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Design of Power Bank with Buck-Boost Converter

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Abstract - *Recent years have seen a mass manufacturing and production of portable electronic devices and gadgets, such as smart phones, digital notebooks, digital cameras, portable players like DVD player, PDA and MP3 player, Global Positioning System devices and health care devices, etc., Presently these all products have become the need of the peoples and mostly all of these products require a battery power supply. But the main problem is the limited capacity of battery, the amount of usage time provided from batteries is often far from ideal. Many of the electronics products users face this problem that the battery of their device runs out of energy at critical moments when they are required for important applications and it is not possible to have a power supply for every portable device; however, a common backup supply can resolve this problem. Normally the power bank does the following three functions; it charges the internal battery and provides power for external electronics devices. Thus in this project* ***"Design of Power Bank with Buck-Boost Converter"*** *is going to be designed and studied. There are certain methods for design of Power Bank, thus considering all methods; Power Bank will consist of different features which will fulfill mostly all specifications required to charge different gadgets with batteries connected in a serial or parallel manner inside the power bank as per requirement. It will give different power level outputs with special protection features like NTC (Negative Temperature Coefficient), and short circuit protection, etc., with efficient battery saving mechanism.*

Key Words: **NTC, Buck Converter, Boost Converter, Short Circuit Protection, Battery.**

1. INTRODUCTION

In the present world, portability has become a very important factor; we are constantly looking for new and innovative ways to add comfort to our lives. One of the most frustrating things that can happen anywhere is to find that your mobile phone or any digital device has run out of power at the moment you need it most. Thus the new technology has arrived to the market that will allow you to abolish this common problem once and for all. Power Banks is a portable charging device that allows you to charge any devices which are charged by USB capable wherever you may be. The concept of power bank is becoming very popular as it has become the need and also its demand is increasing because of fast growth of digital products. Portable Chargers are convenient and because of their small size it has become very easy to carry power bank of large-capacity.

Since the global economy is growing very rapidly, people continued to carry more and more portable electronic products, such as mobile phones, camcorders, laptops, digital cameras, tablets, portable players like MP3 player, PDAs, Global Positioning System devices, DVD player, MP4 player, thermal equipment, healthcare equipment, etc. People have become so much addicted to the technology that he is not able to live without it, and also the digital devices don't have so much of power that it can survive for the whole day when used continuously. Therefore, in order to solve this annoying problem, through continuous research and exploration, finally a new technology power bank has been developed. It can solve a number of mobile devices power supply problems. Also, the safety of power bank is continuously valued by the people. Power bank must have protective measures for short circuit, battery overcharge and over discharge, thermal shutdown and other power supply problems. There should be a high-performance power management technology.

2. BUCK-BOOST CONVERTER

A Buck-Boost converter is a type of switched mode power supply that merges the principles of both i.e. Buck and Boost converter in a single circuit. Like other SMPS designs, it provides a regulated DC output voltage which is taken from either an AC or a DC input. The Buck converter described in Power Bank produces a DC output of 4.20 V, 4.35 V, etc, in a range from 4.50 V to 6.00V the input voltage. The boost converter will produce an output voltage of fixed DC 5.00 V with the input voltage taking from battery ranging from 2.90 V to 4.20 V. A buck converter is the converter which produces the lower voltage than the applied input voltage and the boost converter produces the voltage greater than the applied input voltage. Normally in the Power Bank device, the input supply is given from the wall charger or the

laptop or from any computer. The normal input specification of any power bank is 5.00 V and the batteries that are internally connected to the device are of 4.20 V or 4.35 V thus to charge them buck converter is used and same when the output is given out from the portable device then boost converter is used which normally boosts the battery voltage to the fixed 5.00 V which is the requirement of any device. It is normally a DC-DC converter which suits best for the power bank device with very minimum components required like inductor, etc.

3. ELECTRIC PERFORMANCE

The portable devices normally work on DC supply, it takes DC supply for charging and also delivers the DC supply output. The performance of the devices depends on the components used and the specification of the devices. Normally the electrical specification consists of input voltage, input current, output voltage, output current, battery specification, etc. All the components that are being used on the board depend on the electrical characteristics of the device. Some of the working ranges of the device are mentioned in the Table 1.

Table -1
Electrical Specification

Input Voltage	5.000 V
Working Voltage Range	4.50 V to 5.80 V
Input Current	1.00 A to 2.10 A
Output Voltage	4.95 V to 5.25 V
Output current	Max. upto 3.00 A

The charging and discharging function is described in the Chart 1 & Chart 2, in buck and boost mode, both can be easily understood from the graphical chart.
This describes the behavior of electrical performance in charging mode. Considering the Lithium-ion battery, the battery voltage is normally 2.90 V to 3.40 V when it is fully discharged and the full charged voltage is 4.20 V, thus when the charging starts it normally takes the maximum current which starts decreasing with the rise in battery voltage. Battery tries to maintain its voltage to 4.20 V which is normally called as the CV mode i.e. Constant Voltage mode, thus the device works in CV mode and CC mode, first the CC mode is in operation i.e. constant current mode then the CV mode comes in operation.
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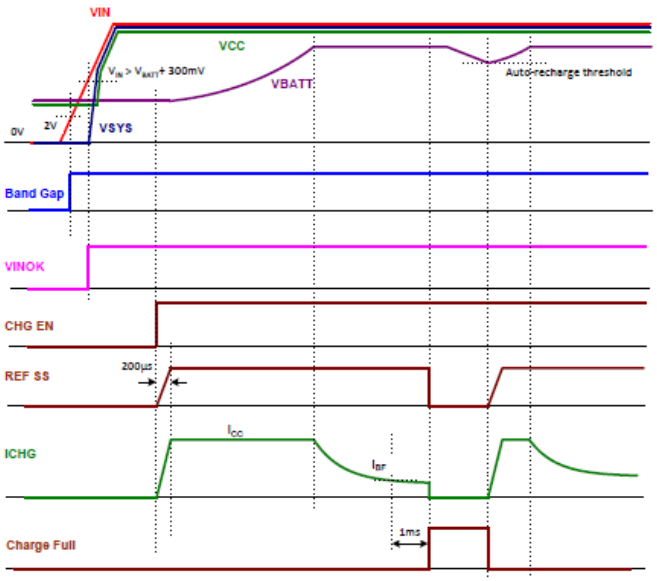

Chart 1. Charging Mode

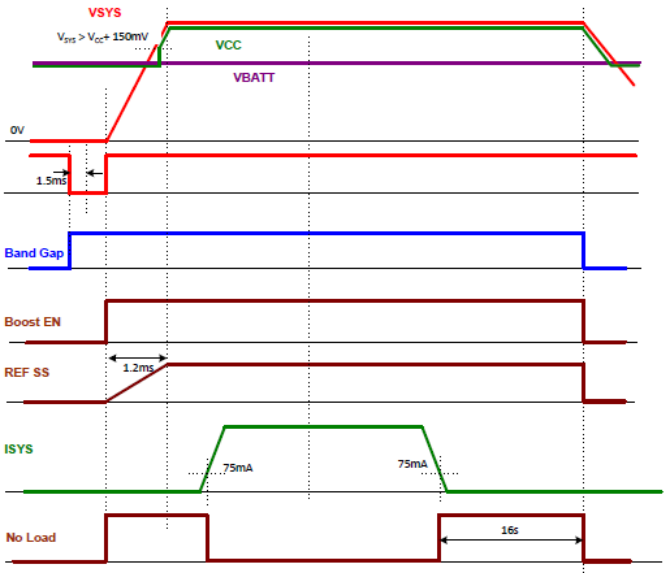

Chart 2. Discharging Mode

4. COMPONENT SELECTION AND PERFORMANCE

As discussed, proper component selection is very important as per the electric specification to get the better efficiency. Power Bank or Portable Charger are specially made to provide the backup to other devices thus efficiency matters the most, because it is the only think for which it has been made. The power bank with better efficiency can give

incredible power, thus proper selection of component is must. The most accuracy is needed in the selection of capacitors and inductor. Inductor plays very important role in the Buck and Boost mode. The current specification of the inductor is so selected that it should not be lower than that of MOSFET current, also the inductor should not saturate at minimum voltage of the battery thus proper value and proper current is very important for the proper working of device. The tolerance level and the value of capacitor and the resistance are also very important to get the proper rated input and voltage.

5. PROTECTION AND SALIENT FEATURES

Different protection features has become the need of the product as most of the expensive devices are connected to the portable chargers. Some of them listed below with detailed explanation, Over Voltage Protection, whenever the device is getting charged and if suddenly the voltage rise then this feature helps to protect the device by making the charging current negligible to zero. Short Circuit Protection, device may get damage by any internal short circuit or if any external short circuited device is connected to it, thus it is very much necessary that the power bank should have internal short circuit protection. Reset Protection, if the device is having integrated over voltage protection then normally whenever there is rise in voltage the product should get reset and whenever the voltage comes in its charging range it should get on automatically. Over Current Protection, the circuit of device should be such designed that it should not deliver over current to the external devices. Thermal protection and thermal shutdown, thermal protection is related to the temperature of the printed circuit board, it should always work in its specified range, the proper working range of the power bank printed circuit board is explained in the Table-2.

Table -2
Operating Temperature Range

Temperature during Charging	0" to +45"C
Temperature during Discharging	-10"C to +60"C
Storage Temperature	-20"C to +40"C
Relative Humidity	≤ 85 %

There are normally two types of thermal protection features that conventional power bank have, the NTC, negative temperature coefficient which normally monitors the battery voltage and the integrated IC which monitors the temperature of the board. Both the protection are very important, the NTC normally works on the battery whenever the temperature of the battery increases the NTC connected to it gives the signal to the controller which stops the operation, because there are chances that the battery should get blast thus it is very important that the operation should be stopped whenever such things happen, the another is the integrated IC monitoring, whenever the board temperature increases above its prefixed range, the controller shuts off the device immediately and automatically gets on when it comes in its operating range, thus the thermal regulation and thermal shutdown of the device is very necessary to avoid any type of thermal damage to the device. Reverse Polarity Protection, DC are devices are such that it should get the proper polarities on its terminal if the polarities are changed then there are chances that the board should get damage thus to avoid that he device must be having the reverse polarity protection. There are number of features that are available on board and also the users demand for number of features, some of them are explained further. Auto-load Detection, most of the users demand for this feature where they went whenever they connect their device the charging should start automatically without pressing any switch, thus there are number of portable devices having inbuilt auto-detection circuit. Fuel-guage indication, batteries are the back-bone of portable chargers thus it is very important to know about the energy left in the battery, thus fuel-guage indication feature is available in the circuit which is available inbuilt in the hardware based controller and programmed on the software based controller. These feature normally monitors the battery voltage and displays the remaining charging, normal fuel-guage energy table is shown in Table-3.

Table -3
Fuel-guage Energy Indication

Battery Level – 3.00 V to 3.60 V	25 %
Battery Level – 3.60 V to 3.80 V	50 %
Battery Level – 3.80 V to 4.00 V	75 %
Battery Level – 4.00 V to 4.20 V	100%

6. CONCLUSIONS

The main aim of this project is to manufacture and design the most efficient Power Bank of best quality by removing all the faults that are being faced in the present power banks. Power bank products which are going to be designed will be having the advantages of high efficiency, low standby current, high interference rejection as well as competitive pricing. Also it should be having modified both charging and discharging parameters. These results in lower costs and much higher flexibility when compared to traditional sol utions in the power bank application market.

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