

REGULATOR FOR REGULATING DIRECT CURRENT FLOWING IN A LOAD POWER SUPPLY CIRCUIT

5 The proposed engineering solution relates to the field of electrical engineering and can be used in load DC regulators that have minor watt consumption.

 Similar technical solutions are known, see for example published on the Internet at:.
Http://radiobooka.ru/radionach/163- regulatory-napryazheniya-i-toka.html information on the DC controller flowing in the load circuit power, which includes:

- 10 - setpoint value of the output current flowing in the load supply circuit configured as a DC voltage source (1 ... 2B) and a variable resistor which is connected at its one terminal to the positive terminal of the DC voltage source;
- DC converter to DC attached to its first (control) input to the output setpoint value of the output current flowing in the load circuit power, and configured in the form of a transistor whose emitter is the first (control) input of the inverter DC voltage into a direct current, the collector It
- 15 is the output of the inverter DC voltage into a direct current, and the base is the second input of the inverter DC voltage into a direct current;
- a source of DC input voltage, its positive terminal connected to the second input of the inverter DC voltage into a direct current and to an input of the setpoint value of the output current flowing in the load circuit supply;
- 20 - a load is connected at its one terminal to the output of the inverter DC voltage into a direct current, and its other terminal to the negative terminal of input DC voltage source.

 Common features of the proposed technical solution and the above technical solutions are characterized:

- 25 - setpoint value of the output current flowing in the load circuit supply;
- DC converter to DC which is connected to its first (control) input to the output setpoint value of the output current flowing in the load circuit;
- the load is connected with one terminal to the output of its inverter DC voltage into a direct current;
- input DC voltage source which is connected at its one terminal to the other terminal of the load,
- 30 and at its other terminal to the second input of the inverter DC voltage into a direct current.

 It is also known a similar solution, see

"Solid-state circuitry," the authors W. Tietze and Schenk X, pp. 174, Moscow "Mir", 1982. Fig. 12.1 1 a), which describes a DC regulator flowing into a load circuit power, that is selected as the closest analogue - prototype and which comprises:

- a setpoint value of the output current flowing in the load circuit power, configured as a source of variable direct voltage;
- DC converter to DC made as a transistor, the collector of which is the output of the inverter DC voltage to the DC current of the operational amplifier, the noninverting input of which is the first input of the inverter DC voltage into a direct current, the inverting input of the operational amplifier is connected to the emitter of the transistor, and the output of the operational amplifier is connected to the base of the transistor, and measuring resistor having one end connected to the emitter of transistor, and the second terminal is a second input inverter DC voltage into a direct current;
- the load is connected at one output to the output of the inverter DC to DC;
- a source of DC input voltage, its positive terminal connected to the other terminal of the load and its negative terminal to the second input of the inverter DC voltage into a direct current;

Common technical features of the solution proposed for patenting, and the technical solutions of the prototype are:

- setpoint value of the output current flowing in the load circuit supply;
- inverter DC voltage into a direct current connected to its first (control) input to the output setpoint value of the output current flowing in the load circuit supply;
- the load is connected at one output to the output of the inverter DC to DC;
- a source of DC input voltage, its positive terminal connected to the other terminal of the load and its negative terminal to the second input of the inverter DC voltage into a direct current.

The technical result that can not be achieved by any of the above-characterized analogous technical solutions is to reduce the consumed electric energy of the power in the regulation of DC current flowing in the load circuit, reason for impossibility of achieving the above technical result is that in the known similar technical solutions constant current, flowing in the load circuit power supply not only provides the feedback signal with the output of the measuring resistor on the inverting input of the operational amplifier, but the supply and the inverting input of the operational amplifier DC offset voltage, which for conventional operational amplifiers are generally quite large, and this leads to significant power consumption of electricity consumed.

Given the characteristics and analysis of known similar technical solutions, it can be concluded that the task of creating a regulator DC current flowing in the load circuit power, with little power consumption of electricity is relevant today.

5 The technical result mentioned above is achieved in that in the regulator DC current flowing in the load circuit supply containing setpoint value of the output current flowing in the load circuit of the power converter the DC voltage into a direct current which is connected to its first (control) input to the output setpoint value of the output current flowing in the load circuit power, a load connected at its one terminal to the output of the inverter DC voltage to the DC current source constantly input a voltage which is connected to its positive terminal to the other
10 terminal of load, wherein the DC converter to DC made as a transistor, the collector of which is the output DC voltage converter to the DC current measuring resistor which is connected at its one terminal to the emitter of the transistor and its other terminal to the second input of the converter DC voltage to DC feedback node which is connected to the emitter of its input transistor, and the operational amplifier which is connected at its inverting input to the output
15 feedback node (made, for example, as a fixed resistor) and to a first terminal of a reference resistor that is connected to its second terminal to the positive terminal of reference voltage source and its output to the base of the transistor, wherein non-inverting input of the operational amplifier is the first (control) input of the inverter DC voltage to the DC current source and the negative terminal is connected to the constant reference voltage setpoint input converter DC voltage
20 to DC.

Running inverter DC voltage into direct current and connection as described above allows, when the input voltage across the load on the inverter DC voltage into a direct current, to convert the input DC voltage, eventually, a steady direct current, which depends on the output value voltage setpoint value of the output current flowing in the load supply circuit

25 When the output current flowing through the measuring resistor inverter DC voltage into a direct current at the measuring resistor voltage drop occurs, which is a feedback signal through the feedback unit is supplied to the inverting input of the operational amplifier inverter DC voltage into a direct current. Simultaneously to this same inverting input of the operational amplifier with a DC voltage converter reference voltage in the constant current through the reference
30 resistor is supplied a bias voltage that ensures the working mode of the operational amplifier. Said bias voltage is practically independent of the magnitude of the output current measuring

resistor either from the nominal. Under the influence of the feedback signal output from the feedback node to the inverting input of the operational amplifier, the output current is stabilized, and the stable value of output current determined by the voltage arriving at the non-inverting input of the operational amplifier from the output of the setpoint value of the output current
 5 flowing in the load circuit supply.

Thus, in the proposed technical solution, unlike the prior art, the formation of the bias voltage at the inverting input of the operational amplifier, which provides the operating mode of the operational amplifier is not connected to form a feedback signal that stabilizes the magnitude of the output current at a predetermined level, which allows to select reasonably small

10 denomination measuring resistor, and thereby substantially reduce power consumption of electricity of the proposed regulator DC flowing in the load circuit.

This is confirmed by simple calculations.

Let U required bias voltage at the inverting input, see the operational amplifier, which provides the operating mode of the operational amplifier $U_{bias} = 2.0$ V.

15 Let it be required to stabilize the three values of the output current controller DC current flowing in the load circuit supply: $I_{out} = 0.1$ A; 1.0A; 10.0A.

In the case of the prototype to generate the bias voltage of 2.0 V at a current of 0.1 A is required to select a measuring resistor $R = U_{rev} / I_{vyh} = 2.0 / 0.1 = 20$ ohm.

Power prototype electric power consumption at a current of 0.1 A:

20 $P_{np} = I_{вых}^2 \times R_{изм} = 0,1^2 \times 20 = 0,2$ Вт. $P_{ave} = I_{vyh}^2 \times R_{MOD} = 0,1^2 \times 20 = 0.2$ watts.

At a current of 1 A 0 in the prior art is required to choose measuring resistor

$R_{meas} = U_{bias} / I_{outp} = 2.0 / 1.0 = 2.0$ ohms.

A Power consumption of electric energy with a current of 1 A 0 составляет $P_{np} = I_{вых}^2 \times R_{изм} = 1,0^2 \times 2,0 = 2,0$ Вт. is $I_{vyh}^2 \times R_{MOD} = 1.0 \times 2.0 = 2.0$ watts.

25 At a current of 10.0 A is required in the prior art to choose measuring resistor with the nominal value of the resistor

$R_{meas} = U_{bias} / I_{outp} = 2.0 / 10.0 = 0.2$ ohms.

A Power consumption of electric energy with a current of 10.0 A is $P_{np} = I_{вых}^2 \times R_{изм} = 10,0^2 \times 0,2 = 20$ Вт. $P_{ave} = I_{vyh}^2 \times R_{MOD} = 10,0^2 \times 0.2 = 20$ watts.

30 The proposed technical solution nominal measuring resistor can be chosen arbitrarily small, e.g., 0.1 Ohm, regardless of the required bias voltage.

Then, at a current of 0.1 A power consumption of electrical energy in the measuring resistor in the proposed technical solution is: $P_{\text{тр}} = I_{\text{вых}}^2 \times R_{\text{изм}} = 0,1^2 \times 0,1 = 0,001 \text{ Вт.}$ $P_{\text{тр}} = I_{\text{вых}}^2 \times R_{\text{MOD}} = 0,1^2 \times 0,1 = 0,001 \text{ watts.}$

At a current 1.0 A power consumption of electrical energy in the measuring resistor is:

5 $P_{\text{тр}} = I_{\text{вых}}^2 \times R_{\text{изм}} = 1,0^2 \times 0,1 = 0,1 \text{ Вт.}$ $P_{\text{тр}} = I_{\text{вых}}^2 \times R_{\text{MOD}} = 1,0^2 \times 0,1 = 0,1 \text{ watts.}$

At a current of 10.0 A power consumption of electrical energy in the measuring resistor is: $P_{\text{xp}} = I_{\text{вых}}^2 \times R_{\text{изм}} = 10,0^2 \times 0,1 = 10 \text{ Вт.}$ $R_{\text{xp}} = I_{\text{вых}}^2 \times R_{\text{MOD}} = 10,0^2 \times 0,1 = 10 \text{ watts.}$

We shall consider that the proposed technical solution, more power is dissipated in the feedback node and a reference voltage source.

- 10 Assume that the feedback unit is designed as a resistor $R_{\text{yoc}} - 3,9 \text{ Ком}$ that in practical terms the implementation ensures reliable operation of the apparatus constructed in accordance with the proposed technical solution.

Then the power consumption in the feedback node will be $P_{\text{yoc}} = U_{\text{cm}}^2 / R_{\text{yoc}} = 0,4^2 : 3900 = 0,00004 \text{ Вт.}$ $P_{\text{ONU}} = U_{\text{cm}}^2 / R_{\text{yc}} = 0,4^2 : 3900 = 0,00004 \text{ watts.}$ Power consumption of the

- 15 reference voltage source in the proposed technical solution has approximately the same value.

Add the amount of power to the previously calculated and we reduce the calculation results in a comparison table:

Table Aggregated results of calculations

№	Output current of the direct current regulator, A	Consumed power in the prototype, Вт.,	Consumed power in the proposed design, Вт.	Consumed power gain, times
1	0.1	0.2	0.00108	~ 200
2	1.0	2.0	0.10008	~ 20
3	10.0	20	10.00008	~ 2

- 20 The table shows that the gain of the power consumption in this example may be tens or hundreds of times. Those skilled clear that U_{bias} voltage see the inverting input of the operational amplifier providing its operating mode, depending on the type of operational amplifier, and may be equal to 0,4V and 1.0V, and 4,0V and more; DC output current regulator may be units of

milliamperes, and tens of amperes. In all these particular cases, the correct selection of the measuring resistor, feedback node, and voltage reference in the proposed technical solution allows to reduce the energy consumption of electric power in comparison with the prototype in the tens or even hundreds of times.

5 What is and is shown to achieve the above technical result.

Proposed regulator DC current flowing in the load circuit power, is explained by the following description and the drawing, which shows a functional diagram of DC regulator flowing into a load circuit power, which comprises:

- dial - 1 of the constant current flowing in the load circuit power, configured as a source - 2 DC
- 10 voltage and variable resistor - 3 which is connected to its first terminal - 4 to the positive terminal - 5 source - 2 DC voltage, and its other terminal - 6 to the negative terminal - source 7 - 2 DC voltage;
- DC converter - 8 into direct current formed as a transistor - 9, the measuring resistor - 10 which is connected at its one terminal - 11 to the emitter - 12 transistor - 9, and the operational
- 15 amplifier - 13 which is connected to its inverting input - 14 to yield - assembly 15 - 16 and feedback to the first terminal - -18 17 a reference resistor which is connected to its second output - to a positive 19 vyvodu- source 20 - 21, the reference DC voltage,
- wherein the non-inverting input - 22 of the operational amplifier - 13 inverter DC to DC - 8 through the first (control) input - 23 inverter DC voltage - 8 into direct current is connected to the
- 20 third terminal - 24 variable resistor - 3, which is an output - 25 setpoint - 1 of the constant current flowing in the load circuit power output - of the operational amplifier 26 - 13 is connected to the base - transistor 27 - 9, and the negative terminal - source 28 - 21 is connected a constant voltage to the second terminal - 29; measuring resistor - 10 and a second input - the inverter 30 DC to DC - 8;
- 25 - load - 31, is connected at its one terminal - to the manifold 32 - transistor 33 - 9, which is a yield of - 34 inverter DC voltage into a direct current - 8;
- the source - 35 DC input voltage, its positive terminal connected - to the other terminal 36 - load 37 -
- 31, wherein the - terminal 38 source - 35 DC voltage a housing (common connection point of the
- 30 structural elements) of the proposed DC regulator flowing into a load circuit power - 31, and is connected to the other terminal - 29 measuring resistance - 10 constituting the inverter DC

voltage into a direct current - 8, through a second input - the inverter 30 DC to DC - 8 and also to the negative terminal of the source-7 - 2 DC voltage setpoint - 1 Majestic s direct current flowing in the load circuit supply, through output set point -39 - 1 of the constant current flowing in the load circuit supply.

5 The proposed DC regulator flowing into a load supply circuit operates as follows.

From the output of - 25 Setpoint - 1 the output current flowing in the load circuit power - 31, on the first (control) input - 23 inverter DC to DC - 8 (the non-inverting input - 22 of the operational amplifier - 13) is fed required voltage providing a predetermined constant current flowing in the load circuit supply - 31.

10 Said voltage may be created, for example, by using a DC voltage source 2, the positive and negative -5-7 terminals of which is connected a variable resistor 3, a third output - to the output 24 of which - 25 Setpoint - 1 values of the output current flowing a load circuit power - 31, the required driving voltage is applied. *зада* With voltage stabilizer made of, for example, on the operating amplifier- 13, transistor 9, and node 16 communication- feedback stabilizes the voltage

15 on the measuring transducer resistor- 10 8-DC voltage into a direct current, whereby through the measuring resistor- 10 current will flow, which is independent from the audio output voltage converter 8-DC voltage into a direct current or the load 31, and its value will be determined by measuring denomination resistor- 10 and the reference value of the output voltage *tchika*-1 output current flowing in the load circuit supply. In this case, if the output voltage setpoint value

20 of the output 1 of the current flowing in the load supply circuit, connected to the non-inverting ("+") input 22 of the operational amplifier--8 converter 13 DC voltage to the DC current is greater than the voltage at the inverting ("-") input of operational amplifier 14, 13 connected to the transistor 12 emitter- 9 and 10 to the measuring transducer resistor- 8-DC voltage into a direct current through the feedback communication- node 16, the output 26 of the operational

25 amplifier- 13, which is connected to the base of transistor-27 -9 be a voltage at which the transistor -9 opened and the voltage at the measuring resistor- 10 will grow as long as the voltage at the inverting input 14, an operational amplifier 13 becomes equal in magnitude to the output voltage setpoint -1 output current flowing in the load circuit supply. At this point, the output voltage of the operational amplifier 13 will cease to increase, the voltage across transistor 12

30 emitter--9 also cease to grow and be a value at which the voltage at connection point 12 emitter-transistor 9 and the measuring resistor- 10 will be equal to the voltage at the non-inverting ("+")

input 22 of the operational amplifier -13 (taking into account the voltage drop at the feedback node communication- 16, and the voltage at the first reference resistor input- 17 18 a connected to its second terminal 19 to the positive terminal 20 of the reference source on conjugation-21), and this state will be maintained when the load 31 is changed. Consequently, when changing the load 31 in load 31 to flow a constant current constant, whose magnitude is determined by the value of the output voltage setpoint value of the output 1 of the current flowing in the load circuit power and nominal value of the measuring resistor- 10.

In this operating mode the operating amplifier- 13 defined by the bias voltage, coming from the reference resistor- 18 through 20 output source of the reference voltage 21 to the input 14 of the operational inverting- amplifier- 13, whereby the denomination of the measuring resistor- 10 may be chosen sufficiently small, regardless of the magnitude required bias voltage, so that power dissipation in the resistor becomes also small enough.

Thus, the proposed regulator DC current flowing in the load supply circuit, due to separate formation of the bias voltage on input 14 of the operational invertiruyuschem- usilitelya- 13 and the feedback signal input to the same input through a feedback communication- node 16, it becomes possible to sharply reduce the power consumption of electrical energy.

It should be noted that the proposed solution can be implemented in many different ways. For example, transistor-9 can not only be bipolar, but also the MOS transistor, and BTIZ- transistor, and in general any linear control element.

The output voltage setpoint-1 output current flowing in the load circuit power, may also be created in other ways than those described, for example, by converting the pulse-width modulation control voltage; a code conversion control protocol (e.g., DALI) to the control voltage; or by any other control action in converting a control voltage.

For power setpoint-1 output current flowing in the load circuit power and provide a source 21 of reference voltage supply circuit common may be used; as a source of reference voltage and -21 rezistora- reference current generator 18 can be used, and so on.

All these methods implement ultimately proposed technical solutions allow to obtain the same technical results: reduce the power consumption of electrical energy due to separate formation of the bias voltage (at the inverting input of the operational amplifier) and a feedback signal (input to the same input via feedback node due to the measuring resistor).

Claim

1. Regulator DC current flowing in the load circuit supply comprising setpoint value of the output current flowing in the load circuit of the power converter the DC voltage into a direct current which is connected to its first input to the output of the setpoint value of the output current flowing in the load circuit power, a load connected one its output to the output of the inverter DC to DC current and DC voltage source which is connected to its positive terminal to the other terminal of the load, its negative terminal to the second input of the inverter DC voltage into a direct current, characterized in that the converter DC voltage to DC made as a transistor, the collector of which is the output DC voltage converter to the DC current measuring resistor which is connected at its one terminal to the emitter of transistor and at its other terminal to the second input of the converter DC voltage to DC feedback node which is connected to its input, the emitter of the transistor and the operational amplifier which is connected at its inverting input to the output of the feedback node and to the first terminal of the reference resistor that is connected to its second terminal to the positive terminal of reference voltage source and its output to the base of the transistor, and the non-inverting input of the operational amplifier is a first input inverter DC voltage to the DC current source and the negative terminal of a constant reference voltage is connected to the second input transducer constant voltage to DC.