A Special Robust Solution for Battery Based Power Supply

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***Abstract*—The use of mobile devices has become general, their spread is self-evident. As a Power-source either an accumulator or a battery is used. (The next, we do not differentiate between the rechargeable accumulator and battery, only referring to a battery.) In either case, if the devices do not work, do not work properly, replace them. In either case, if the electronic devices do not work, do not work properly, the batteries are charge, or we replace batteries.**
In this paper, we examine whether a discharged battery is really empty. If not, what can be more possible to extract from it the total energy. All of these activities as a result of power supply devices and mobile devices become more robust operation.

I. INTRODUCTION

The usual approach to the battery power-supply model is shown in Figure (1). On the figure U_g is source voltage of the chemical cells, R_g the internal resistance of the battery, R_l is internal resistance of the device, of load, U_l is voltage of load.

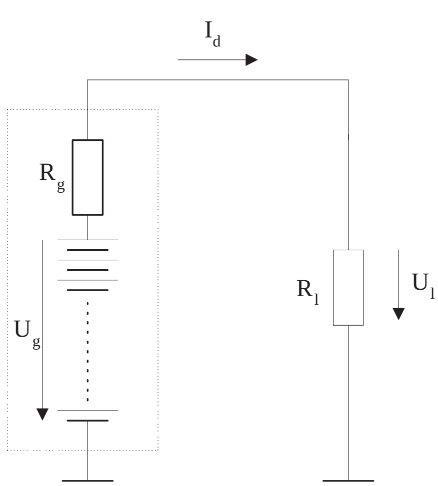

Fig. 1. Usual battery based power-supply model.

During the operation, I_d discharge current flows according equation 1;

$$I = \frac{U_g}{R_g + R_l} e^{-\frac{t}{C_b(R_g+R_l)}}; \tag{1}$$

where C_b is capacity of battery. If we put on that voltage (U_b), and current (I_b) of capacitor are constant, can be calculated value of stored energy with equation 2;

$$E = U_b \cdot I_b \cdot t. \tag{2}$$

As we know the greatness in a capacitor stored energy is in equation 3

$$E = \frac{1}{2} C_b U_b^2. \tag{3}$$

For example if a battery has 1,5V source voltage, and 2000mAh capacity, by equation 2 can calculate stored energy, it is 10800J. Wit equation 3 from result of equation 2 is calculable capacity of battery, it is in example; 9,6kF.

Thus, on the basis of the model of Figure (1) is an approximate function of time can define to the battery voltage changes at continuous discharge
(equation 4).

$$U_l = U_g \cdot e^{-\frac{t}{C_b(R_g+R_l)}}. \tag{4}$$

In the figure (2) is shown as a function of battery voltage in time at discharge [14] .

The equations that are used previously (equations 2 and 3), have a significant approximations. If you are an approximation

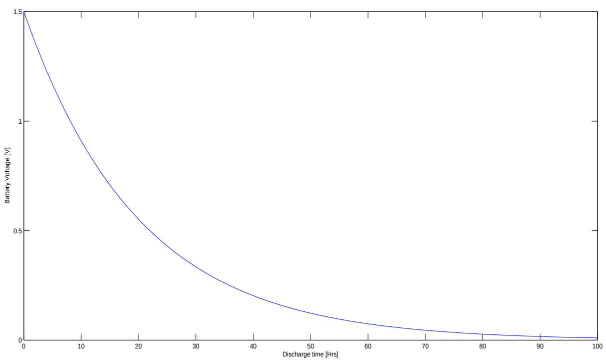

Fig. 2. The change voltage of the battery at discharge in idealized state.

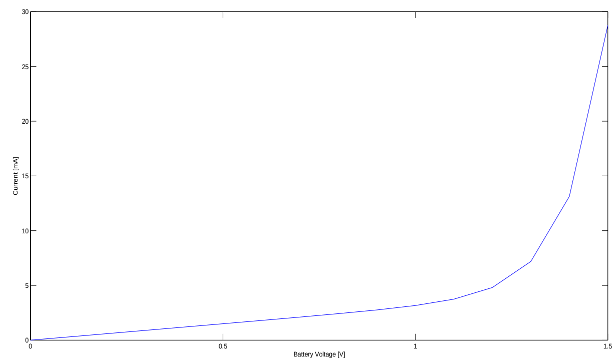

Fig. 4. supply voltage and supply current characteristics of a MP3 player electronic equipment in standby mode.

of the physical, electronically content to be carried out, it would be the correct way to write these (5, 6).

$$E = \int_0^T \big(U(t) \cdot I\big) dt. \tag{5}$$

$$E = \frac{1}{2} C_b \int_0^T \big(U(t)^2\big) dt. \tag{6}$$

Together with the previous approaches can be applied, in terms of further examinations.

II. Really model of electronic devices

On Fig. 3 is seen really power relation model of semiconductor based electronic devices [20]. In the figure U_g and R_g are voltage and inner resistance of battery, U_l and R_l equivalent parameters of electronic device.

A typical semiconductor-based electronic devices can operate in the event of a battery voltage is greater than a semiconductor specific threshold voltage (U_s). Its value depends on the type of semiconductor (manufacturing technology of silicon structures, Shottky or not, BJT or FET…etc.) and the circuit environment [16].

Thus, the electronic equipment from power-supply side is viewed it were an internal voltage generator ($U_s = I_s R_{ll}$). It follows that the equipment voltage-current characteristic is nonlinear [15].

Fig. 4 shows a supply voltage and supply current characteristics of a semiconductor-based really electronic equipment [18]. It can be observed that below the threshold voltage the internal resistance is greater (R_{ll}) as above (R_{ll}).

According in equation 4 described voltage-time function now is definable in equation 7;

$$U_l = (U_g - U_s) \cdot e^{-\frac{t}{C_b(R_g+R_l)}} + U_s, \tag{7}$$

and is seen on Fig. 5.

This also means that at normal application the battery is only to the threshold voltage can discharge [9]. Thus, using the former approach greatness of remaining energy in the battery is (equation 8);

$$E = \frac{1}{2} C_b U_s^2. \tag{8}$$

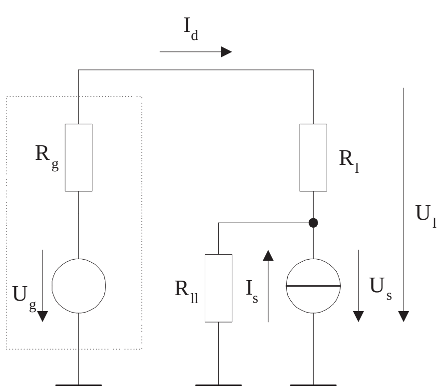

Fig. 3. Really power relation model of semiconductor based electronic devices.

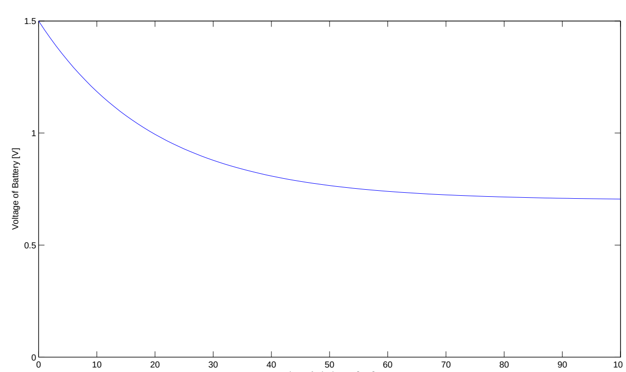

Fig. 5. The discharge characteristic of a battery in case of a semiconductor-based device.

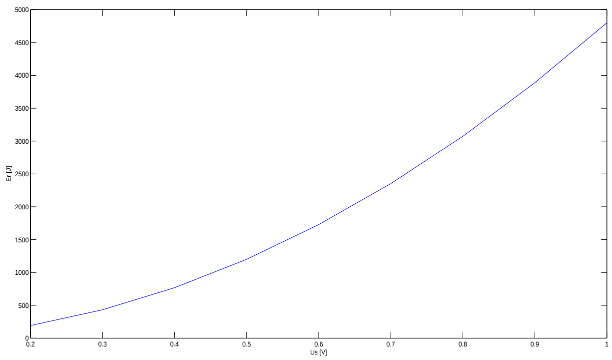

Fig. 6. Remaining energy in function of discharge voltage case at 200mAh battery.

In our previous example, if the $U_s = 0,5V$, and battery capacity is 9,6kF, the rested energy (E_r) is approximately 1200J, and if $U_s = 0,8V$ than $E_r = 3000$J. It is hardly plausibility but this is highly wasteful, inefficient solution, with large environmental component.[13] [17]

Fig. 6 shows a function of remaining energy of battery (E_r) and discharge voltage (U_s).

III. Proposed Solution

The appropriate solution is a switching-mode power supply (SMPS) that can operate at very low voltages and on output can produce the desired voltage value, together with own power voltage [5].

The proposed arrangement is shown on Fig. 7. The power supply operates by I_d current of battery and its output produces a stabilized voltage [1]. Because the power supply is also consists semiconductors, so it has its minimum operating voltage (U_{ss}). If manage to achieve that (9);

$$U_{ss} << U_s, \tag{9}$$

so from battery obtained energy is larger.

The structure of the proposed power supply is shown on Fig. 8. Battery (U_s, R_s) connect to input of SMPS, and on output is

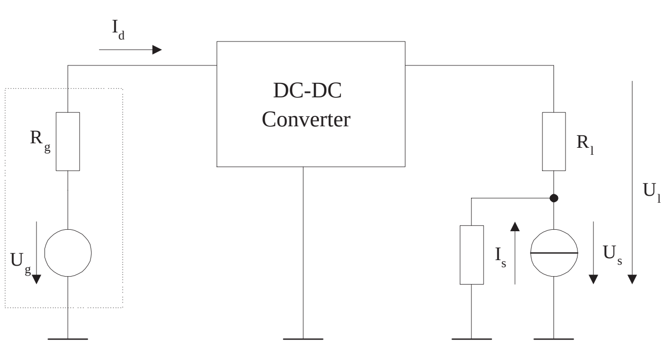

Fig. 7. Proposed arrangement to extracting more energy from battery.

a load (R_l). The power supply unit boost type, therefore, the output voltage may be higher than the input voltage [12].

The pulse width modulation (PWM) unit gets feedback signal from the output, which is also the operating voltage as well [4]. If the PWM control unit opens the FET (T_s), the coil (L_b) builds a magnetic field [2]. If the FET is closed the energy of coil trough a diode (D_s) gets to the load [19]. If the output voltage is too high, the PWM's pulse width decreases, while otherwise grow [3]. C_f a filter capacitor for suppress the high frequency component in DC voltage at output.[6] [7] [8]

So that the a switching-mode power supply unit able work case of low input voltage we must use appropriate semiconductors in position T_s, D_s. Nowadays choice of the appropriate components, this value can be down to 200mV.

And now calculated with the 0,2V voltage at 9,6kF battery 200J is obtained. The results show significant improvement. It is important to note that the power supply's operation need energy, but we are sure that the balance is still high.The robustness of this solution is operating with a lower supply voltage range. [10] [11]

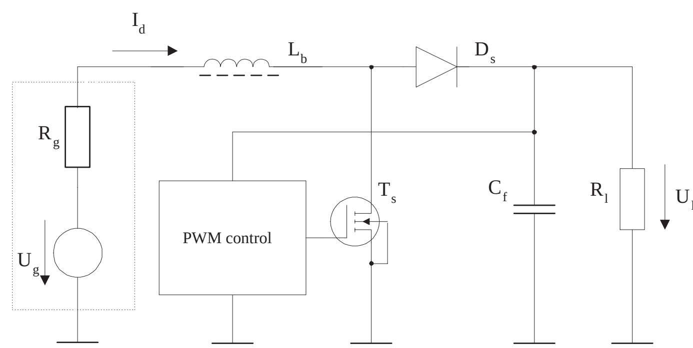

Fig. 8. Structure of boost type switching-mode power supply, with battery and load.

IV. Conclusions

The price of the devices, because need an additional power supply, is increased, but at expensive devices just a few percent [4].

At proposed method is an important aspect of above discussed discharge voltage levels, power demand of device, how often should replaced batteries.

Further work is needed to elaborating a proposed switching-mode power supply unit [2].

In the future, we will deal with the possibility of a greater operating range, thus increasing the robustness of the method.

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