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Household use of autonomous power sources in conditions of limited resources: blackout experience

Abstract: During power outages, the use of universal mobile batteries, also known as power banks, has become extremely relevant. The prices of such devices have increased dramatically, and there have also been problems with the supply of these devices. Questions remain open regarding the correspondence of the declared characteristics with the real possibilities of universal mobile batteries, since some suppliers install demolished power cells, which make it possible to reduce the price of the battery for the final purchase. The article provides information on the possibilities of reusing power elements from laptop batteries in conditions of limited resources. The processes of creating universal mobile batteries for powering mobile phones, laptops, network equipment (ONU terminal and router), just like providing emergency lighting are considered. The object of research is lithium-ion batteries. The subject of research is the processes of reusing batteries in everyday life. The operation method is to increase the duration of operation and increase the efficiency of the use of laptop batteries. The author concludes that the proposed implementation is more energy-efficient due to a larger number of current converters. The reproducibility of the proposed implementations is also noted.

Keywords: power supply, lithium-ion batteries, universal mobile batteries, 18650 battery.

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Побутове використання автономних джерел живлення в умовах обмежених ресурсів: досвід блекаутів

Анотація: Під час відключень електроенергії вкрай актуальним стало використання універсальних мобільних батарей, також відомих як павербанки. Ціни на такі пристрої різко збільшилися, також виникли проблеми з постачанням цих пристроїв. Відкритим залишається питання стосовно відповідності заявлених характеристик реальним можливостям універсальних мобільних батарей, адже деякі постачальники використовують зношені елементи живлення, що дає змогу знизити ціну батареї для кінцевого покупця. У статті представлено інформацію щодо можливостей

повторного використання елементів живлення з акумуляторів ноутбуків в умовах обмежених ресурсів. Розглядаються процеси створення універсальних мобільних батарей для живлення мобільних телефонів, ноутбуків, мережевого обладнання (абонентський термінал ONU та маршрутизатор), а також забезпечення аварійного освітлення. Об'єкт дослідження – літій-іонні акумулятори. Предмет дослідження – процеси повторного використання акумуляторів у побуті. Метою роботи є збільшення тривалості експлуатації та підвищення ефективності повторного використання акумуляторів ноутбуків. З'ясовано, що запропоновані реалізації є більш енергоефективними внаслідок відсутності додаткових перетворювачів струму. Також відзначається відтворюваність запропонованих реалізацій.

Ключові слова: джерело живлення, літій-іонні акумулятори, універсальні мобільні батареї, акумулятор 18650.

Introduction

The high specific capacity of lithium-ion batteries is one of the reasons for their popularity, because now almost all devices use exactly such power elements in their batteries (*Pistoia, 2014*). Mobile phones, tablets, laptops and other devices are no exception, during the operation of batteries their natural degradation occurs, as a result of which the battery life of the device decreases. In such situations, universal mobile batteries come in handy, with the help of which it is possible to charge the device in the absence of a stationary power grid.

In the secondary market, it is possible to find offers with non-working laptop batteries. As a rule, such batteries cannot be used for their intended purpose due to their wear or due to the fact that an emergency situation occurred with this battery and the battery controller programmatically blocked the possibility of using this battery. Such a battery can either be restored or become a donor directly of power cells (*Tetskyi & Perepelitsyn, 2023*). Old models of laptops mostly used power cells of the popular 18650 format, modern batteries use power cells of other formats. It was the elements of the 18650 format that were used for the tasks under consideration.

During power outages, the tasks of energy storage for household use became relevant. Primary consumers are:

- mobile phones;
- laptops;
- network equipment (if the Internet provider uses appropriate technologies for providing access to the network and has uninterruptible power sources on its equipment).

In the room, the creating emergency lighting task is also relevant.

The article has an applied nature and contains a description of the processes of solving the above-mentioned tasks in the conditions of blackouts. The given implementations are reproducible.

An overview of the main material

A worn-out laptop battery can be disassembled and power cells are removed from it (in the cases under consideration, such cells were cells of the 18650 format). It is worth noting that such actions are not allowed by battery manufacturers, as evidenced by the corresponding inscription

on the battery case. Handling any chemical power sources requires specific knowledge. All actions were performed by qualified persons in compliance with all safety rules. Damage to lithium-ion batteries can cause them to catch fire (*Harper et al., 2019*).

During the degradation of lithium-ion power cells, their following parameters change: capacity, internal resistance, and self-discharge (*An et al., 2018*). Parallel connection of cells allows to increase the capacity of the group, serial connection of groups of cells allows to increase the voltage of the assembly of cells.

For worn-out cells, the discharge current has a significant impact during capacity measurement. In the case of parallel connection of the cells, the load current is distributed, which makes it possible to obtain a larger capacity. Experiments were conducted on measuring the individual cell pairs capacity and measuring the four cell pairs capacity connected in parallel under the same discharge conditions. The wear of the studied power cells was about 70%. It was found that the total capacity of four cell pairs group connected in parallel is greater than the sum of individual pair capacities, an increase of 15% to 30% of the capacity was recorded.

The voltage of one fully charged 18650 cell is up to 4.2 V maximum, cells also differ in capacity and maximum discharge current (*ICR18650-26F…, 2009*; *INR18650-25R…, 2009*). The serial connection of three groups of cells gives a voltage of 12.6 V, which is analogous to the voltage of common car batteries. Other voltage ranges have also been considered in previous studies (*Perepelitsyn & Tetskyi, 2023*).

Among the tasks considered, the first task is charging mobile phones. The standard charging voltage is 5 V, fast charging protocols can have up to 20 V, but they require additional converters and are more complex to implement (*Burzyński et al., 2018*). Power cells extracted from non-working laptop batteries can be combined with a step-up or step-down DC converter to obtain a charging voltage of 5 V. In the absence of converters, linear voltage stabilizers of 5 V with a current of up to 1.5 A can be used (*L7805CV, 2018*).

The second task was to provide power to laptops. Modern laptop power supplies have an output voltage of 19 V to 20.5 V. It is rational to use five series-connected groups of cells, which corresponds to a voltage of 21 V in a fully charged state and 15 V in a fully discharged state. Different laptops have been found to have different acceptable input power limits, with an average deviation of 1.5 V. This means that the laptop will report external power failure when the external battery voltage drops to 17.5-18.5 V, corresponding to approx. half charge.

Household cordless power tools (like screw gun) often use batteries with a voltage of 21 V in a fully charged state. Such a battery can also be connected to a laptop as an external power source without additional current converters. If there is a need to use a 12 V battery to power the laptop, then it is rational to use a step-up converter. Using a 12-220 inverter in such a case is irrational, as it is a double conversion with losses, that is, 12 V DC is converted by the inverter to 220 V AC, the laptop power supply converts 220 V AC to 19-20.5 V DC.

The third task is to provide power to user network equipment. As a rule, such equipment has a supply voltage of 9 V or 12 V. Such voltages are close to the voltages of fully charged two or three consecutive groups of lithium-ion cells (8.4 V and 12.6 V, respectively). This power option has been tested, it is suitable as an emergency, but it is not convenient for conditions of regular power outages, as it requires manual switching of the power supply to the stationary power grid during the restoration of the power supply, and the discharged cells must be charged

in time. Having a supply of cells and chargers for them simplifies this task. The most convenient way is to implement a low-power uninterruptible power supply for network equipment. If there is a stationary power supply, the battery is charged, and the equipment is powered in bypass mode. When the stationary power supply is turned off, it switches to battery power without restarting the equipment, which is a very convenient solution for the user.

The last task is to create emergency lighting in the room. LEDs of different power supply voltages are suitable for this. It is possible to choose any power supply voltage because of the possibility of serial connection of power elements (*Huseynov, 2018*). In conditions of limited resources, LEDs from non-working lamps can be used for this. As a rule, such LEDs have a power supply of about 12 V. It is possible to remove them from the cooling radiator by heating them with a gas burner or lighter. Similarly, it is possible to heat the tip of the soldering iron if you need to solder small elements. To ensure the long-term operation of LEDs, it is necessary to limit their current, such a task can be implemented with the help of a long thin wire from an old twisted pair.

Discussion

The expediency of using non-working laptop batteries to obtain power cells and their further domestic use in conditions of limited resources has been established. Solar panels can be used to charge such batteries in the event of a complete lack of stationary power supply. If there is no solar panel controller, then it is necessary to select the appropriate voltage of the batteries that will be charged. For example, to a panel with an output voltage of 40 V, it is possible to connect two batteries of 21 V in series, if they have the same capacity, or control the charge level, if the capacity is different. One 12 V battery and two 12 V lamps can be connected to a panel with an output voltage of 36 V.

Conclusion

Thus, studies show that the general knowledge of the basics of electrical engineering, the principles and features of the operation of chemical current sources can be fully applied during unpredictable conditions. The level of increase in capacity of cells connected in parallel has been experimentally determined, which makes it possible to extend the term of their use before final disposal. Variants of creation and use of autonomous power sources in conditions of limited resources are determined.

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