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INFORMATION DEVIAS ON THE BASIK OF UNIFUNCTION TRANSISTOR STRUCTURE

On the base of reactive properties of unijunction transistor, there had been developed the elements of information devices, which, in comparison with the known analogues, have the improved technical characteristics, namely: improved reliability, good quality, lower level of noise, small dimensions.

Key words: *unijunction transistor structure, generalized transformer of immitence.*

Introduction

Use of achievements in the latest technologies and element base caused significant progress in creation of different information devices. But very often the obtaining of high characteristics is achieved dew to increasing their complexity, dimensions, mass and cost. Further improvement of quality requires the development of theory for building and search for the new principles of physical realization of devices, which differ by multifunctioning, low energy consumption, high sensitivity, stability of characteristics, improvement of speed of response and reliability. Present stage of development of elementary base considers the semiconducting elements and devises with negative differencial resistance as the perspective, which is explained by a range of their advantages. Unijunction transistor is one of them. Unijunction transistor structure is a multifunction electronic device, the use of which allows to improve technical parameters of information devices, improve their efficiency and create the qualitative new elements on their basic.

The object of the work is to improve technical characteristics of the elements of information devices due to use of potentially unstable unijunction transistor structure.

Theoretical research

One of the problems in the electronics is the realization of high gain-band-width inductive coil in the integral kind. There the following requirements to it: manufacturability, value of inductivity, good quality, stability, correspondence of frequency range and dimensions. Very often in microchips there is no need in using peculiarities of inductive coil ton accumulate the magnetic field, but it is necessary to ensure the phase shift between current and voltage by 90^0. This peculiarity is realization by transistor equivalents of inductivity. Transistor equivalent of inductance coil (fig. 1) is received in the results of a substitutions of bipolar avalanche transistor by the unijunction one which improved the reliability and decreased level of noises.

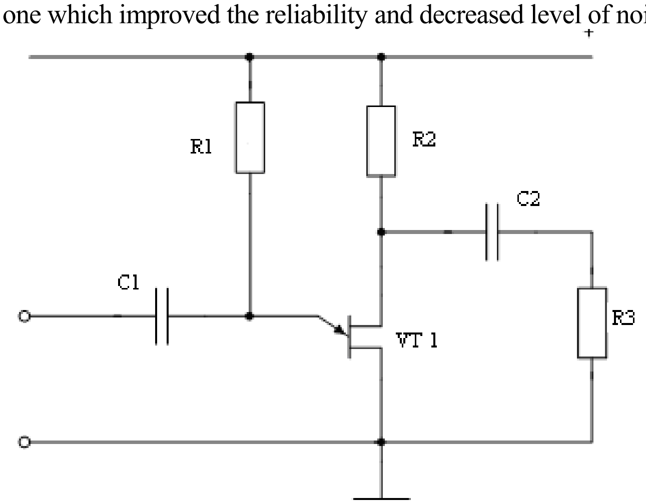

Fig. 1 Transistor equivalent of inductance coil

Unijunction transistor VT1 has a transfer coefficient of direct current $\alpha_0 > 1$, which allows to realize the good quality semi conductive inductivity on its base. Complex transfer factors $\alpha=\mu_e\ \beta_п$,, where μ_e and $\beta_п$ – coefficient infection of emitter function and transfer of minority carries in the base region; α_o – low frequency coefficient of transistor transfer of current. With high current of emitter $\mu_e=1$. Low frequency transfer coefficient of current $\alpha_o=1+M_п / M_p$, where M_p and $M_п$ – mobility, accordingly, of electrons and holes in the base region. For silicon transistor: $M_п$=1300 sm^2/per sec.; M_p=470 sm^2/per sec Considering this α_o=3,8. Transfer coefficient $\beta_п$ is partly dependable and is described by formula $\beta_n = M \cdot e^{-j\theta} = M \cdot (\cos\theta - j\sin\theta) = \beta_{n1} - j\beta_{n2}$, where M=sin Q/Q, Q=$\omega \cdot \tau_n$ – transit angle of minority carries through the base, τ_n – time of transit of minority carries between the emitter and output of the first base. Considering that minority carries of current drift through the base under influence of electric field at speed of $V_{dr}=10^5$ – 10^6 cm/sec with the length of the base L=200 micromillimeters, we find $\tau_n = 5 \cdot 10^{-9}$ sec Full resistance of emitter function is determined $Z_e=r_e/(1+j\,\omega\, r_e c_e)$, where r_e and c_e – differential resistance and capacity of emitter function. With the current 5мA we have r_e=5 Ohм, c_e=80 pF. The resistance of the base is determined through the transfer coefficient of current in the circuit with the common first base $\beta_0=R_{b1}/(R_{b1}+R_{b2})$, where R_{b1} and R_{b2} – base resistance between the emitter and output of the first base, emitter and output of the second base correspondingly. For transistor КП117 if equals β_0=0,7. Therefore R_{b2}=2,4 R_{b1}, $R_{b1}+R_{b2}$=7 kOhm.

Using method of nodical potentials, we find the input resistance of the circuit: $Z_{eb1} = Z_e + \frac{R_{b2} \cdot (R_{b1} + R_н)}{R_{b1} + R_{b2} + R_н} \cdot (1-\beta)$, where $\beta = \alpha_0 \beta_n$.

Therefore: $R_e Z_{eb1} = R_e Z_e + \frac{R_{b2} \cdot (R_{b1} + R_н)}{R_{b1} + R_{b2} + R_н} \cdot \mathrm{Re}(1-\beta)$,

$$\mathrm{Im}\, Z_{eb1} = \mathrm{Im}\, Z_e + \frac{R_{b2}(R_{b1} + R_н)}{R_{b1} + R_{b2} + R_н} \cdot \mathrm{Im}(1-\beta).$$

Considering that Re(1-β)<0, and Im(1-β)>0, we find that the total input resistance of the circuit has a negative real $R_e Z_{eb1}<0$ and inductive – imaginary component $\mathrm{Im}Z_{eb1}>0$. Value of equivalent inductivity is L_{eb1}= Im Z_{eb1}/ω. Since the transistor works in the active region and the process of full augmentation is absent, it ensures more lower level of noise in comparison with avalanche inductive transistor

The second variant of transistor equivalent of inductance coil is built on the base of the circuit with negative differential resistance (fig. 2). As distinct from the first circuit (fig. 1), use the output circuit of unijunction transistor allows to improve the signal amplitude and improve the value.

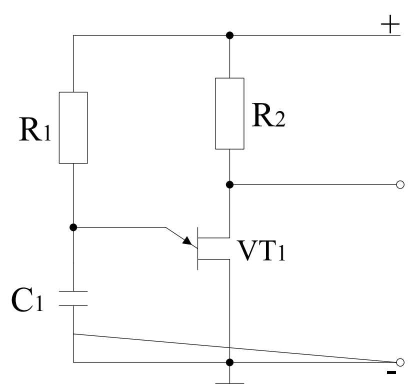

Fig. 2. Semiconductor inductance

Unijunction transistor is a generalized immitance converter with coveting coefficient $T = (1-\alpha)$. Its output conductivity $У_{b1b2}$ depends on the coefficient of conversion and a value of the converted capacity of capacitor C_1: $У_{b1b2} = j\omega C_1 (1-\alpha)$. With high values of emitter current $\alpha_0 > 1$, than the reactive part of output conductivity equals: $\mathrm{Im}\, У_{out} = -j\omega C_1(\alpha_0 - 1) < 0$. That is, the reactive part of output inductivity is an inductive with the equivalent of inductance of: $L_{out} = 1/\omega^2 C_1 (\alpha_0 - 1)$.

Researches of immitance converter (IC) on the basis of unijunction transistor structure showed that it ensured the realization of high-quality analogues of inductance and depending on voltage polarity on emitter, it has the peculiarities of a convector or an inverter of the immitance. It allows to realize on its base the parallel and high-quality series oscillatory circuits without the use of inductance coils, which are the base for building the active band-pass filters and band-rejection filters. It also realizes the possibility of electric control over the central frequency of the controlling voltage on the transistor VT_1, operating in the mode of the immitance converter with common drain (fig. 3).

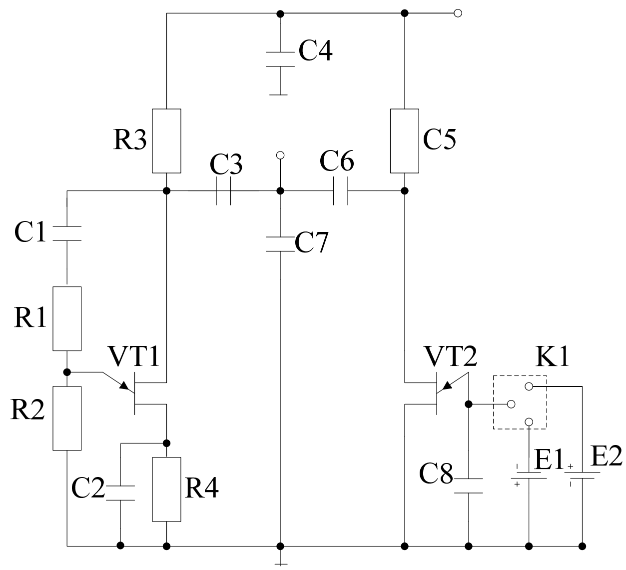

Fig. 3 .Electric schematic diagram of active electrically controlled oscillatory circuit

In the result of direct transformation of resistance of the resistor R_1, the input immitance between the transistor source and transistor drain has low-quality inductance character, with, together with the capacity C_7 realizes the parallel oscillatory circuit. The second transistor VT2 is connected in parallel to the capacity C_7, ensuring the immitance converter with common source, having converted the capacity immitance C. Depending on voltage polarity transistor gate VT2 this converted exhibits properties of immitance converter or inverter. With the positive gate potential if exhibits properties of immitance convertor and its output immitance is capacitive with negative active constituent, which ensures high-quality of oscillatory circuit on frequency:

$$f_{01} = \frac{1}{2\pi\sqrt{(C_7 + C_{d2})L_{d1}}}, \qquad (1)$$

where C_{d2} and L_{d1} – capacity and inductance between the source and the drain of transistor 2 and transistor 1, correspondingly. Supplying blocking voltage to the transistor gate VT_2, it works as immitance inverter and converts capacitance of the capacitor C_8 into the inductive one with negative active constituent. If ensures high-quality of the oscillatory circuit on the second frequency $f_{02} = \frac{1}{2\pi\sqrt{C_7(L_{d1} + L_{d2})}}$, where L_{d2} – inductance between the source and the drain of transistor VT_2. In case when $C_7 >> C_{d2}$, which is achieved by choice $C_8 << C_7$, on condition $L_{d2} >> L_{d1}$ (achieved by choosing R_1), we receive the contract ratio with frequency equal $f_{01} / f_{02} = \sqrt{L_{d2} / L_{d1}}$. Resulting electric schematic diagram of active oscillatory circuit is presented on fig.3, for controlling over potential of emitter we use commutator K_1 and two shift sources. E_1 and E_2.

Experimental research

Using elements of conductivity matrix of unijuction transistor and formula for calculation of input and output conductivity [3] , and using Mathcad, there had been determined the frequency dependences of output (fig. 4) and input (fig. 5) conductivity of transistor, switched on the circuit with common base.

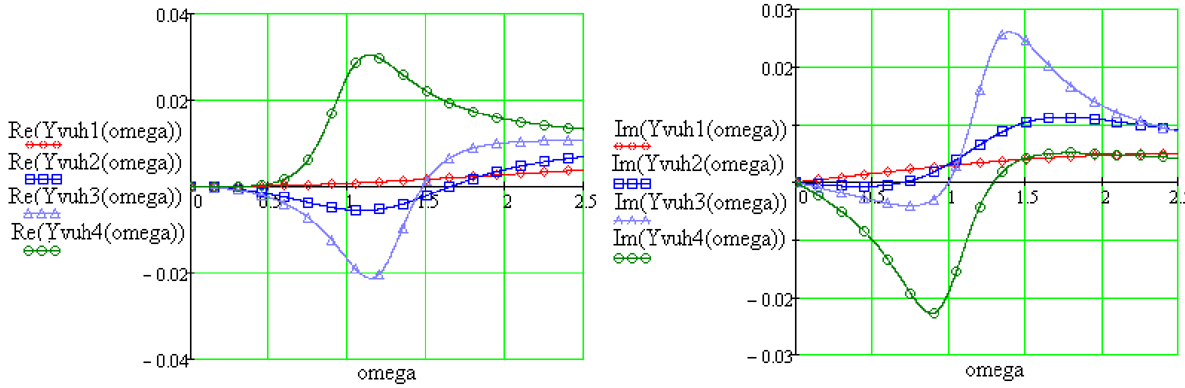

Fig. 4 Dependence of real (a) and imaginary (b) components of output conductivity on frequency correlation

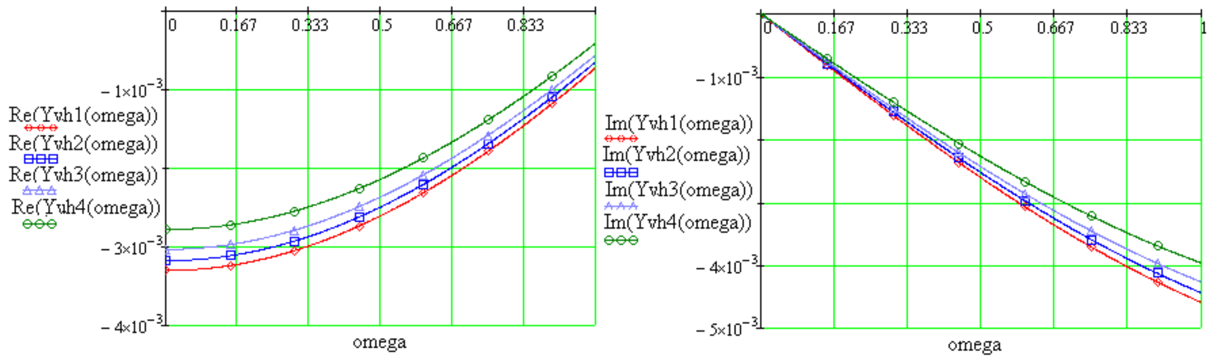

Fig. 5. Dependence of real (a) and imaginary (b) components of input conductivity on frequency correlation

The results of experimental researches, presented in fig. 4 – 5, show that in frequency ranges to Ω=1, the unijuction transistor structure has negative real and imaginary inductive components of input conductivity, the full input conductivity has negative real component and inductive imaginary component. It allows to realize the analogues of inductivity and oscillatory circuits on the basis of unijunction transistor structure.

Using experimental methodics, described in [4], there had been conducted the experimental researches of the developed devices on the basis of transistor КТ117Б. The researches showed that the transistor equivalent of the inductive coil ensures the inductivity up to 30 μHn on frequency up to 1 GHz, semiconducting inductance ensures the value of inductivity up to 7 μHn on frequencies smaller than 1,7 GHz. Oscillatory circuit, realized on unijuction transistor structure with I_e=7 мА, ensures on frequency 0,1 GHz high-quality of 120 units with temperature non-stability of frequency 10^{-4} (% degree^{-1}). Voltage change on emitter from -1,2 V to +0,1 V ensures frequency change from 0,1 GHz to 100 MHz.

Conclusions

1. On the base of unijunction structure there had been developed equivalents of inductance and oscillatory circuit. Transistor equivalent of inductance coil and semiconductor inductance, have small dimensions, construction simplicity, high-quality level, high temperature stability and reduced noise level.

2. Transistor equivalent of inductance coil ensures inductance up to 30 mcHn on the frequency up to 1 GHz. Semiconductive inductivity ensures value of inductance up to 7 mHn on frequencies, lower than 1,7 GHz.

3. Oscillatory circuit, realized on unijunction structure with $I_э$=7 mA, ensures on frequency 0,1 GHz the high-quality of 120 units with temperature non-stability of 10^{-4} (%degr^{-1}). Voltage change on emitter from -1,2 V to +0,1 V ensures frequency change from 1 GHz up to 100 MHz.

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