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# Basic requirements for DC converters for system monitoring and control of batteries

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**ABSTRACT**: Magnetic modulation studies for DC converters for monitoring and control systems and operation of batteries.

**KEYWORDS:** Operating modes of the battery, autonomous power sources, pulse-width regulator, overcharge, control circuit, linear characteristic.

## I.INTRODUCTION

The requirement for DC converters (DCC) for Autonomous power supplies (APS) is determined based on the specific modes of operation of the APS. Consider the features of the APS with charging buffer battery (AB).

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## II.ENERGY EFFICIENCY

Currently, there is a problem of increasing the energy efficiency of APS containing a primary source (PS) and buffer AB. In many facilities, a solar battery (SB) is used as a PS. One of the ways to improve the energy efficiency of such APS is to maximize the use of SB energy. At the same time, consumers are powered by SB, and the fully charged AB is maintained within the limits necessary to compensate for its self-discharge, which is hundredths of the rated current.

The basic scheme of APS is shown in picture.1.1. It consists of a PS control scheme (CS), a pulse width Adjuster (PWA) and DCC chains in the AB. As PS is used here CB. You can distinguish the following three modes of operation of such APS:

-the first is the discharge mode of AB, which takes place at $U_p < U_{АБ}$, (where $U_p$- voltage at the output of the PWA; $U_{АБ}$- voltage at the terminals of AB) which basically corresponds to the unlit state of the SB and the load is powered by AB;

-the second is the AB charge mode from the SB, in which the control circuit must provide such a control signal that the voltage $U_p$ at the output of the PWA regulator has its maximum upper limit (for the load) value. In this case, the energy of the SB is spent on the charge of the AB and on the power of the load. CS controls the voltage on the AB, the value of which can be judged on the degree of charging the AB. When providing a set value of the voltage on the AB corresponding to its full charge, and the IP on the signals of the CS goes into the third mode;

-the third - charging buffer AB is the longest-running and responsible for the work of APS, as here, the threat of a possible overcharging of the battery is invalid under the terms of the rules of operation. This mode starts with a full charge of battery and ends with the termination of the illumination SB. Thus the output voltage $U_p$ shire is maintained at a level below the charging current AB amounted to a few hundredths of the rated current value AB, which is technologically necessary to compensate for self-discharge of AB. In this mode, low-current charging AB can be unlimited time, and this mode ensures the preservation of the resource AB.

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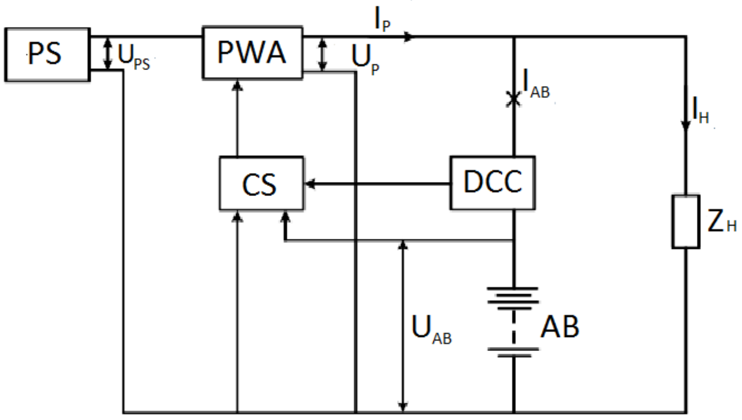


Picture.1.1 The typical pattern of APS with the charging buffer AB.

Ensuring the stability of the charging current by adjusting the value of $U_p$ does not significantly affect the values of the voltage and load current, since the change of $U_p$ from its basic value for the stability of the charging current is insignificant. Conversion and control of the current $I_{AB}$, including its charging values, must be carried out by a device that meets certain requirements. Only then will the described system be effective

Most often, sealed cadmium-Nickel batteries are used in such AIP. For such batteries, the charging current AB should not exceed 0.01 of the nominal. Otherwise, the battery may be overcharged, the voltage on it will rise and the AB will fail.

In this AIP the current AB mode charging is maintained within $I_{\text{АБ}} = I_{\text{п}} \pm \Delta I$ ,where $I_{\text{п}}$- current charging AB; $I_{\text{п}} < 0{,}01 I_{\text{ном}} I_{\text{ном}}$- - rated current AB; ΔI - the limits of the current regulation of recharging.

The value of ΔI depends on the error of the entire control process, which includes the DCC, control circuit and regulator. It is usually a few tenths of an ampere.

If the current AB will be less than $I_{\text{п}} - \Delta I$, then there will be a slow discharge of the battery, which is undesirable. At a current greater than $I_{\text{п}} + \Delta I$ the AB can recharge and fail. Therefore, to maintain the current AB within $I_{\text{п}} \pm \Delta I$ it is necessary that in this range of currents the output voltage of the DCC as the setter of the law of regulation is proportional to the value of the current $I_{AB}$, and its sign indicates the direction of this current.

However, when switching high-power loads, the current AB for some time required for regulation, can take quite large values close to the nominal (up to several hundred amps). And the direction of this current can be different depending on whether the load is connected or disconnected. Therefore, in the rest of the current range, the output signal of the DCC should carry information about the direction of the current in the controlled circuit.

## III.RESULTS AND DISCUSSIONS

Thus, the static characteristic of the DCC for APS with charging buffer AB should have a proportional dependence $U_{\text{вых}} = f(I_{AB})$in the section $I_{\text{п}} - \Delta I < I_{AB} < I_{\text{п}} + \Delta I$ and a two-way restriction in the rest of the operating range of currents.

A high linearity of the static characteristic is required to ensure more accurate regulation of the AB current in the $I_{\text{п}} - \Delta I < I_{AB} < I_{\text{п}} + \Delta I$ section. For picture.1.2 the required static characteristic of the PPT is shown.

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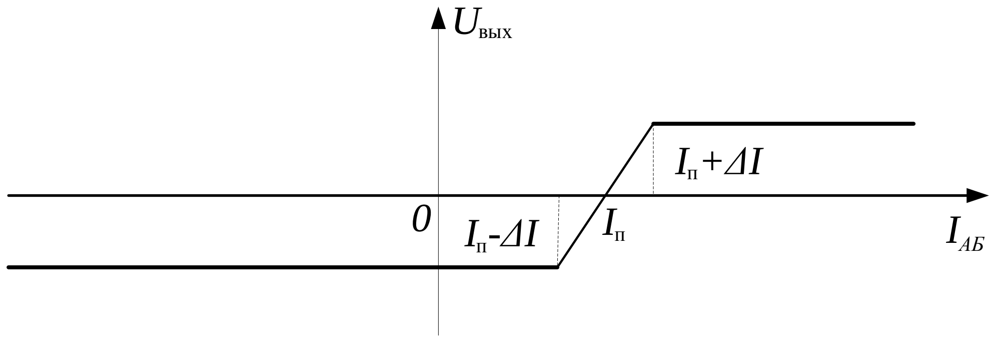



Picture.1.2. Required static characteristic of DCC.

The need to measure small currents (on the order of tens of milliamps) requires a high differential sensitivity of the DCC. Let us determine the approximate value of the differential sensitivity, which should have a DCC for APS with charging AB.

In most cases, the signal from the output of the primary Converter to the DCC is amplified by operational amplifiers (OY), which are inherent in the zero drift and the corresponding error voltage at the output. For the diagram shown in Picture.1.3, the error voltage, according to, will be equal to:

$$\Delta U_a = \Delta i_0 R2\left(1+\frac{R_N}{R_g+R1}\right)+\Delta U_0\left[\left(1+\frac{R_N}{R_g+R1}\right)\left(1+\frac{R2}{R_\alpha}\right)+\frac{R_N}{R_\alpha}\right]$$

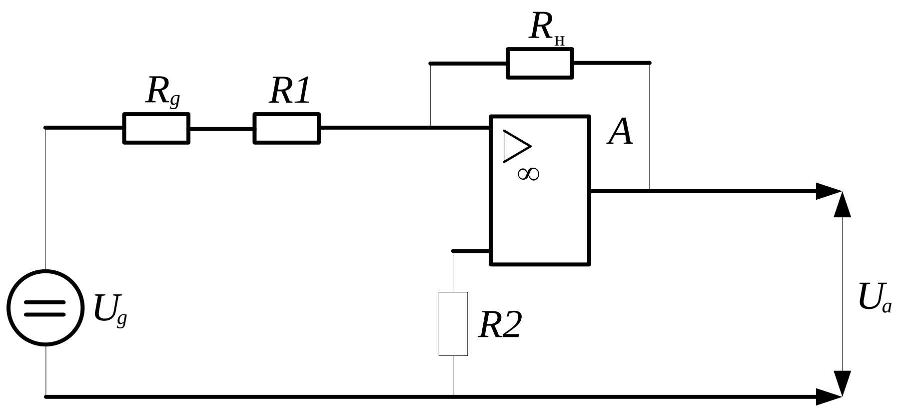
There are; $\Delta i_0$- the difference of the input currents of OY; $R_\alpha$- input differential resistance OY; $\Delta U_0$- the absolute value of the temperature drift of offset voltage OY;

The relative error δ of the output voltage is determined by the expression:

$$\delta = \frac{\Delta U_a}{VU_g}$$

There are $V=\frac{R_N}{R_g+R1}$; $VU_g$ input voltage. From (1.2) is the minimum voltage at the input CS for a given allowable error: $U_{gmin} = \frac{\Delta U_a}{\delta V}$

In our case, the voltage $U_g$ is the output voltage DCC $U_{вых}$,, amplified OY. Hence, the required differential sensitivity of DCC are defined as: $K_T=\frac{dU_{вых}}{dI_x}\approx\frac{U_{gmin}}{\Delta I_x}=\frac{\Delta U_a}{\delta V\,\Delta I_x}$, where $\Delta I_x$- the increment of current in the controlled circuit.




Picture.1.3. Circuit switching OY to determine the voltage error.

The accuracy of maintaining the charging current of the AB in the APS should be such that the minimum charging current compensates for the self-charging of the AB during the entire service life, and the maximum does not exceed the value at which the AB is recharged. Minimum charging current required to compensate for Samothrace AB equal to $I_п-\Delta I$, and the maximum permissible current, in which AB is not recharged for a long time equal $I_{\text{п}} + \Delta I$. This current range is determined by the parameters AB, time-varying (increasing the self-discharge during aging), as well as under the influence of external factors – humidity, temperature, pressure.

The value ΔI is the permissible error of the entire control path. Studies show that it should normally be 0.002-0.005 of the rated current of the AB. The PT error is included in the total error of the control path, so it can be roughly said that the permissible absolute error of the PT when measuring the charging current of the AB should not exceed 0.002 of the nominal current of the AB.

Since the reliability Of the APS SB and buffer AB are quite stringent requirements, the reliability of its elements, which include the DCC, should be high. In addition, since the DCC is a measuring device, it is necessary to ensure low energy consumption on the power supply circuits and on the input.

An important requirement for APS is to ensure a minimum weight and dimensions of the DCC.

## IV. CONCLUSION

Thus, generalizing it can be said that the PT, controlling the charging currents of the AB in the APS, the following requirements are imposed:

- sensitivity to the direction of current in the controlled circuit;
- high differential sensitivity;
- high measurement accuracy;
- high linearity of static characteristics in the current range $I_{\text{п}} \pm \Delta I$
- maintain the conversion ability in the area of high currents;
- high reliability;
- low power consumption;
- small weight and dimensions.

Thus, ppts used in the systems of control and regulation of the charging current of the buffer AB in the APS must meet the above requirements.

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