Centre of Excellence (CoE), a MeitY and U.P. Government sponsored project implemented by CDAC Noida and India Cellular Electronics Association (ICEA)

Grand Challenge Contest 2021
Design Report

General Information

Team Name	Hertz
Registered Email ID	anandpsadanandan@gmail.com
Problem Statement Code	P-001
Problem Statement	To design a low-cost Power bank.

Team Details

	Team Lead	**Team Member 1**	**Team Member 2**
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Checklist of files to be attached with the e-mail:

1) Attached Schematic file (PDF format): Yes ☑ No ☐
2) Attached Layout file (PDF format): Yes ☑ No ☐
3) Attached BoM list* (PDF format)): Yes ☑ No ☐
4) Attached Gerber files(zip format or compressed format): Yes ☑ No ☐
5) Attached Centroid (Pick and Place) file*: Yes ☑ No ☐
6) Attached IPR undertaking form (PDF file): Yes ☑ No ☐

1 General Details

1.1 Hardware Tools Used

- Proteus : For Schematic drawing & PCB designing
- Fusion 360 : For 3D modelling
- Ultimaker Cura : Slicing software, to convert the 3D model into G-code
- AutoCAD : For designing 2D graphics and Block diagrams

1.2 Software tools used

- 3D printer: For printing the designed 3D model
- CNC Milling machine : For making the PCB with high accuracy
- Laser printer : For making PCB by toner transfer method
- Soldering station : For all kinds of micro soldering purposes.
- Digital Storage Oscilloscope : For analysing the wave forms of DC-DC converter circuits and communication lines.
- Multi-meter : For the precise calibration of cut-off thresholds of battery management circuit.

1.3 Technical Specification

INPUT

- Charging voltage: 5V +/- 0.5V
- Intake current: 1A (Max)

OUTPUT

- Rated output Voltage: 5.1V
- Power: 18.5Wh x 2
- Rated output Current: 2A
- Rated output Current: 2A

CAPACITY

- Capacity: 5000mAh x 2
- Internal battery nominal voltage: 3.7V
- Battery technology: Li-Po

PROTECTIONS SPECIAL FEATURES

- Adaptive charging technology
- Supports communication with Android Application
- Advanced Charge scheduling functionality
- Driven by intelligent control algorithms
- Type-C compatible
- Instant battery replace design
- Intelligent Short circuit protection
- Dynamic load current monitor (For preventing system malfunctions [if any].)
- Over temperature protection
- Overcharge protection
- Deep discharge protection
- Purely automatic charging functions
- Constant-Current/Constant-Voltage Charging technology (To improve battery life.)
- Soft start charging technology (Limits Inrush Current.)
- Charging Status indicators (LED based)
- Ultra-Low Power-Down Current (To prevent discharge in protection mode.)

PHYSICAL FEATURES

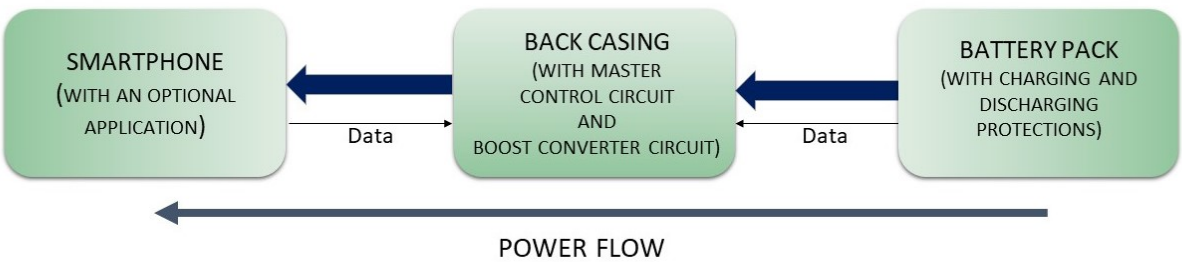
- Dimension: 148.80mm x 72.80mm x 14mm (LxBxH)

2 Summary of Product

In the modern scenario, it is difficult to get a quality power bank for smartphones at a cheaper price and also people prefer a lighter, portable and compact option. Recharging the only power bank, then using it afterwards may cause a delay in the relative time between charging the phone with it and of the power bank.

An assembled view of the product

In our project, we plan to design power banks from a different perspective. The product that we provide is a specially-designed back casing and 2 slip and slide batteries. The batteries resemble the shape and size of credit cards and can be replaced at the provided space, it will be connected to the type-c USB port of the phone by means of a connector from the back casing. The power in the card can directly charge the phone.

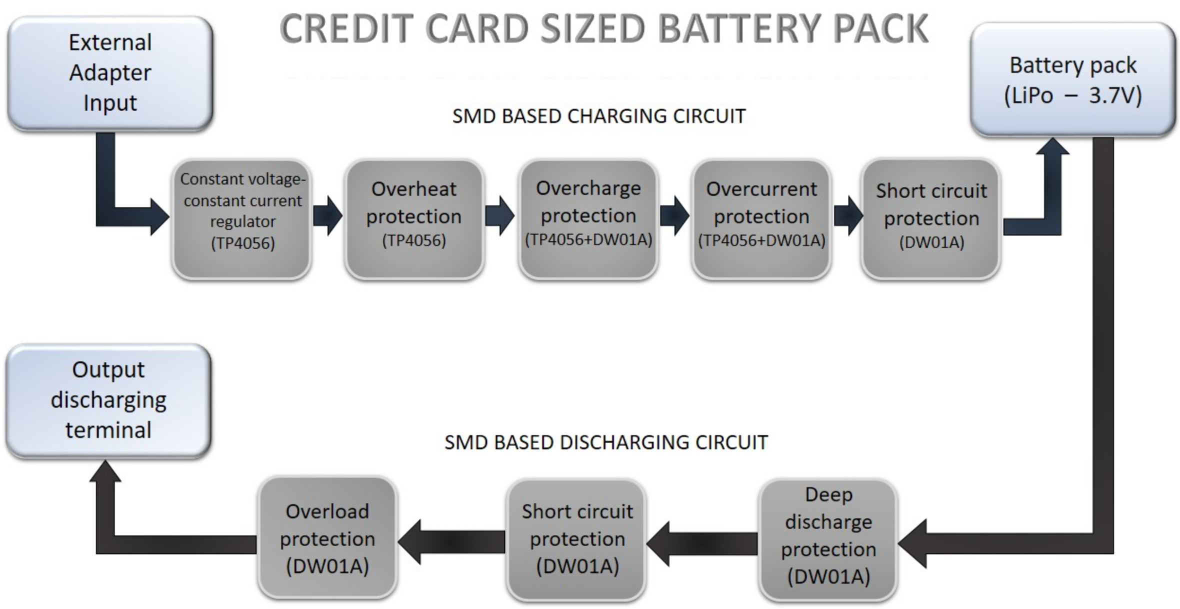


Parts of the product

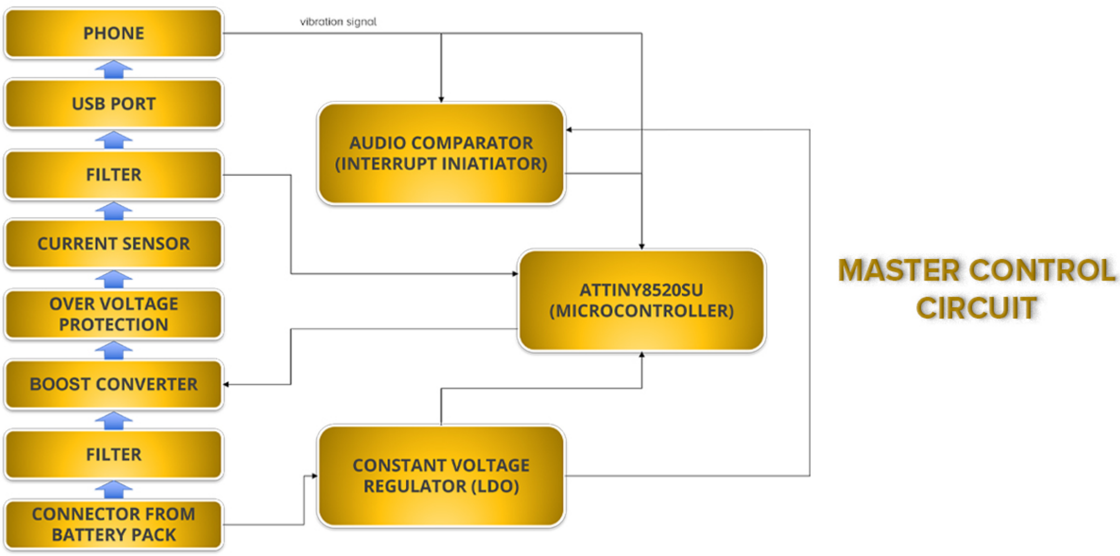
An assembled view of the product

An optional in-app communication for charging is also enabled. The batteries are of Lithium Polymer cells so it is safe, cost-effective and the use of analog based dedicated Lithium-polymer charge and discharge control chips proves to be economical. The user need not have to worry about the problem of using a single power bank and subsequently recharging it, while we have two of them for the same price.

3 Detailed Block diagram of the product design



Block diagram of battery pack



Block diagram of master control

4 New/Extra features incorporated in the product design

4.1 Adaptive charging

This feature has been incorporated into the design to ensure better power delivery from the product to the device. It enables the back cover to sense the phone battery state, whether power is being actively drawn from it or not and send real time data to the microcontroller to alter the charging current accordingly.

4.2 Noise Filtration & Harmonics Reduction

The noise in a circuit is the undesired ripples of DC voltages in the circuit. It can be filtered effectively by pi capacitors. Pi filter capacitors are capacitive filters that are used to reduce the effect of such noise sources on the circuit, which leads to its improved performance. It is an arrangement of capacitors with an inductor. Pi filters do it more accurately since multiple capacitors are used at the input side and they are selected to offer low reactance and repel the majority of the nuisance frequencies or bands to block the AC ripples.

The harmonics reduction can be done by employing a low filter capacitor. Capacitors are normally sensitive to harmonic currents as their impedance decreases proportionally to the order of the harmonics present. The harmonic content can be brought to a reasonable limit , by inserting filters next to the load. At higher frequency harmonics, using a low filter capacitor is ideal. This effective tuning helps to reduce the distortion due to harmonics of different frequencies.

5 Detailed explanation of circuitry

5.1 The Circuit inside the Battery

The provided removable battery has an inlet, in which a type-C plug can be inserted for the charging purpose. The positive charging terminal of the plug is connected to the TP4056 (U2) Protection Module's Chip enable pin 8 in order to keep the chip on during the ON state of power supply. The thermal protection of the circuit is done via the temperature sensing of the thermistor(R6) connected to pin 1 (TEMP) of the module. The pin 2 (PROG) is the program pin to set the charging current. It is grounded through a resistor (R1). The current through the battery I_{BAT} can be changed accordingly.The equation for the charging current is given by,

$$I_{BAT} = \frac{V_{PROG}}{R_{PROG}} \times 1200$$

Since the voltage at the program pin is constant(1V),by changing the resistance R_{PROG},at the program pin the charging current can be set by us. The pin 4 of the module is connected to the Power supply(Vcc), with a capacitor of few microfarads for filtering of ripples in the incoming voltage and also to reduce the harmonics. The pin 6 (!STDBY) of the module is the standby pin which is connected to the red LED (D1) which turns ON when the phone is charging. The pin 7 (!CHRG) is connected to a green LED (D2) which turns ON when the battery is fully charged.

The pin 5 (BAT) of the module is connected to the Lithium ion cell(3.7V), which is connected through a 100 ohm resistor (R2) to the DW01A Battery protection IC which includes the additional protections inside the removable battery. Battery terminal voltage is taken up by the IC through Vcc and GND pins. Capacitors in the order of microfarads are connected to minimise the ripples in the incoming voltage. The measurement of voltage is continuously done by the voltage dividers inside the IC. Through these voltage measurements, the required protections are enabled. The 1K ohm resistance (R5) is connected and grounded through the pin 2 (CS) of the IC. This resistance is connected so as to indicate to the IC that the charger is connected and also for overcurrent protection purposes. The battery can get charged upto 4.2 V and discharges at a voltage of 3.0 V.

The protections are divided it into 3 sections:-

1. Over Charge Protection
2. Deep Discharge Protection
3. Overcurrent Protection

5.1.1 Over Charge Protection

The Lithium-ion battery can be charged through the OTG Cable upto a voltage of 4.2 V. Any further increase from this value is not favourable. Since the IC measures the voltage through the circuit, when the battery voltage exceeds the value 4.2 V it activates the overcharge protection pin, the dual power MOSFET connected to the respective pin goes off, giving the required protection.

5.1.2 Deep Discharge Protection

When connected to the load, the battery discharges and the value 4.2 V gradually decreases. When it reaches 3.0 V, the voltage measurements of the IC activate the pin 1 (OD) of the IC, thereby turning OFF the respective MOSFET connected to it and the discharging occurs through the golden terminals near the type-C inlet, thus enabling the deep discharge protection of the circuit.

5.1.3 Overcurrent Protection

When the connected load absorbs an overcurrent or gets short-circuited due to some unexpected reasons, the 1K ohm resistance reads a higher voltage. When this voltage exceeds a specific threshold value the IC recognises it as an overcurrent or a short circuit depending upon the threshold value and the value read by the resistor. This activates the pin 3 (OC) of the IC to work and thereby overcurrent or short-circuit protection is effectively achieved.

5.2 Master Control Circuit

The master control circuit is located within the bottom compartment of the back cover included in the design. It functions to facilitate the conversion of 4.2V DC output of a lithium-ion battery to a steady 5.0 V DC voltage.

The circuit includes multiple levels of protection taking into account various possible risk factors and vulnerabilities. It also has been designed to deliver power in a very steady, fast and efficient way.

To explain this circuit in better detail, we may divide it into the following sections :-

1. Feedbacking and control system
2. Thermal protection system
3. Voltage regulation system
4. Master control system and companion application

5.2.1 Feedbacking and Control System

The microphone(U2) receives incoming audio signals and passes them onto the negative lead of the operational amplifier(LM393) as corresponding voltage variations, while the positive lead of the op-amp is held at a fixed potential. An audio signal of suitable amplitude would cause a spike in the voltage at the negative lead. The op-amp functions as a comparator in this case and would produce a low or zero output at pin 1. This change from high to low is fed into the microcontroller (ATTINY8520SU) at pin 5.

The signal/pulse length is measured by the microcontroller and only a signal of specific pulse length is accepted. This signal corresponds to the start of the idling period of the phone and thus triggers the microcontroller to an active and operational state. All other components in the master control circuit and their functioning is set in motion from here on.

5.2.2 Thermal Protection System

R7 is a thermistor used to sense the temperature of the device while charging. It is a Negative Temperature Coefficient(NTC) thermistor and thus as the temperature rises, the value of resistance decreases, which would result in a higher current and a higher voltage. This voltage across the thermistor is read by the microcontroller via pin 2. If this voltage exceeds a particular predefined value, the microcontroller would stop functioning and enter sleep mode.

5.2.3 Voltage Regulation System

The most crucial part of the master control circuit certainly involves the boost converter and its related circuitry. The converter used is FP6277 which is a current mode boost DC-DC converter with PWM/PSM control. The converter's functioning is based on a feedback mechanism, where the output voltage is constantly monitored and altered simultaneously.

The shunt resistor R10 is connected to the type-c outlet of the phone case and thus output current of the master circuit flows across it. The voltage across the resistor would thus give the output voltage which is connected to the leads 5 and 6 of op-amp U3: B. The op-amp generates a corresponding amplified signal which is fed into the microcontroller(U4) at pin 3.

The choice of resistors R_f (R15 and R16) and R_i (R13 and R14) has been made in accordance with the required gain for the shunt voltage. The derivation of these values is given below for reference :-

Voltage drop across R10 (0.01Ω - shunt resistance), during a current flow of 3A is given by,

$$\begin{aligned} V &= IR \\ &= 3 \times 0.01 \\ &= 0.03\text{v} \end{aligned}$$

Let required amplified output voltage be V_o = 3.3 V, We have (V2 - V1) = 0.03 V
Taking R_i = 1000 Ω

$$V_o = \frac{R_f}{R_i}(V2 - V1)$$

$$\begin{aligned} \Rightarrow R_f &= \frac{V_o \times R_f}{V2 - V1} \\ &= \frac{3.3 \times 1000}{0.03} \\ &= 110,000\,\Omega \end{aligned}$$

And thus the gain of the op-amp output is given by,

$$gain = R_f/R_i = 110k/1k = 110$$

This amplified voltage is now read by the microcontroller. The microcontroller decides as to whether the voltage requires any further boosting and gives a suitable output at pin 6. This output is read by the boost converter via the enable(EN) pin. A high input would trigger the working of the boost converter which internally consists of an oscillating coil to amplify the input voltage. This process occurs in a repeated fashion, where the output voltage is incremented by a slight value at the end of each iteration.

The FP6277 has an additional layer of protection facilitated by pin 7, which is connected to R9 whose resistance value determines the overcurrent trip limit. We require a trip limit of 5.0A, then the required value for R9 is given by,
And thus the gain of the op-amp output is given by,

$$
\begin{aligned}
I_{OCP} &= \frac{180000}{R9} + 0.2 \\
\Rightarrow R19 &= \frac{180000}{I_{OCP} - 0.2} \\
&= \frac{180000}{5 - 0.2} \\
&= 37500\,\Omega
\end{aligned}
$$

$\therefore$ Choosing a standard value of resistance, $R9 = 36k$

The resistors R1 and R2 determine the master output voltage and have been chosen accordingly. We require an output voltage of 5.0V, then the values of R1 and R2 are given by,

$$V_{OUT} = 0.6(1 + R1/R2)$$

$$
\begin{aligned}
Let\, R2 &= 10kW \\
\Rightarrow R1 &= (V_{OUT}/0.6 - 1) \times R2 \\
&= (5.1/0.6 - 1) \times 10 = 75\,k\Omega
\end{aligned}
$$

A completely drained phone battery would require minimum voltage for charging and as it approaches full charge, the output voltage is incremented gradually and steadily (keeping the V_o slightly higher than the phone battery voltage) till it reaches the maximum value i.e. 5.0 V. At this point the device is completely charged. The charging voltage and the phone battery are now equal and thus the charging is stopped. This cutoff of charging current is independent of any external signals and thus works regardless of whether the device is powered on/switched off.

5.2.4 Master Control System and Companion Application

The microcontroller used in the circuit is ATTINY8520SU, which is a low-power CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture. The power required for the working of the microcontroller and all the other analog components in the circuit is provided by the auxiliary supply setup formed by AMS1117(U5), which supplies a steady 3.3 V. It is responsible for receiving multiple inputs from the other circuit components and maintaining an optimal operation of the complete circuit. It also determines the sleep/wake cycles of the complete circuit. The primary operations performed by it include:-

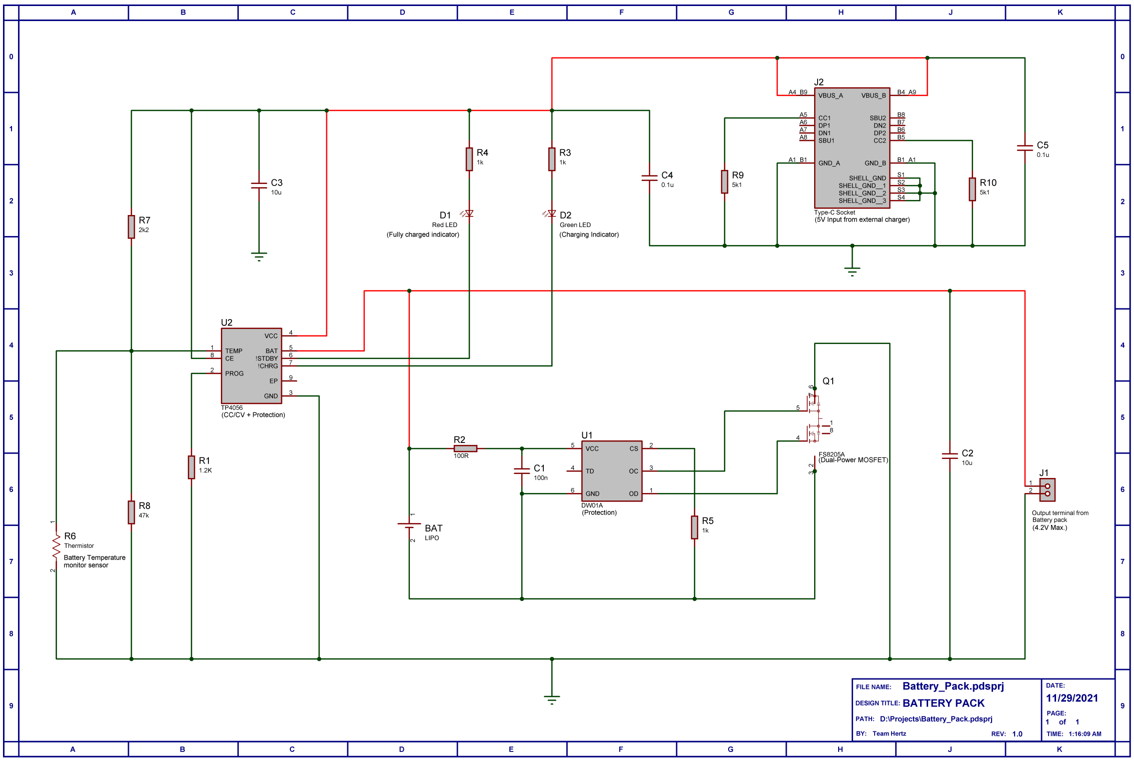
- Measuring the pulse length from the op-amp (U3: A) microphone (U2) combination and controlling the sleep and active states of the circuit.
- Receive the voltage across the thermistor (R7) and determine whether the device is overheating.
- Receive the output voltage of the boost converter (U4) and determine whether it requires further boosting.

Companion IOS/Android Application: An additional mobile application would be developed to assist the functioning of the product which would provisionally include the following features:-

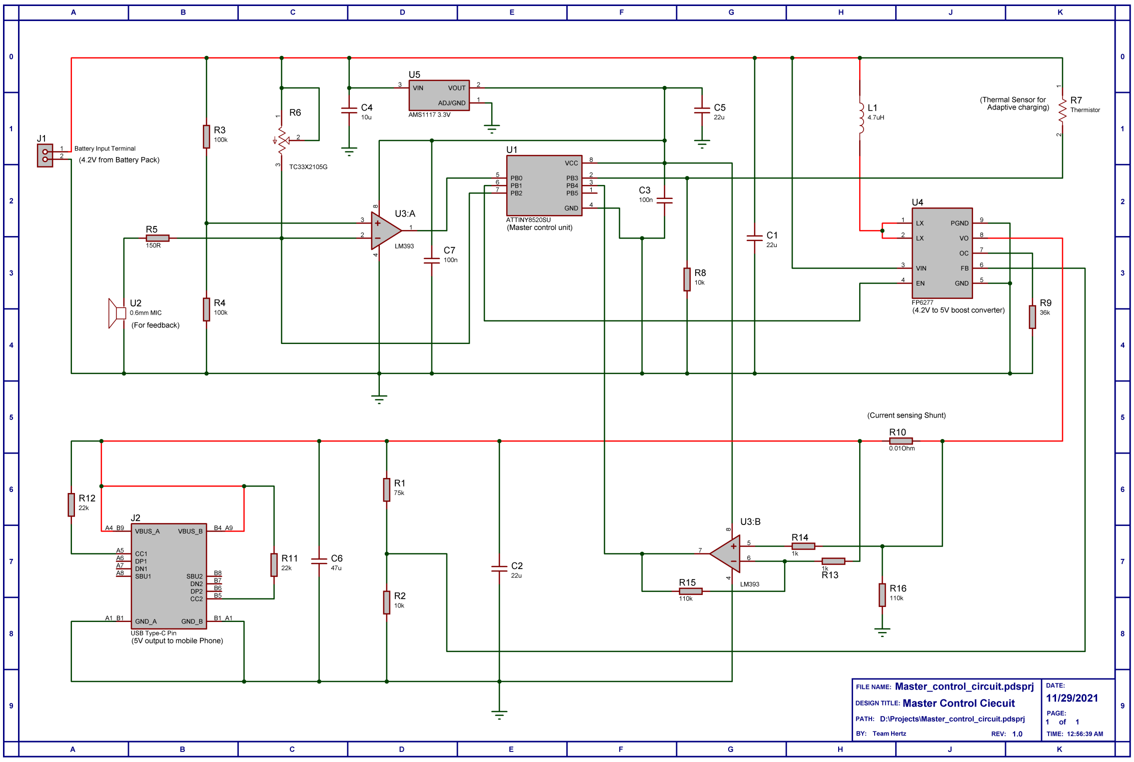
- Device idling period detection
- Low battery notification
- Advanced charge controlling
- Battery health monitoring
- Battery temperature monitoring

*The product can also be used without the app, since we are using current sensing techniques

6 Screenshot of Schematic of the product design

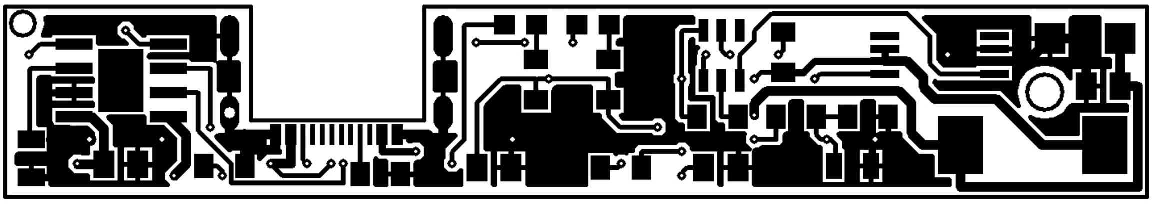


Battery Pack Circuit

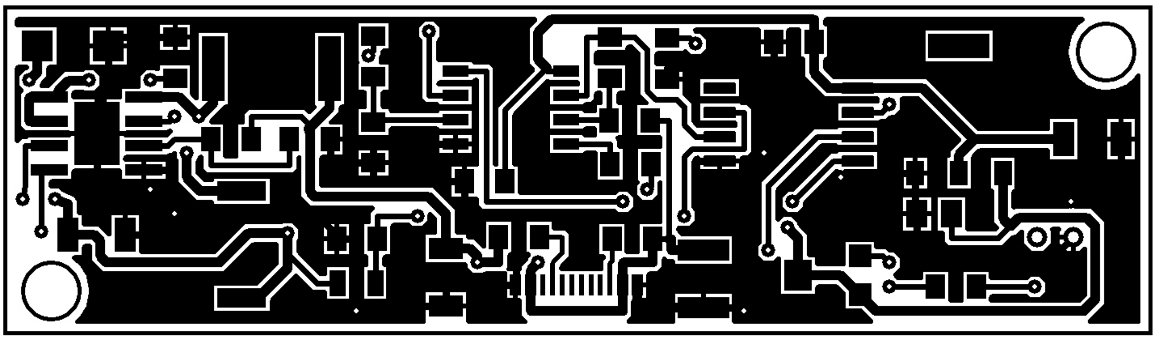


Master Control Circuit

7 PCB Layout Top layer

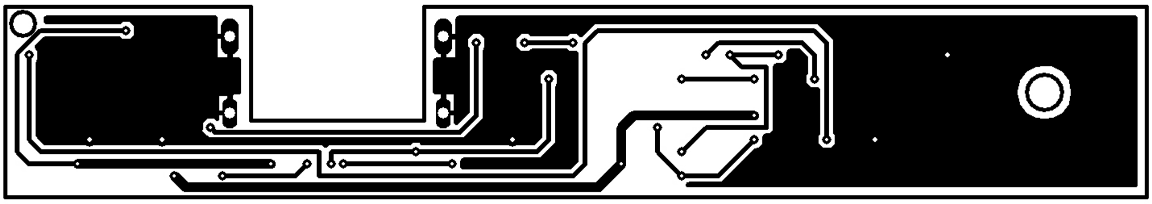


Battery Pack - Top Layer

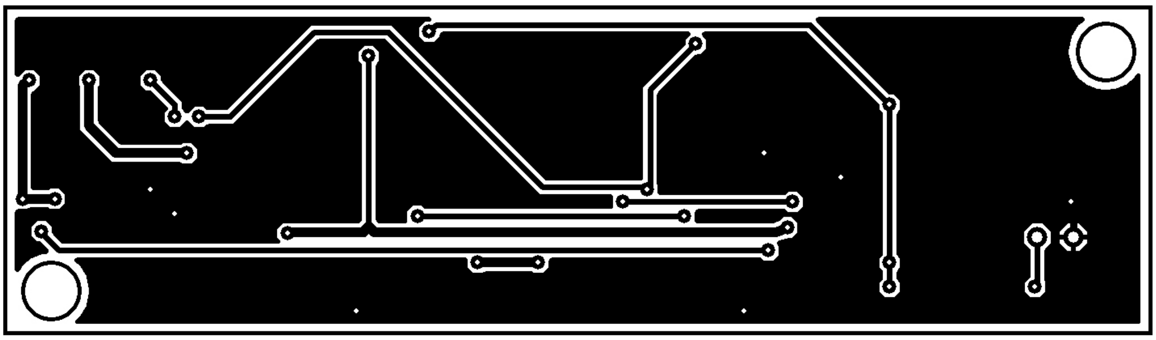


Master Control - Top Layer

8 PCB Layout Bottom Layer

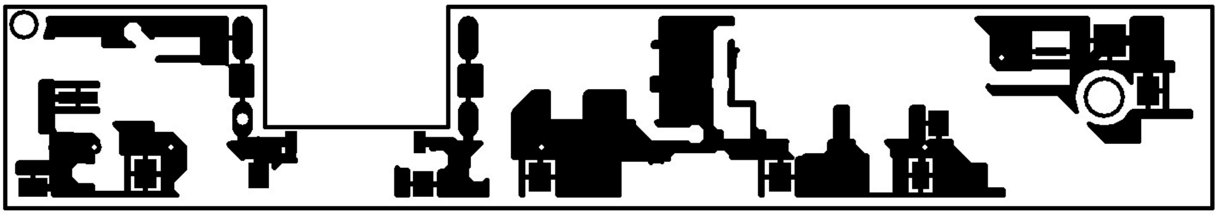


Battery Pack - Bottom Layer

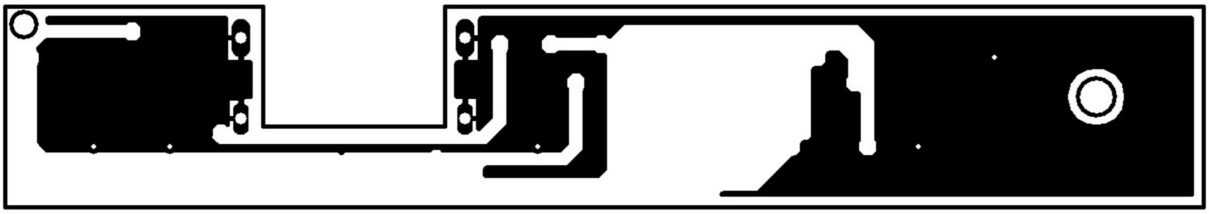


Master Control - Bottom Layer

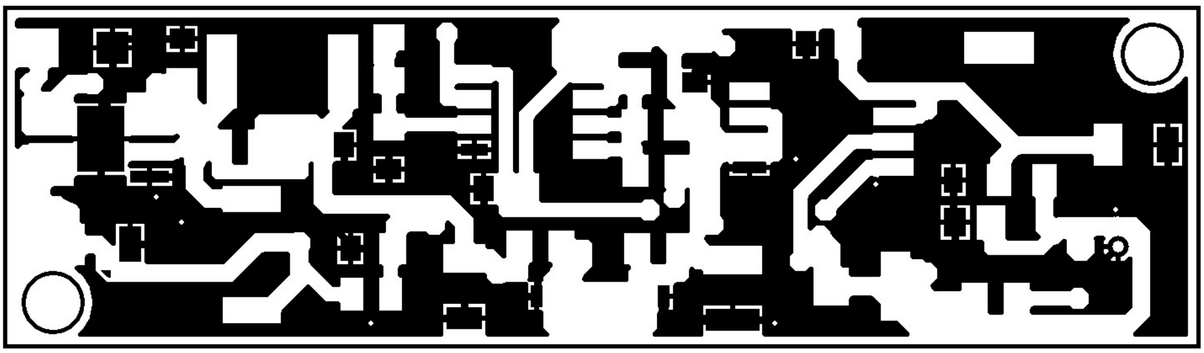
9 PCB Layout Ground Layer



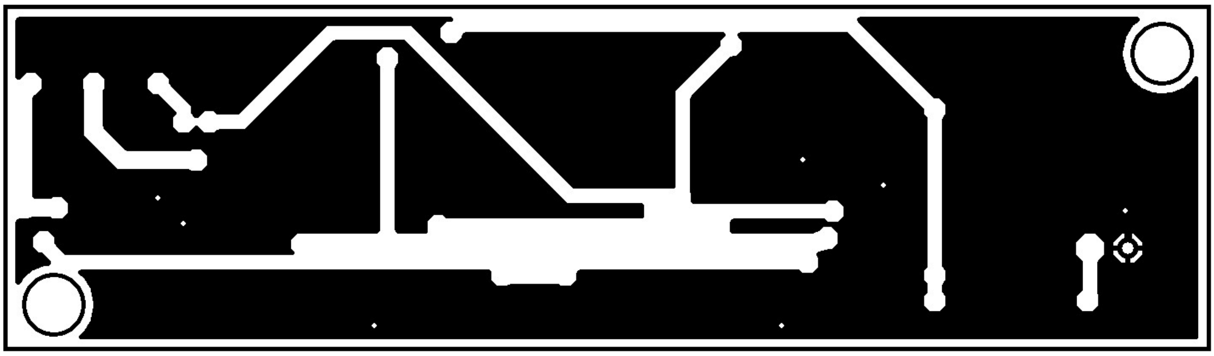
Battery Pack - Top Ground Layer



Battery Pack - Bottom Ground Layer



Master Control - Top Ground Layer



Master Control - Bottom Ground Layer

10 Gerber Files description

The details of the gerber files are as follows:

- Layers/Artworks :-
  1. Top Copper
  2. Bottom Copper
  3. Top Silk
  4. Top resist
  5. Bottom Resist
  6. Top Paste
  7. Top Assembly
  8. Edge
  9. Drill
- Gerber Format : RS274X
- File Units : Imperial(thou)
- Resolution : 500 dpi

The top and the bottom signal layer is of copper. The silkscreen layer is included on the top signal layer. Solder mask or the solder resist is applied on the top and the bottom signal layer of the Printed Circuit Board. The paste mask is applied on the top signal layer only. The board components are assembled on the top layer. The edge plating is done throughout the top and bottom surfaces of the board and is of copper.

11 Board dimensions

Battery Pack PCB:-
Width 60 (mm) x Height 10 (mm)

Master Control PCB:-
Width 60 (mm) x Height 17 (mm)

12 Number of layers of the PCB

Number of layers of the PCB : 2

13 Techniques to mitigate EMI

Electromagnetic interference can be absorbed by the circuit components as well as released. The Printed Circuit Board is enclosed within a thin layer of metallic shield. This shielding reduces the absorption of Electromagnetic Interference to a great extent. Also, this thin metallic shielding is grounded to the same point as that of the system ground. So this interference can be significantly reduced.

Passive capacitor filters are used at appropriate points in the Battery pack circuit and the master control circuit in order to reduce the Electromagnetic Interference released along the circuit. These filters prevent the undesired signals from entering the power supply and the circuit. The use of electronic chalks alongwith the filters helps to mitigate the interference in the form of radio frequency waves.

14 Factors to improve the Efficiency

All the components in the Battery pack circuit and the master control circuit are having 83% or more efficiency individually. So the overall efficiency increases to a much higher value since individual components are energy efficient. After simulations, the circuit has proven to be about 80% efficient after a 20%(approximate) heat loss.

The usage of high frequency converters also increases efficiency. The components included in the circuit work at a higher frequency. So the inductors placed in the circuit need a lower number of turns of the coil, this decreases the resistive component in the circuit, resulting in a low heat loss.

Also, the regular monitoring of the current, voltage and temperature is done in the circuits implemented in the battery pack and the case. So excess voltage or current is effectively controlled and also at high temperature the thermistor protects the load. So no energy is wasted in the form of heat and other means since overload protections are provided. Hence the useful power output of the circuit increases as compared to the input power, and so the efficiency of the circuit is gradually improved.

15 Techniques to mitigate THD

The Total Harmonic Distortion occurs due to the individual components' oscillating frequency leading to deviation in the base frequency. We have designed an optimum product keeping in mind the various unnecessary diversions from the desired output. Also components used in the design are of standard values, which inturn has an overall responsibility to decrease the harmonics.

In addition to that, harmonics reduction can be done effectively by employing low filter capacitors at necessary places in the circuit. Capacitors are normally sensitive to harmonic currents as their impedance decreases proportionally to the order of the harmonics present. The harmonic content can be brought to a reasonable limit , by inserting filters next to the load. At higher frequency harmonics, using a low filter capacitor is ideal. This effective tuning helps to reduce the distortion due to harmonics of different frequencies.

In the master control circuit, the boost converter FP6277 is used. The internal switching in this converter works on the basis of Pulse Width Modulation (PWM) Technology. This technology is scientifically proven to reduce the Total Harmonic Distortion in a circuit.

Additionally, each Integrated Circuit (IC) in the circuit requires decoupling capacitors, so incase of a voltage drop at the input, these capacitors give the required power to the IC to maintain the supply voltage level. This implementation also reduces the harmonics in the circuit.

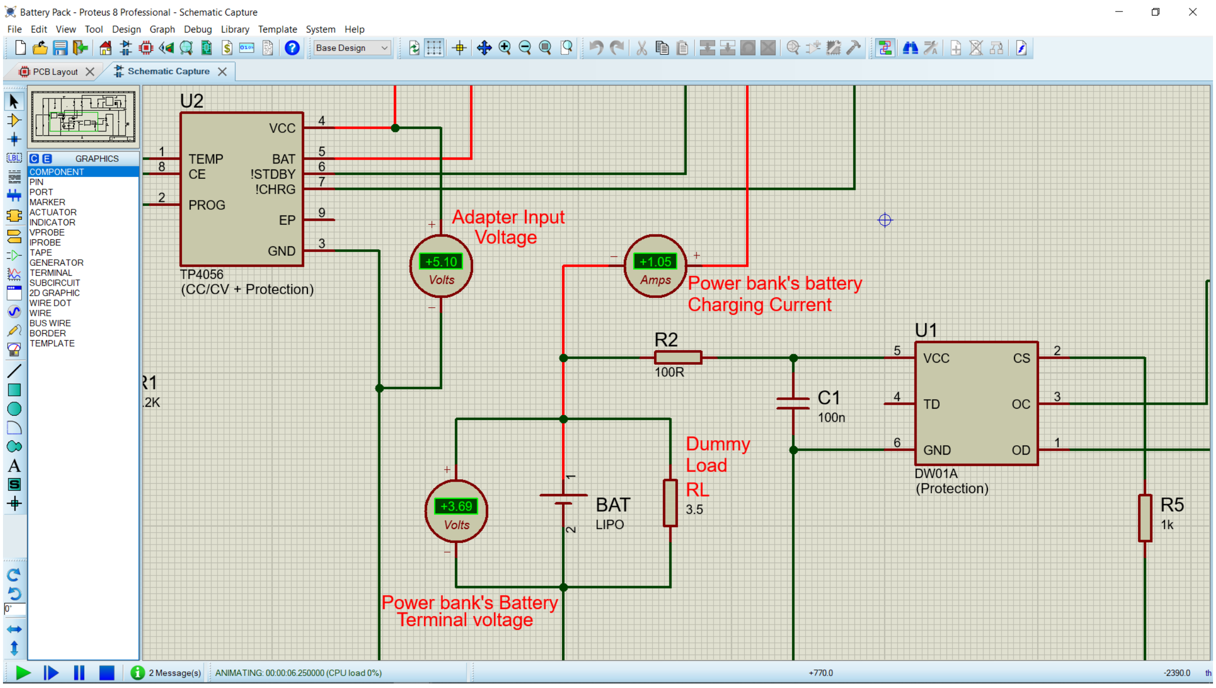
16 Factors to improve Power Factor

The whole circuit works on a DC Power supply. If the components added are of a standard recommended value, automatically the efficiency gets improved and efficiency improves only when the power factor is of a desired value. Also, the external charger's power factor greatly influences the rest of the circuit, since the working of all the circuit components depend on the input power. So if the external charger is of a higher power factor value, automatically the power factor in the design improves.

Also, to increase the power factor, static ceramic capacitors are added to the electrical system by connecting them in parallel to the components that normally work on a low power factor. These capacitors act as the generators of reactive current. The generation of reactive current improves the load circuit power factor, since it has provided the leading current which neutralizes the lagging inductive component of the load current. Thus, the power factor in the product design is improved to a greater extent.

17 Explanation of test/simulation results

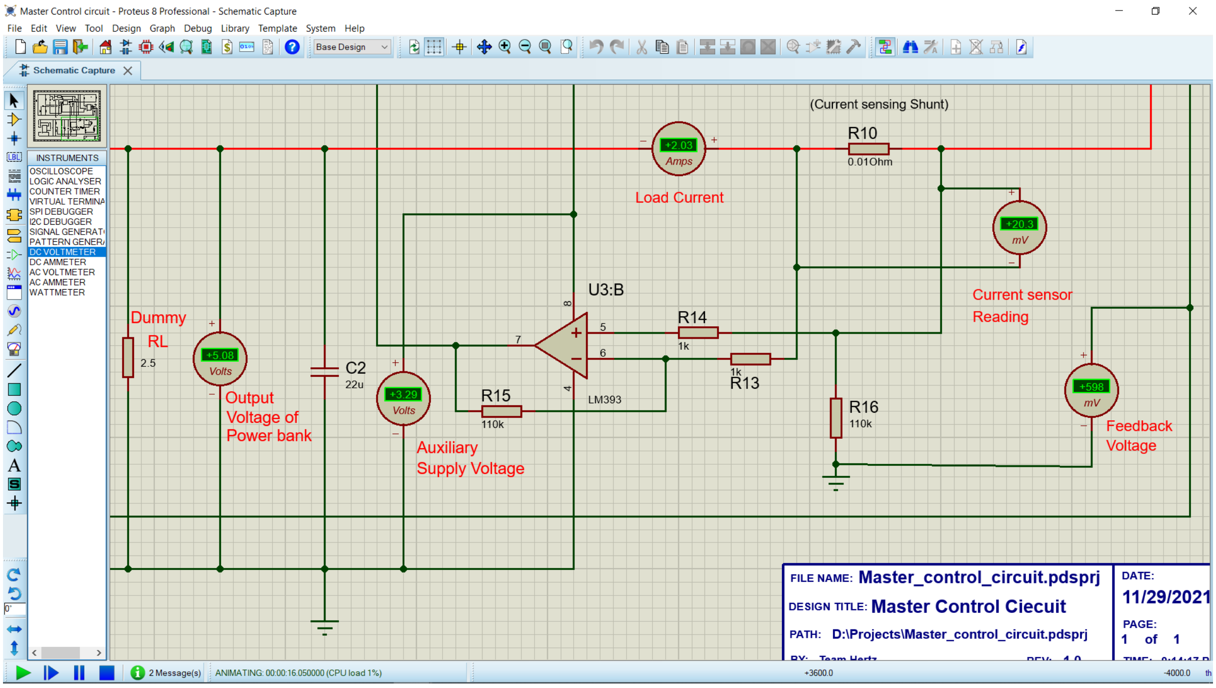
17.1 Battery Pack



Simulation of battery pack circuit

The adapter input voltage of around 5 V is reduced by the circuit to a maximum of 4.2 V charging voltage. The TP4056 IC has decided the charging voltage to charge on a stable current. The battery is charging at a constant current of 1.5A, starting from a value of approximately 3.7 V. The dummy load represents the battery, which gets charged from a value of 3.7V(approximately) to 4.2 V maximum value.

17.2 Master control



Simulation of master control circuit

The dummy load represents the smartphone which draws power from the circuit. Across this load the voltage varies around 5 V. At that instant, the current flowing through the load is about 2.03 A. The resistor, R10 is the current sensing shunt resistor. There will be a voltage drop in the order of millivolts through this shunt resistor. The favored feedback voltage of the system is 0.6 V. The favoured values may slightly deviate due to internal resistances of components.

There is an auxiliary supply of 3.3 V(stable value), since the battery voltage can fluctuate. So, to keep up a constant reference voltage, an auxiliary supply is kept with a voltage of about 3.3 V.

18 Bill of Material

18.1 Battery Pack

S.No.	Name of the component (as mentioned in the schematic)	Description	Manufacturer Part Number	Manufacturer	Quantity	Unit cost (in INR)	Total Cost (in INR)
1	C1	100n	LCSC Part # C94108	LCSC	1	Rs. 0.51	Rs. 0.51
2	C2-C3	10u	LCSC Part # C181790	LCSC	2	Rs. 1.87	Rs. 3.74
3	C4-C5	0.1u	LCSC Part # C94108	LCSC	2	Rs. 0.51	Rs. 1.02
4	R1	1.2K	LCSC Part # C336858	LCSC	1	Rs. 0.56	Rs. 1.12
5	R2	100R	LCSC Part # C491180	LCSC	1	Rs. 3.45	Rs. 3.45
6	R3-R5	1k	LCSC Part # C491180	LCSC	3	Rs. 1.02	Rs. 3.06
7	R6	22k	LCSC Part # C143716	LCSC	1	Rs. 45.15	Rs. 45.15
8	R7	2k2	LCSC Part # C139913	LCSC	1	Rs. 0.22	Rs. 0.22
9	R8	47k	LCSC Part # C102018	LCSC	1	Rs. 0.10	Rs. 0.10
10	R9-R10	5k1	LCSC Part # C164003	LCSC	2	Rs. 0.25	Rs. 0.50
11	U1	DW01A	LCSC Part # C868733	LCSC	1	Rs. 4.53	Rs. 4.53
12	U2	TP4056	LCSC Part # C725790	LCSC	1	Rs. 4.92	Rs. 4.92
13	Q1	FS8205A	LCSC Part # C16052	LCSC	1	Rs. 17.31	Rs. 17.31
14	D1	Red LED	LCSC Part # C440517	LCSC	1	Rs. 1.12	Rs. 1.12
15	D2	Green LED	LCSC Part # C440517	LCSC	1	Rs. 1.12	Rs. 1.12

16	BAT, 3.3 V	LIPO	-	-	1	Rs. 550.00	Rs. 550.00
17	J1	Output terminal from battery	-	-	1	Rs. 0.00	Rs. 0.00
18	J2	Type-C Socket	GCT Part USB4520-03-0-A	GCT	1	Rs. 50.00	Rs. 50.00
						Grand Total:	Rs. 687.870

18.2 Master Control

S.No.	Name of the component (as mentioned in the schematic)	Description	Manufacturer Part Number	Manufacturer	Quantity	Unit cost (in INR)	Total Cost (in INR)
1	C1-C2,C5	22u	LCSC Part # C93135	LCSC	3	Rs. 3.35	Rs. 10.05
2	C3,C7	100n	LCSC Part # C94108	LCSC	2	Rs. 0.51	Rs. 1.02
3	C4	10u	LCSC Part # C90544	LCSC	1	Rs. 3.58	Rs. 3.58
4	C6	47u	LCSC Part # C515691	LCSC	1	Rs. 22.85	Rs. 22.85
5	R1	75k	LCSC Part # C104503	LCSC	1	Rs. 0.09	Rs. 0.09
6	R2,R8	10k	LCSC Part # C108451	LCSC	2	Rs. 0.20	Rs. 0.40
7	R3-R4	100k	LCSC Part # C118847	LCSC	2	Rs. 0.21	Rs. 0.42
8	R5	150R	LCSC Part # C253459	LCSC	1	Rs. 0.32	Rs. 0.32
9	R6	1MR	# TC33X-2-105G	Bourns	1	Rs. 0.10	Rs. 0.10
10	R7	22k	LCSC Part # C143716	LCSC	1	Rs. 45.15	Rs. 45.15

11	R9	36k	LCSC Part # C168444	LCSC	1	Rs. 0.14	Rs. 0.14
12	R10	0.01Ohm	Digikey P.10UTR-ND	Digikey	1	Rs. 30.20	Rs. 30.20
13	R11-R12	22k	LCSC Part # C304826	LCSC	2	Rs. 0.21	Rs. 0.42
14	R13-R14	1k	LCSC Part # C204136	LCSC	2	Rs. 1.02	Rs. 2.04
15	R15-R16	110k	LCSC Part # C204163	LCSC	2	Rs. 0.31	Rs. 0.62
16	U1	AT-TINY8520SU	LCSC Part C152192	LCSC	1	Rs. 123.62	Rs. 123.62
17	U2	0.6mm MIC	# ROM-2238P-NF-R	PUI Audio,	1	Rs. 22.34	Rs. 22.34
18	U3	LM393	LCSC Part # C7955	LCSC	1	Rs. 13.38	Rs. 13.38
19	U4	FP6277	LCSC Part # C88312	LCSC	1	Rs. 47.58	Rs. 47.58
20	U5	AMS1117 3.3V	LCSC Part # C347222	LCSC	1	Rs. 5.79	Rs. 5.79
21	J1	Battery Input Terminal	-	-	1	Rs. 13.38	Rs. 13.38
22	J2	USB Type-C Pin	GCT # USB4120-03-C	Global Connector Technology	1	Rs. 40.50	Rs. 40.50
23	L1	4.7uH	# A921CY-4R7M=P3	Murata	1	Rs. 28.20	Rs. 28.20
						Grand Total:	Rs. 469.61

19 Centroid (Pick and Place) file

19.1 Battery Pack

Designator	Footprint	X-Position	Y-Position	Rotation	Layer
U2	GCT_USB4520031A_REVA	17.42	-3.9	180	TOP
U1	SOP127P600X1759N	6.1	-3.9	0	TOP
Q1	SOT236	37.65	-2.6	0	TOP
C4	SOP65P640X1208N	49.12	-2.58	0	TOP
C1	CAPC2012X100	6.1	-8.3	0	TOP
C3	0805_CAP	40.9	-2.4332	-90	TOP
C2	CAPC2012X100	37.6	-8.5	0	TOP
C5	CAPC2012X100	57.7	-4.2	180	TOP
D1	CAPC2012X100	25.7	-8.5	0	TOP
D2	603	27.1	-1	0	TOP
R4	603	30.9	-1	0	TOP
R6	0805_RES	27.9	-3.8668	90	TOP
R1	THRMC2012X50N	44.52	-8.4	0	TOP
R3	RESC2012X50	1.27	-7.985	-90	TOP
R5	0805_RES	31.7	-3.8668	90	TOP
R2	0805_RES	37.4332	-5.8	180	TOP
R7	0805_RES	32.3668	-8.5	0	TOP
R8	0805_RES	41.5668	-5.8	0	TOP
R9	0805_RES	45.3332	-5.8	0	TOP
R10	0805_RES	19.7332	-8.8	0	TOP
BAT	0805_RES	11.5332	-8.4	0	TOP
J1	LIPO PAD	54	-7.3	0	TOP
J2	TERMINAL	56.75	-1.7	0	TOP

19.2 Master Control

Designator	Footprint	X-Position	Y-Position	Rotation	Layer
U3	SOIC127P620X170-8	26.5	-5.235	0	TOP
U1	SOIC127P798X2168N	41.07	-6.105	0	TOP
U5	SOT229P700X1804N	50	-5.34	0	TOP
U4	SOP127P600X1759N	4.8	-6.6	0	TOP
U2	MIC_ROM2238PNFR	55.05	-12	0	TOP
R7	THRMC2012X50N	18.42	-14.4	0	TOP
R3	0805_RES	19.3	-2.5668	-90	TOP
R4	0805_RES	19.3	-7.0668	-90	TOP
R5	0805_RES	49.8332	-14.6	180	TOP
R6	TRIM_TC33X2105G	43.1	-14	180	TOP
C4	CAPC2012X100	48.7	-10.8	180	TOP
C1	CAPC3216X140	4.8	-11.9	0	TOP
C5	CAPC3216X140	57	-6.9	0	TOP
C6	CAPC3225X100	36.6	-14.2	270	TOP
J2	TYPE C CONNECTOR	29.95	-14.5	0	TOP
C2	CAPC3216X140	23.1	-14.1	90	TOP
C3	0805_CAP	41.3332	-1.8	-180	TOP
C7	0805_CAP	25.1332	-9.1	180	TOP
L1	IND_A921CY4R7MP3	12.4	-12.4	90	TOP
R11	0805_RES	32.8668	-12.1	0	TOP
R12	0805_RES	26.9332	-12	180	TOP
R13	0805_RES	32.7332	-5.9	0	TOP
R10	RESC6432X70	13.95	-3.2	180	TOP
R14	0805_RES	32.7668	-8.2	0	TOP
R16	0805_RES	34.7	-2.6668	-90	TOP
R15	0805_RES	31.7	-2.6332	-90	TOP
R1	0805_RES	11.8332	-6.9	180	TOP
R2	0805_RES	15.9668	-6.9	0	TOP
R8	0805_RES	18.4332	-12.1	180	TOP
R9	0805_RES	8.9	-2.6332	90	TOP
J1	TERMINAL	3.55	-2	180	TOP

20 Any Other Relevant Information

At different stages of brainstorming, prototyping and modelling the concept, a lot of information had to be devoured from numerous external resources most of which cannot be not be accommodated to this limited synopsis. Hence here are some of the references we found useful at the time of development.

20.1 External References

1. An extended collection of photos of the 3D Model and Block Diagrams : https://drive.google.com/drive/u/0/folders/1EGEI7KlcN9sly1OqtrqAfpdaZnEzriVc

2. Lithium polymer battery : https://en.wikipedia.org/wiki/Lithium_polymer_battery

3. Buck–boost converter : https://en.wikipedia.org/wiki/Buck%E2%80%93boost_converter

4. Charge controller : https://en.wikipedia.org/wiki/Charge_controller