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# Powerful controlled current and voltage generators

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**ABSTRACT:** The article explores the possibility of using a bipolar transistor as a powerful controlled current and voltage generator. An implementation of a controlled current and voltage generator based on a three-structure injection voltaic transistor is proposed. The results are obtained by simulating the operation of a bipolar transistor in the injection - voltaic mode using the Multisim 10.1 hardware - software environment.

**KEYWORDS:** controlled current generator, controlled voltage generator, injection-voltaic effect, three-structure injection-voltaic transistor, photovoltaic station.

## I. INTRODUCTION

The theoretical analysis of the photo-electric effect analogy in solar cells with the injection-voltaic effect in multilayer semiconductor p-n structures and the prospects for creating a high-current and low-voltage (supply voltage on the order of the contact potential difference) of the electronics element base are given in [1-4].

In semiconductor microelectronics, stable current generators are widely used, the task of which is to keep the output current constant with changes in load and input (supply) voltage. An ideal stable current generator should have a horizontal section on the volt-ampere characteristic (IVC), characterized by an infinitely large value of dynamic resistance. Stable current generators used in microelectronics have a small value of the generated current (up to 1 mA). Powerful controlled stable current generators based on bipolar transistors have not been developed. At the same time, a bipolar transistor operating in the injection-voltaic mode is already such a powerful controlled current generator. Based on such a generator, you can create electronic circuits that are stable with a significant increase in operating temperatures.

## II. CONTROLLED CURRENT GENERATOR

A bipolar transistor operating in the injection-voltaic mode can serve as a controlled transistor. In this case, the current generator can be controlled either by setting the emitter-base voltage of the $E_B$ (Fig. 1.1, a), or by the emitter currents $I_E$ (Fig. 1.1, b) or of the $I_B$ base (Fig. 1.1, c) of the bipolar transistor.

In fig. 1.1 shows the schemes for removing the current-voltage characteristics of the bipolar transistor in the injection-voltaic mode when controlling the voltage of the $E_B$ and the emitter currents $I_E$, $I_B$. In the diagrams, the characterograph (XIV) was used as the load. The load current-voltage characteristics for the bipolar transistor ZTX968 (pnp - structure) in injection-voltage mode are calculated on the basis of the proposed mathematical models of a controlled current generator, whose parameters are determined by the standard method for controlling the $E_B$ voltage (curves 1–4) 4 ') are shown in Fig. 2

On the horizontal part, the characteristic of a bipolar transistor has a high dynamic resistance. Therefore, it can be considered as a current generator for external circuits that have a lower internal resistance.

In fig. 3 shows the load current-voltage characteristics of the bipolar transistor in the injection-voltaic mode with base current $I_B$. at the same time, the voltage of the injection-volt EMF corresponds approximately to the voltages when controlling the $E_B$. In the idling mode, the value of the injection-voltage EMF decreases due to a decrease in the level of injection at a fixed base current (Fig. 3). For a bipolar transistor, when the base current is controlled in the short-circuit mode, the base-emitter voltage is higher (curve 1) than in the idle mode (curve 2).

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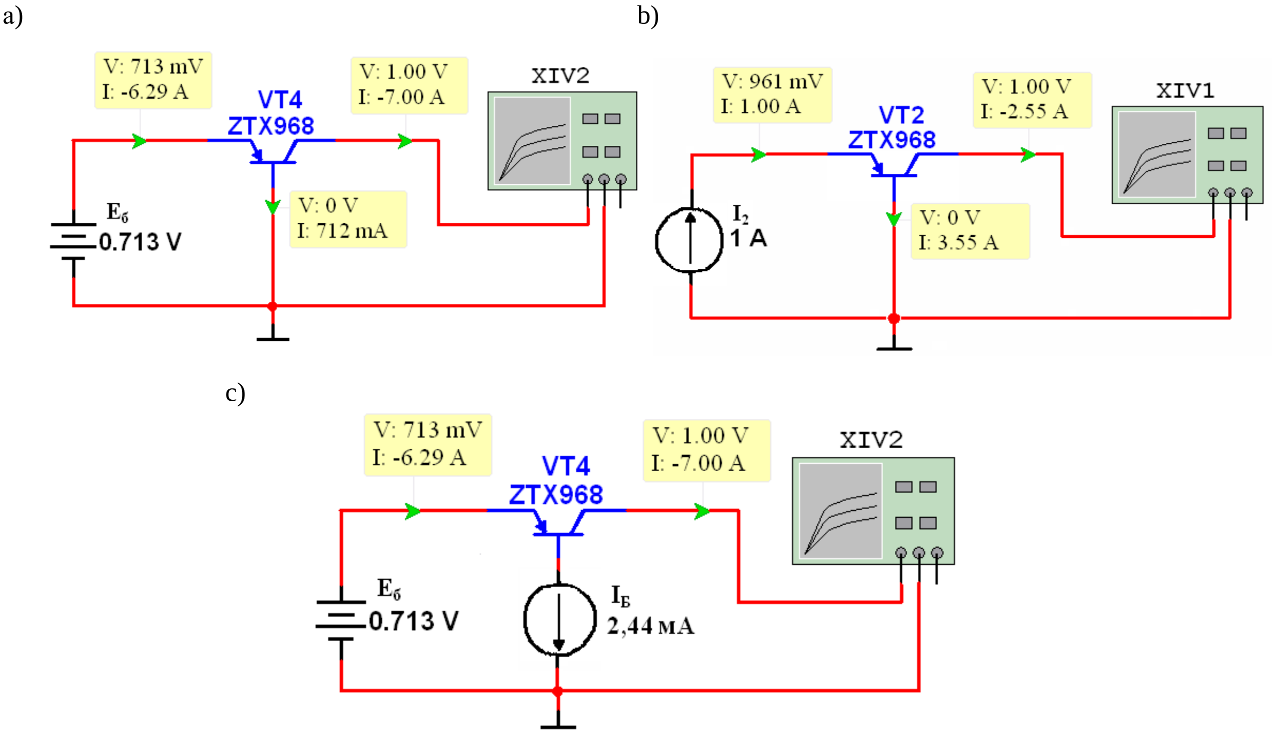


Fig.1. Schemes of a controlled current generator with control: voltage $E_B$ (a) and currents $I_E$ (b), $I_B$ (c).

Current and voltage controlled current generator circuits have high conversion efficiency.

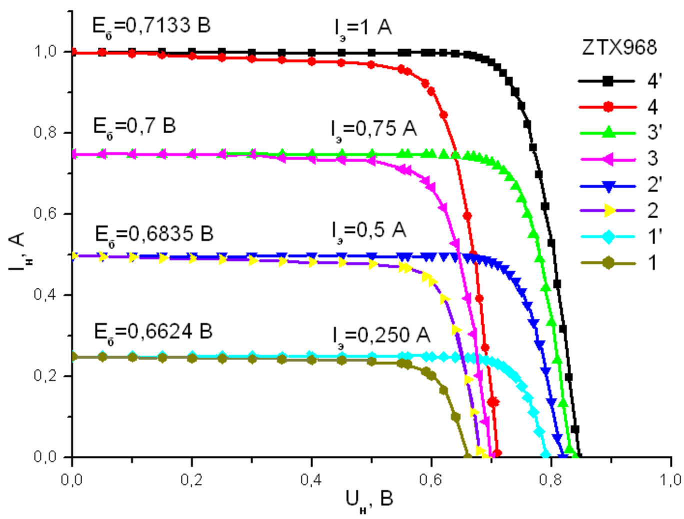


Fig.2. Load the current-voltage characteristicsof the p-n-p bipolar transistor ZTX968 in the injection-voltaic modewith control: voltage (1-4) and emitter current (1′-4 ′).

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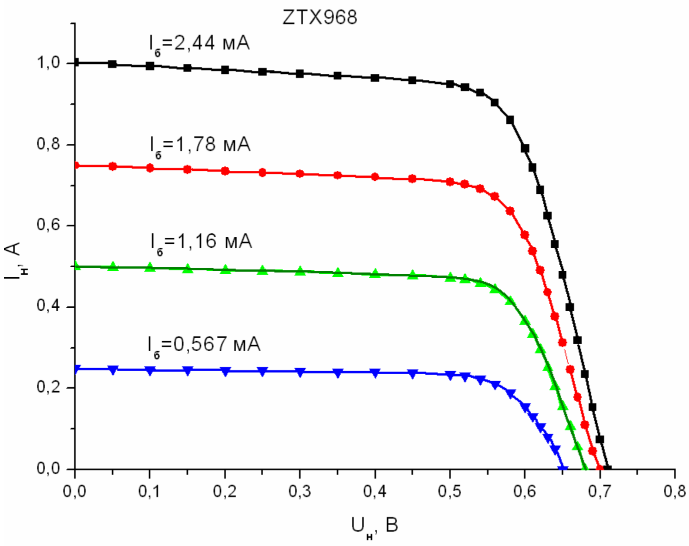
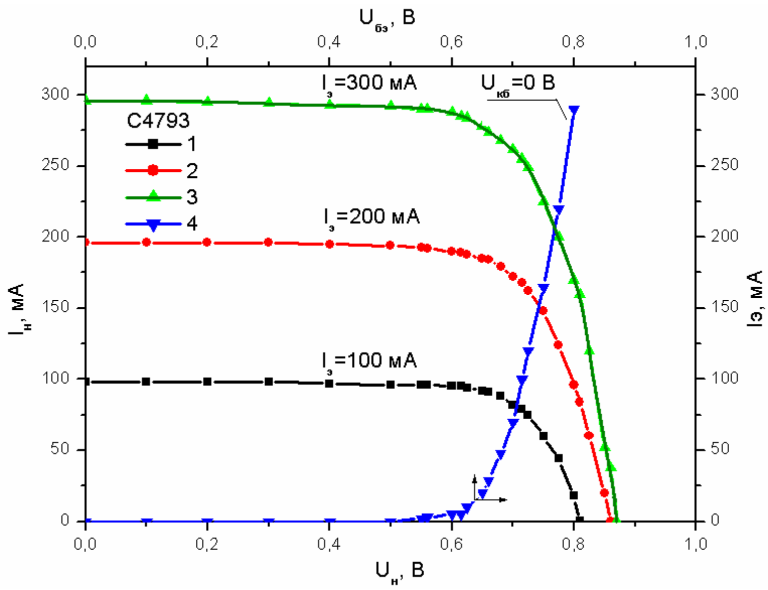



Fig.3. Load the current-voltage characteristics p-n-p bipolar transistor ZTX968 in injection-voltaic mode when controlling the base current.

In the considered circuits, a bipolar transistor controlled by voltage, emitter current or base current acts as a controlled current generator with a dynamic range of about 0.5-0.7 V (Fig. 2 and 3). To increase the conversion efficiency, a circuit with a fixed base current value (Fig. 1, c) should be used by sequentially switching on the $E_B$ and $I_E$ control circuits (Fig. 4). In this case, the base current is converted into the emitter current (the current is amplified), then the bipolar transistor repeats the current in the active mode as a voltage amplifier, which increases the dynamic range of the current generator from 0.5-0.7 V to $E_K$ = 20 V.

In fig. 4 shows the experimental load and input current-voltage characteristics of the bipolar S4793 and 2SC5200 transistors. They fully confirm the simulation results and show that in idle mode when controlling the emitter current, the concentrated ohmic resistance of the bipolar transistor $R_B$ leads to a voltage shift of the injection-voltage EMF by the magnitude of the voltage drop $I \cdot R_B$

a)



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б)

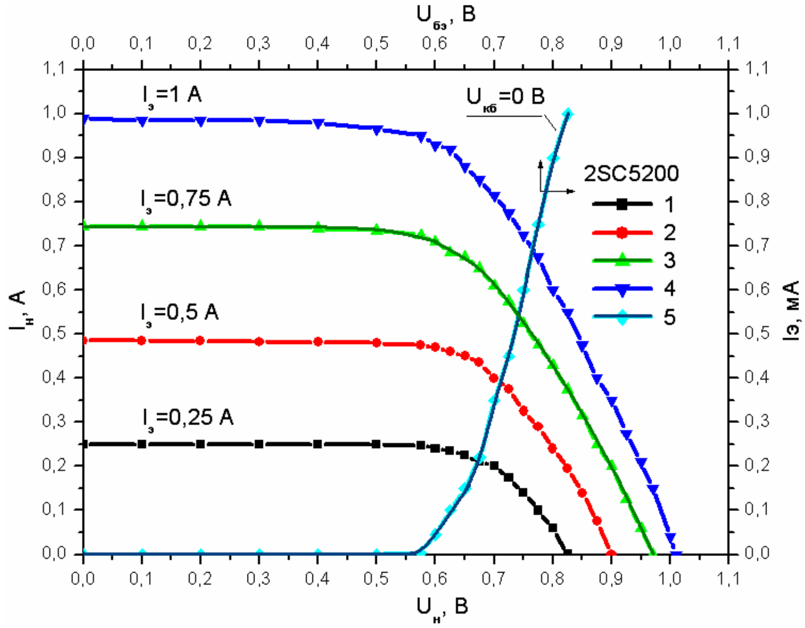


Fig.4. Load and input current-voltage characteristics of the bipolar transistor type C4793 (a) and SC5200 (b).

From fig. 4 it can be concluded that with direct series connection of cascades controlled by voltage $E_B$ and current $I_E$, the input characteristic (curve 5) goes beyond the horizontal portion of the current generator corresponding to the mode. It should be noted that in this case the current-controlled transistor is a non-linear load for a transistor controlled by a voltage $E_B$. In order for the current-controlled cascade to operate in the current-limiting mode, its input characteristic must be shifted to the lower voltage range of the voltage-controlled cascade, which can be done by on the offset voltage $E_{CM}$ bias voltage source between the bases of the cascades (or bipolar transistor in the diode switching on). When controlling the $E_B$ voltage, the current varies in the range from 0 to 1 A. When the load resistance value changes, the output voltage varies from 0 to 20 V. In the specified range of current and voltage changes, the dynamic resistance of the controlled voltage generator is almost infinite.

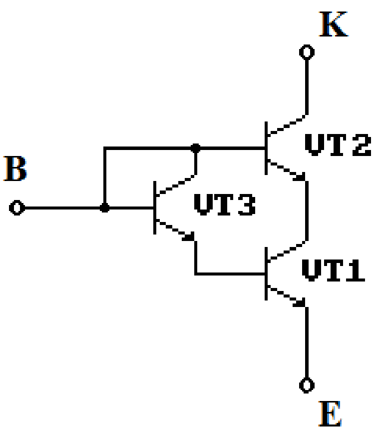


Fig.5. Scheme of a three-structure the injection-voltaic transistor.

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In fig. 5 shows a circuit of such a composite bipolar transistor, in which VT1 is in injection-volt mode. As a result, we get a three-structure injection-voltaic transistor [5].
In fig. 6 shows the input and output characteristics of the three-structure injection-voltaic transistor, made of three transistors ZTX968. In the switching scheme of a three-structure injection-voltaic transistor with a common emitter in active mode, the base-emitter voltage control increases the signal power, and when the collector-emitter voltage changes in the range from 1.5 V to 10 V, the collector current remains almost unchanged (Fig. 6, b).

a) b)

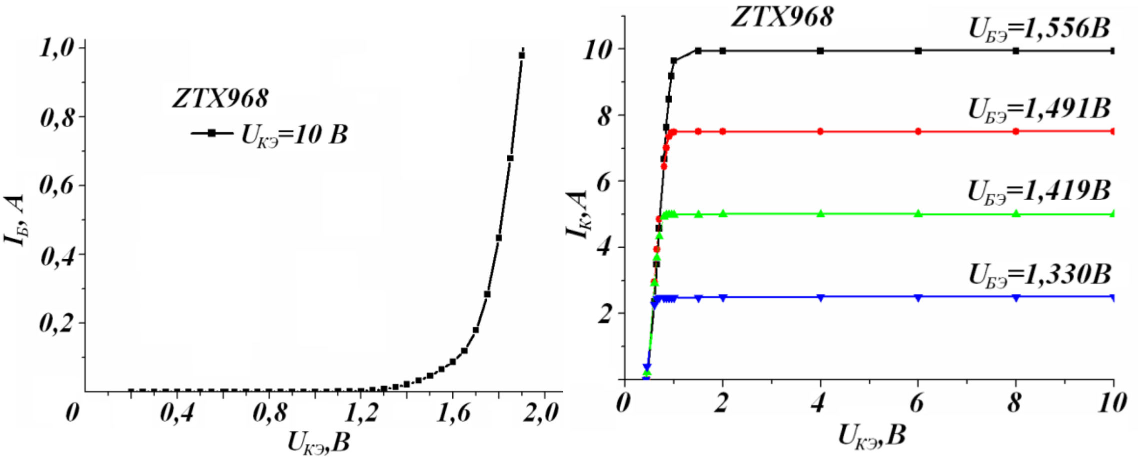


Fig.6. Input (a) and output (b) of the current-voltage characteristic of a three-structure injection-voltaic transistor.

To create an effective controlled current generator, it is actually necessary to implement a three-structure injection-voltaic transistor, which allows amplifying the signal, it does not have the Earle effect and thermal instability. Thus, of the three unstable bipolar transistors, the ideal composite bipolar transistor is created.

## III. CONTROLLED VOLTAGE GENERATOR

In semiconductor microelectronics, stable voltage generators are widely used, the task of which is to keep the output voltage constant at changes in the load value and the input (supply) voltage. An ideal stable voltage generator should have a vertical section on the current-voltage characteristic, characterized by an infinitely small value of dynamic resistance. Stable voltage generators used in microelectronics are low power. Powerful controlled stable voltage generators based on injection - voltaic bipolar transistors have not been developed. At the same time, the bipolar transistor in injection-voltage mode of operation is already a controlled voltage generator, on the basis of which it is possible to create semiconductor devices that are resistant to high operating temperatures and to power instability with high values of the output current.
The voltage generator based on the bipolar transistor can be controlled in the injection-voltaic mode for a given value of the $E_C$ voltage source (Fig. 7, a and b), with the maximum load current determined by setting the base current $I_B$ or the bias voltage of the base $E_B$ of the bipolar transistor.
The simulation of the bipolar transistor in the injection-voltaic mode was carried out using Multisim 10.1. Silicon BT ZTX968 (pnp structure) was used for the simulation.
The load current-voltage characteristics of the bipolar transistor ZTX968 (pnp structure) in the injection-voltage mode with the EC voltage control (curves 1–4) are shown in Fig. eight.
On the vertical part of the characteristic, the bipolar transistor has a low dynamic resistance. Therefore, it can be considered as a voltage generator for external circuits that have large internal resistances.
In the three-structure injection-voltaic transistor, there is no Earle effect and thermal instability is significantly weakened.

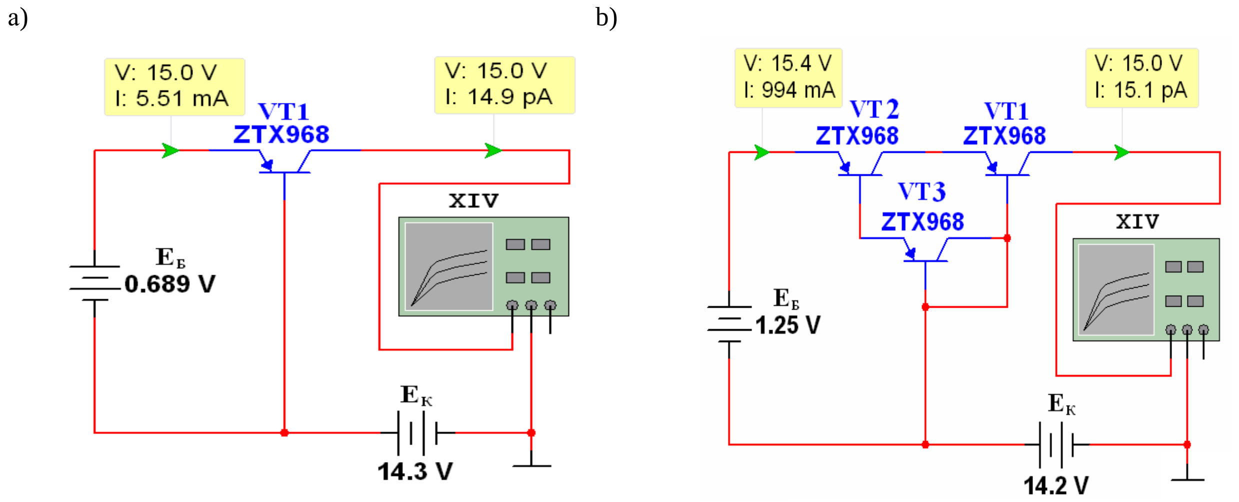


Fig.7. Scheme of a controlled voltage generator on a bipolar transistor (a) and a three-structure injection-voltaic transistor (b).

The load current-voltage characteristics of the bipolar transistor (Fig. 8, curves 1 and 2) with voltage control $E_K$ = 14.3V and $E_K$ = 29.3 V correspond to the voltage $U_N$ = 15 V and $U_N$ = 30 V, respectively, in the load current range 0 ÷ 0 , 4 A. The efficiency of a controlled voltage generator is not more than 50%.

The load current-voltage characteristics of a three-structure injection-voltaic transistor (Fig. 8, curves 3 and 4) with voltage control $E_C$ = 14.2 V and $E_C$ = 29.2 V correspond to voltages $U_N$ = 15 V and $U_N$ = 30 V, respectively, in the load current range 0 ÷ 1 A. The efficiency of a controlled voltage generator is about 90%.

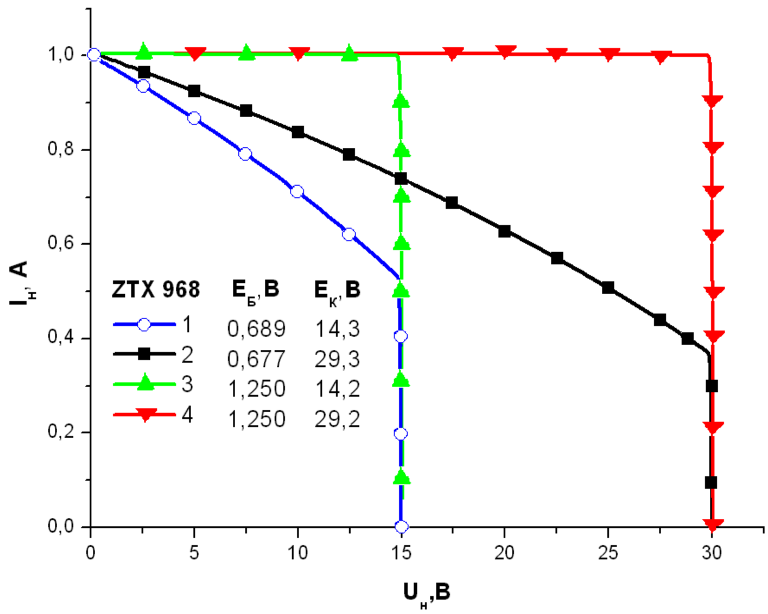


Fig.8. Load current-voltage characteristic of the bipolar transistor ZTX968 (pnp structure) in the injection-voltaic mode with $E_C$ voltage control.

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From fig. 8 it can be concluded that with direct series connection of stages, one voltage controlled $E_B$ and the second current driven emitter, the input characteristic goes beyond the horizontal section of the current generator corresponding to the mode. It should be noted that in this case, the current-controlled transistor VT1 is a non-linear load for the transistor VT2, controlled by the voltage $E_B$. In order for the current-controlled cascade to operate in the current-limiting mode, its input characteristic must be shifted to the lower voltage range of the voltage-controlled cascade, which can be done by turning on the VT3 transistor in the diode mode as a source of bias voltage $E_{CM}$ between the bases of the cascades.

## IV. CONCLUSION

Thus, of the three unstable bipolar transistors, the ideal composite bipolar transistor is created.
It is shown that to create a controlled current and voltage generator it is necessary to implement a three-structure injection-voltaic transistor. In the three-structure injection-voltaic transistor, there is no Earle effect, and thermal instability is significantly weakened.
The three-structure injection-voltaic transistor will find application in battery chargers, voltage converters, power amplifiers, electric motor control systems in solar tracking systems in photovoltaic stations and other power electronics devices that require a highly reliable controlled voltage generator.

## REFERENCES

[1] Edwin W Greeneich. Analog Integrated Circuits-New York, Chapman & Hall, 1977.341 p.
[2] Aripov Kh.K., Bstanov Kh.H., Maksudov Zh.T. Injection Voltaic Transistor / Application No. INDP 9600714.1 announced on July 22, 1996. Patent R. Uz. No. 4601 dated 05.22.1997, Bull. № 1.
[3] N.B. Alimova, New Injection – Voltaic Effect Elementary Basis// 9nd International Conference on Electronics, Information and Communication, Tashkent, 24-27 Sept., 2008. pp. 520-523.
[4]AripovKh.K., Alimova NB, BustanovKh.Kh., ObedkovYe.V., ToshmatovSh.T. Connection of photovoltaic effect in solar cells with injection voltaic effect in multilayer semiconductor structures // Heliotekhnika. 2009, № 1, p. 15-21.
[5]AripovKh.K., BustanovKh.Kh.,Mavlyanov A.R., Maksudov D.T. Composite Injection Voltaic Transistor / Patent of the Republic of Uzbekistan No. IAP 02107 dated 09/26/2001. Publ. Bull № 5, 10/31/2001.