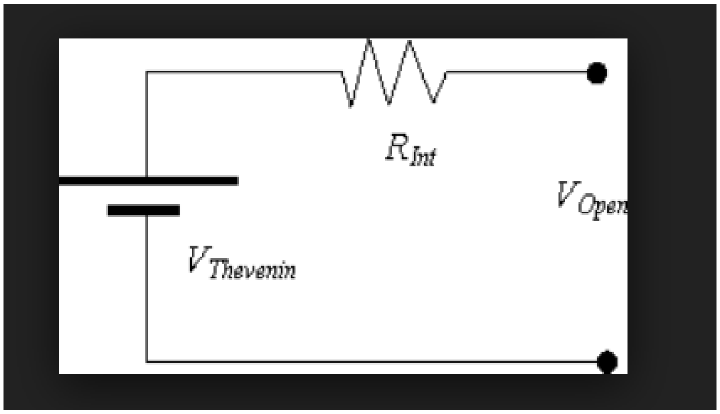
The transfer function graph is as shown above where U is the Control input and H(U) is the control output. The graph depicts that the relation between the Output and input is exponential.

$$\mathcal{H}(U) = \overline{x}_2 = \frac{1}{(1-U)}$$

The above mentioned equation is the transfer function equation for the dc-dc boost converter that is used to plot the graph shown just above the equation.

Things learned: -

1) Using thevenin's theorem imagining, the circuit to be described by just a thevenin's resistance in series with a voltage source (Vth = open circuit voltage), across a load resistance RL,



The value of the thevenin's resistance is 85.06 ohms when measured practically and is 81 ohms theoretically. The thevenin's voltage is 6.02 volts and the output current is thus 70.32 mA practically and is 75 mA practically. This current is not sufficient for charging the phone. As the phone requires approximately 1-2A to get charged properly. Thus, an led that requires about 20 mA only is used for testing the circuit.

2) The circuit requires the use of a fuse for protection from devices that draw large currents like the Mobile phone.

3) The circuit needs to be modified in order to charge the phone and increase the reliability. Latest model of the circuit uses a dc-dc boost converter to charge the voltage from 3.5v to 6.2v. But, the current is very low i.e. < 75mA. The circuit needs a current boosting mechanism as well so that it can be capable of charging the phone.

4) The circuit that is designed for two way use works perfectly on the input side and charges the lithium battery properly. However, on the output circuit has a weak current drive and thus can be used to charge an led or a mini USB LED torch with a very small current rating.

5) The capacitors ordered initially didn't match the required footprints and thus had to be reordered as the footprints were designed using 0603 size.

6) The schematic was changed according to the requirements and the availability of the components (The capacitors were changed to ceramic instead of electrolytic for surface mount devices) and the decoupling capacitors values were changed according to the parts available.

7) IC TP4056 was replaced with LTC 4058 (Li-ion charger IC) making appropriate changes in the circuit, due to the unavailability of IC TP4056.

8) Several test points are being added to the circuit in order to test the voltages at various points in the circuit.

9) The test points added in the circuit were useful only to measure the voltages at various points. Several other test points could have been in series orientation to measure and test the current at different points in the circuit.

10) The current flow through a power bank should be constant even when the battery through the power bank discharges. Thus, we were able to observe the current value constant through 39Hrs of discharging of battery.

11) Typically, the efficiency of any power bank circuit is much more than 90%. But, due to the circuit limitations, the efficiency of this power bank is limited to 71.317%.

Theoretical calculation: - (vout/vin) = 1/(1-D)
Thus, 6.06/3.5 = 1/(1-D)
D = Duty Cycle = 42.19%
D= 1 – ((vin * efficiency)/(vout))
Therefore, efficiency = 71.317%.

12) When an LED is used as the load for the power bank circuit, it will take about 33.3 hours or 1.39 days (calculated theoretically) to discharge completely if the Lithium ion battery is being charged previously.

Theoretical calculation: -

18650 LI-ion cell = 2500mAH capacity
Output current of the circuit: - ~ 75mA
Thus, the time required for discharging is:- 2500mAH/ 75mA = 33.3 hours or 1.39 days.

In comparison to this, we find the practical time for discharging the LED to be: - 39 hours or 1.625 days.