Implementation of 12V/50,000mAH Power Bank for Portable Devices from Used Lithium Laptops Battery

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***Abstract*- The growing need of energy demand for consumer devices has become worrisome in developing countries like Nigeria. There is no adequate energy to charge consumer products due to lack of electricity. The spent lithium battery for laptop can be a solution to the energy demand by reconfiguration of these batteries for further used. In this paper, we collected spent lithium batteries and reconfigured them to produce a power bank of 12V/50000mAH. The lithium batteries were effective and efficient in use.**

***Keywords:* renewable energy, battery reconfiguration, lithium battery, efficiency**

I. INTRODUCTION

A power bank is a device that can be used to provide energy to mobile device during downtime on the phone. In communication, apart from the accessibility of network service, constant supply of power on our mobile devices is also considered as important element for smooth and continuous communication [1]. The mobile user becomes worried when the power level of the battery is low during call activity and the hope or possibility of recharging the mobile battery becomes unobtainable [1]. The challenge of most available power bank devices is that it has a fixed number of USB ports ranging from one to two and cannot make a provision for higher voltage especially when there is need to power device that require more than 5V from the power bank [2]. It becomes necessary to provide a means where multiple phones can be charged from a single power bank device and also to provide a higher voltage for other low power device using a used lithium laptop battery. Most used lithium battery are being disposed after their first life cycle. But most of these used lithium batteries can still be used to power low application devices if the nominal voltage value is within 2.5V and above [3]. This effort will reduce the wastage and hazard of disposing used LiBs in our surrounding. The used lithium batteries can be connected in series and parallel to get desired current and voltages for optimum power bank utilization [4].

II. LITERATURE REVIEW

The review of [5], conducted a research which was practically implemented on performance analysis of power bank with recycled lithium battery. The idea is to determine the capacity of a recycled lithium battery and it was charged with AC source and was used to charge mobile phone. However, the backup hour of this work was very low and cannot supply dc current for a long time. The work of [6], developed a portable and a low cost power bank. The AC input source was rectify to obtain a DC voltage and with LM7805, 5V output voltage was obtained and was connected to a USB ports which can be used to charge phone from the port. However, with this approached it cannot be used to power electronics dc equipment that required a voltage greater than 5V.

The review of [7], constructed a simple cost effective and portable power bank for mobile phones with 9V battery and used LM7805 to produced 5V output. The problem associated with this method is that it uses a conventional battery (primary battery) that cannot be recharged after it has being used up and the battery will have to be discarded and will always need a replacement. [1], designed and developed a solar power phone charging box with a deep cycle battery of 12V/18AH and 500W inverter which produced a 220V AC and a 5V/500mA DC via USB port. The sun produces light energy and this energy was converted to electrical energy through solar cells. With this method, it will unable to deliver power when needed during cloudy period and the rate at which it charge mobile phones is very low.

The work of [8] carried out a study in designing a charger helmet as power bank which are used by motorcyclist. Solar cells are placed at the middle outer part of the helmet which is directly exposed to sun, and the solar energy is converted to electrical energy via the solar cells which is used to charge the battery. However, this work only found it usage or application by motorcyclist alone and cannot generate electricity during the night or cloudy period when there is little or no sun at all.

Design and constructed of solar based power bank by [9] which convert the light energy from the sun to electrical energy by means of solar panel. The electric power generated is used to charge the battery and it can be used to power mobile devices and cannot produce greater than 5V as dc output voltage.

The work of [10] illustrated the importance of charging mobile phones with solar energy. Solar energy is a free energy and thus, it can be used to generate power. The photovoltaic cells convert the light energy from the sun to electrical energy which is used to charge a 12V battery and produced an output DC voltage of 5V through a USB port and was use to charge a mobile phone. The 12V battery was further connected to an inverter to produce a 230V AC to power other light electronics. However, this will not deliver power during cloudy period and the backup hour is relatively low.

III. METHODOLOGY

The design is section into several blocks which can be implemented separately to reduce the complexity of the design. Fig. 1 and Fig. 2 depicts the block diagram of the whole system and the entire circuit diagram respectively.

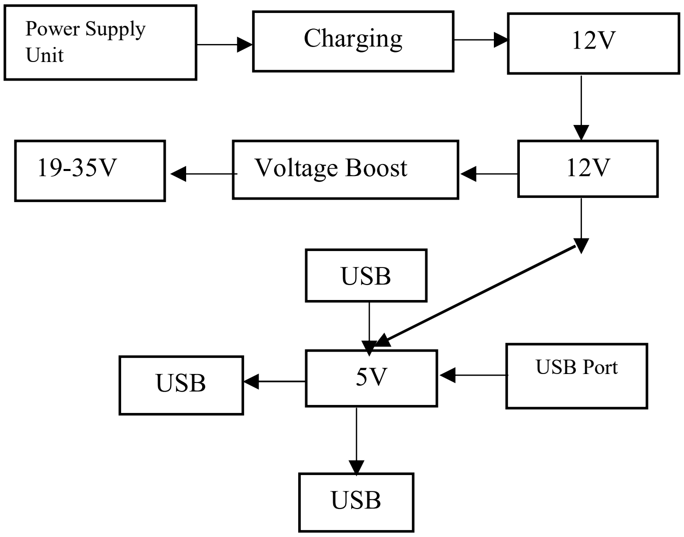

Fig. 1The block diagram of the 12V/50,000MAH Power Bank for Portable Devices from Used Lithium Laptops Battery

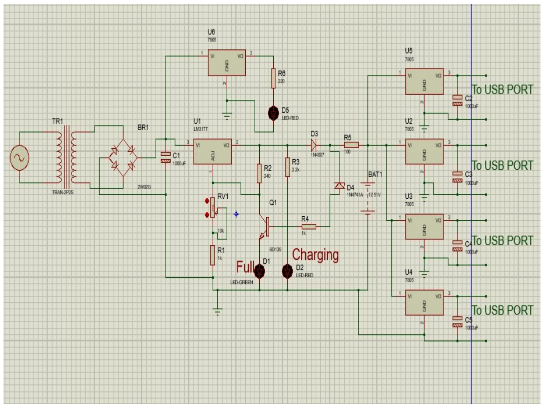

Fig. 2The Circuit Diagram of the 12V/50,000MAH Power Bank for Portable Devices from Used Lithium

3.1 Components Used

The component used are; Resistor, Capacitor, 220/240 Stepdown Transformer, Bridge Rectifier, LM317T, Voltage Regulator, Light emitting diode (LED), Switch, DC Plug, USB Module, Printed Circuit Board (PCB), BT-C3100, Cell holder.

3.2 System Modular Design

The system modular design comprises of Power supply unit, Charging circuit, LED circuit, Battery pack unit, Booster circuit unit and USB port unit.

3.2.1 Power Unit

The research adopt three section (3) for the power supply unit namely; Transformation Stage, Rectification stage and the Filtering stage. At the transformation stage, a step down transformer of 220/240V AC was step down to 15V at the secondary side of the transformer. The sinusoidal AC signal is converted to a direct current DC using a bridge rectifier. During the first positive half cycle, diode D1 and D4 are forward biased and current flow through only these diodes while diode D2 and D3 are reverse bias while in the negative half cycle, diode D2 and D3 are forward biased and current flow through only these diodes while diode D1 and D4 are reversed biased. After rectification, it was found that the waveform obtained is not a pure DC waveform due to the present of ripples in the circuit. This unwanted ripple in a DC circuit is called noise and when it is used in such a scenario, it creates malfunction in the circuit. An electrolytic capacitor was used to reduced or attenuate (filter) the ripple to some extent to give a pure DC waveform at the output as shown Fig. 2.

3.2.2 Charging Circuit Unit

The charging unit monitors and controls the activities of the battery such as charging the battery and to cut-off when is fully charged. It has 11.3V Zener diode used for stabilizing the voltage to a desired level and also serve as a means of protection to the battery against over voltages. A variable resistor of 10kΩ was used to vary the output voltage of LM317T. With the collector of BD139 (NPN transistor) connected to the base of the adjustable voltage regulator and the emitter to the LED as illustrated in Fig. 2. It also avoid total drainage of the battery.The controller charge rating is defined by the equation 1 as;

$$P = IVE$$

3.2.3. LED Circuit

The circuit in Fig. 2 consist of two LEDs (Red and Green) which are used for indication purpose. The LEDs are connected to the charging circuit. When the battery is charging, the red LED will be ON while the green is OFF and when the battery is fully charged, the charging circuit will prevent the excessive charge and the red LED will turn OFF and the green will be ON.

3.2.4. Battery Pack Unit

A battery is said to be dead if it cannot hold charges anymore and their performance can be determined by their state of health (SOH). Lithium-ion battery are known to be charge with constant current and constant voltage (CC-CV). For a battery to be reused, it has to possess the following characteristics; (i) must have a nominal voltage of 2.5V and above (ii) Must not excrete any gases or fluid in the two terminal and the whole body and (iii) The two terminal must not rust or corrode.

The following process were carried to unpack the used lithium battery pack;

1. Mechanical Separation
2. Sorting and Testing
3. Connection of the cells

After collection and gathering of various laptops batteries, the batteries are disassembled from the plastic case as display in Fig. 3 with the use of cutter and plier. The plastic cover were opened and the connecting wire are removed. The Fig. 4 show the batteries and the case after separation.

The batteries are first analyzed by means of physical method of separation and those that are already corrode or rust are removed as display in Fig. 5 and Fig. 6 respectively. A multi-meter was used to measure each cell voltage and those with nominal voltage of 2.5V and above are separated from those of lower voltage. The battery with nominal voltage that are sort out are then analyze using BT-C3100 to determine their state of health (SOH), state of charge (SOC) and their state of discharge (SOD) and their performance. The batteries with null readings are removed and cannot be use for this research work as in Fig. 7.

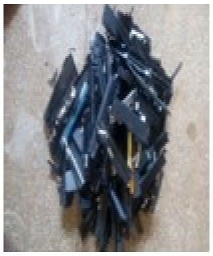

Fig. 4: Case of various batteries after disassembled

Fig. 5Batteries that are corrode and rust

Fig. 6 Batteries of nominal voltage of 2.5V and above

Fig. 7 Various batteries performance

Fig. 8 Battery of nominal voltage less than 2.5V

3.2.5 *Connection of the Cells*

The series-parallel connection was employed to achieve 12V/50,000mAh as shown in Fig. 9 and discussed below;

Each rated cell voltage is 4.2V.

Each rated cell AH used for this project = 2200mAh.

Since not all voltage will attained this level when fully charge, a 4.17V is assumed for each cell when fully charge in this design. When the batteries were connected in series, it add up the voltage and when connected in parallel, the current will be increased. Therefore, to get number of cells needed to achieve 50,000mAh, the formula will be used;

$$N_p = \frac{\text{needed mAh}}{\text{rated mAh}}$$

Where, N_p = no of cells needed to be connected in parallel.

Fig. 9: Series parallel connection of the battery

3.2.6 Booster Circuit Unit

A voltage boost converter was used to step up the low DC voltage input to a higher DC voltage at the output. For this purpose, a 12V is fed to the converter as input and the output is vary to achieve 19V output. It takes 1.2-15V as input and 37V maximum output at 3A. For safety operation of the boost converter, the output voltage must be greater than input voltage by 1V.

3.2.7 USB Port Unit

The most available USB are 5V, 1A, 2.1A and 3A to enable connections from the power bank to the phone. For the purpose of the design, four port were implemented as 5V, 1A USB. Input is fed from the battery to LM7805 which regulate the 12V to 5V output and is connected to the USB ports.

IV. RESULTS

The various section of the design of power bank were tested and analyzed on the proteus and breadboard respectively before the final construction was done on PCB and Vero-board. The result of the power supply unit gives a desired value of 12V output voltage. The output voltage was connected to channel A of the oscilloscope and the output waveform was obtained which gives a pure DC output waveform was obtained as shown in Fig. 10. The circuit charger was tested. The result shows that the batteries were charged to their full level. The green LED was turned ON to indicate that the batteries were fully charged.

Each cell that are arranged in series and parallel in 18650 cylindrical cell holder were measured and tested using multi-meter and an output voltage of 12.51V was obtained. The 12V input voltage fed into the boost converter was varied to obtain an output voltage of 19V as displayed in Fig 11 (the 7 segment display on the converter). Also the multi-meter was also used to verify the same result. The output voltage of the multi-meter shows the same result as displayed.

The output voltage of the USB ports were tested with multi-meter to ascertain the output voltage of 5V output voltage were obtained.

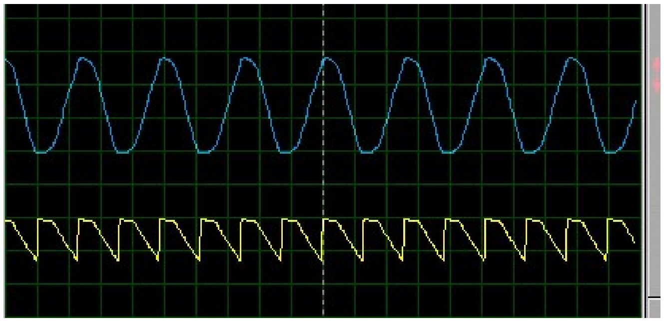

Fig. 10 Showing the input and output waveform of power supply

Fig.11 : Output voltage result of the battery

The results of various tested batteries voltages and levels during discharge with 1A were also recorded as depicted in Table 1 and Table 2.

Table 1: The results of various tested batteries voltages and levels during discharge with 1A

S/N	BATTERY WITH NOMINAL VOLTAGE <2.5 (V)	BATTERY WITH NOMINAL VOLTAGE >2.5 (V)	NEW LAPTOPS BATTERY (V)	TIME (min)
1	3.0	3.0	3.0	0
2	3.18	3.10	3.08	4
3	3.26	3.14	3.11	8
4	3.30	3.16	3.13	12
5	3.34	3.19	3.15	16
6	3.39	3.26	3.20	20
7	3.43	3.29	3.23	24
8	3.48	3.32	3.25	28
9	3.52	3.35	3.27	32
10	3.57	3.39	3.30	36
11	3.63	3.42	3.33	40
12	3.69	3.46	3.38	44

Table 2: The results of various tested batteries voltages and levels during discharge with 1A

S/N	BATTERY WITH NOMINAL VOLTAGE <2.5 (V)	BATTERY WITH NOMINAL VOLTAGE >2.5 (V)	NEW LAPTOPS BATTERY (V)	TIME (min)
1	4.20	4.20	4.20	0
2	4.01	4.10	4.14	4
3	3.80	4.01	4.09	8
4	3.74	3.93	4.05	12
5	3.69	3.88	4.02	16
6	3.61	3.82	4.00	20
7	3.53	3.75	3.98	24
8	3.46	3.72	3.95	28
9	3.39	3.69	3.92	32
10	3.25	3.65	3.90	36
11	3.19	3.58	3.88	40
12	3.07	3.54	3.87	44

V. CONCLUSION

The design of power bank from used lithium-ion laptop batteries has been experimentally proven to work effectively when mobile phones was connected to it through USB ports to charge various devices. The second life of used LiBs was achieved but the workability efficiency has reduced to about 60-70% from that of 90% of its efficiency when it has never been used. With the deployment of used Lithium batteries, it has proven that LiB has second life.LiBs can be connected together to achieve large current and voltage for industrial and household use. It also reduces electronic waste such as lithium-ion battery that can contaminate our environment and can also be connected to inverter to give an AC output voltage.

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