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Method Of Compensation Instability Of Frequency Modulators In The Absence Of The Modulation Signal

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ABSTRACT

Sources of electrical oscillations and frequency modulators (FM) with high stability of the average frequency are required for any data transmission systems, radar and radio navigators. Stability determine the most important parameters of modern electronics - the accuracy of action, speed and bandwidth, noise immunity and stealth action. The aim of this paper is improve the stability of the frequency of the FM.

Keywords - *frequency; modulator; instability; varicap; control; oscillations; capacity.*

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I. INTRODUCTION

Primarily in the development of modulators is necessary to solve two main problems

- Increase the stability of oscillation frequency in the absence of the modulating signal.
- modulating voltage and frequency of the generator should be changed almost proportionally.

One of the most convenient technical solution to the problem is use the frequency stabilizator based on quartz resonator or surface acoustic wave (SAW). But the frequency modulation based on quartz resonator has a contradiction, consisting in the fact that on the one hand it is necessary to ensure high frequency stability under the influence of external factors, but on the other hand it is necessary to change the frequency according to the law of the modulating signal (control signal).

Second solution, use reactive cascade on transistors, but in this case there is a parasitic amplitude modulation, which is desirable to minimize [1]. If this stage is used as the equivalent inductance which will vary due to changes in, for example, the voltage between the base and emitter, will lead to a significant increase in parasitic amplitude modulation, and instability in the absence of the modulating signal is significant, since the collector current will be much higher current divider. Therefore instability of power supply and temperature will significantly affect the value of the emitter current, and therefore the collector.

If used as a cascade of capacity, in circle of the base-emitter should include inductance, which can not be realized by semiconductor technology and, in addition, the second element is also tuned circuit inductance, which is also difficult to implement for semiconductor technology.in this connection, the actual task for this article is increasing the frequency stability in the absence of the modulating signal . .[1]

II. RELATED WORKS

Regime and temperature instability of the frequency modulator in the absence of the modulating signal caused by the instability of power supply voltage leads to a change in voltage on the the varicap and this change the oscillation frequency generated. in this case increase in voltage causes a decrease in capacity of the varicap and increase the frequency and vice versa - reducing the voltage leads to an increase capacity and reduce the frequency. These curves for different types of transitions can be determined by the following expressions .[2]

$$C_{bar} = S\sqrt{\frac{q\varepsilon\varepsilon_0 N_{ap} N_{dn}}{2(N_{ap} - N_{dn})(F_k - U)}} \quad (1)$$

- For sharp p-n junction.

$$C_{bar} = S\sqrt{\frac{q\varepsilon\varepsilon_0 N}{2(F_k - U)}} \quad (2)$$

- For asymmetrically p-n junction.

$$C_{bar} = \sqrt[3]{\frac{(\varepsilon\varepsilon_0)^2 qa}{12(F_k - U)}} \qquad (3)$$

where: F_k - contact potential difference;
ɑ - impurity gradient;
N- impurity density;
S - The area p-n junction;

Nɑp, Ndn - Concentration of acceptor and donor impurities in semiconductors p and n type respectively.

Analysis of these expressions shows, the temperature increase lead to capacity will vary, mainly due to increased contact potential difference.

$$F_k = \frac{kT}{q} ln \frac{P_p}{P_n}, \qquad (4)$$

Where (Pp, Pn) the hole concentration at the interface in semiconductors (p – n) type conductivity, respectively.

To compensate the instability of frequency from the change in temperature, frequency modulator used an inductive dynamic negatron (IDN). Theoretical and experimental studies of inductive dynamic negatrons formed by several authors ([4] and [5]) show that, the increase in the voltage between the emitter and base of transistor IDN leads to an increase of the emitter current and the equivalent inductance, which leads to a decrease of the oscillation frequency, and This makes it possible to compensate for the growth frequency due to a decrease in capacity of the p-n junction varicap. By reducing the voltage between the emitter and the base emitter current is reduced, which reduces the equivalent inductance and increase the frequency of the generator.

Study of the dependence of the equivalent inductance on temperature shows, that its increase increases current IDN emitter and collector, rise of current, in turn causes an increase in inductance. At the same time, as seen from the expressions (1) - (3), the increase in temperature leads to an increase in the contact potential difference and accordingly to reduce the barrier capacitance, so the use IDN enables to compensate the instability due to changes in ambient temperature.

III. THE SOLUTION OF THE PROBLEM.

As follows from the previous studies, possible to use the IDN as the inductive element in the oscillating circuit in frequency modulator to compensate the change in frequency of the modulator due to changed the voltage of power source and temperature, however, this compensation may reduce the frequency deviation, because due to action of the modulating signal and equivalent inductance will vary .

To eliminate the influence of inductance depending on the action modulation signal, IDN is connected in parallel to an oscillation circuit, and the modulation signal applied on the varicap, it is applied between the collector and base of IDN. (Figure 1).

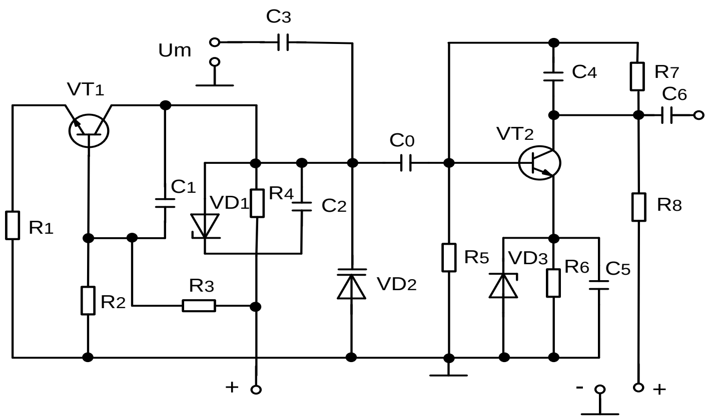

Figure 1. frequency modulator

Schematic diagram of the frequency modulator is shown in Figure 1. There IDN assembled transistor VT1, Zener diode VD1, VD2 provide voltage stabilization on the varicap VD2 and the emitter of the transistor VT2, capacity C5 provides feedback.

where the current collector and the emitter is not independent of the voltage at the collector with the active mode (Fig. 1), the modulating signal does not affect the equivalent inductance of the oscillating circuit by the action of modulating signal.

It is known that the frequency of the oscillations generated when changing the voltage on the varicap varies by law:

$$\omega = \omega_0 / \sqrt{(1+\Delta C / C_0)} \qquad (5)$$

Where $C_0 = C + C_1$, $\omega_0 = 1/(\sqrt{(L C_0)})$ (6)

$$\Delta C = K\left[\left(F_k - U_2\right)^{-2} - \left(F_k + U_1\right)^{-2}\right] \qquad (7)$$

where K - constant , can be calculated taking into account (1), (2), (3).
Then the relative change in frequency can be determined by the expression [6]:

$$(\Delta\omega / \omega 0) = -\Delta C / 2C0 \qquad (8)$$

Similarly, when you change the inductance circuit:

$$(\Delta\omega / \omega 0) = -\Delta L / 2L0 \qquad (9)$$

It should be noted that equation (4) and (5) take place provided that:

$(-\Delta C / 2C0) << 1$ and $(-\Delta L / 2L0) << 1$.

In this case, these conditions are always executed, because it comes to consideration of instability of power supplies and changes in temperature, so changes capacitance and inductance are significantly smaller mean.

From the expressions (4) and (5) that, to compensate for the effect of destabilizing factors, it is necessary to

$$(-\Delta C / 2C0) = (-\Delta L / 2L0) \qquad (10)$$

For IDN value of inductance and active resistance can be determined using a simplified equivalent circuit

$$L = \frac{\left(r_b + R_b\right)\alpha_0 f_\alpha}{2\pi\left(f_\alpha^2 + f^2\right)} , \qquad (11)$$

$$R = \left[r_E + \left(r_b + R_b\right) - \left(r_b + R_b\right)\alpha_0\right]\left(1 + \frac{f}{f_\alpha}\right) \qquad (12)$$

Where r_E - resistance emitter junction; r_b - Resistance of the base region of the transistor; fα - Megeve frequency; R_b - External resistance, turned on a circle basis.

For varicap, equivalent circuit can be represented as a series enabled resistance and barrier capacity and on the basis of which the impedance can be calculated by expression;

$$Z_B = \frac{R_2 + R_2^2 R_1 \omega^2 C_{bar}^2}{1 + \omega^2 C_{bar}^2 R_2^2} + \frac{j\omega C_{bar}\left(R_2 R_1 + R_2^2\right)}{1 + \omega^2 C_{bar}^2 R_2^2} \qquad (13)$$

Where R1 - resistance p and n-region varicap;
R2 - impedance reverse biased p-n junction.

Using the expressions for the impedance IDN and varicap, we obtain an equation from which we can determine the dependence of the resonance frequency and harmonic components of instability of power supply and temperature.

$$\omega^4 L C_V^3 R_{equ} R_V^2 - \omega^3 L C_V \left(L + R_{equ} R_V C_V\right) + \omega^2 R_{equ}^2 R_V C_V^2 + \omega\left(L + R_{equ} C_V\right) = 0 \quad (14)$$

If we neglect the resistance of varicap, the expression (14) takes the form

$$\omega^4 L^2 C_0 C_V (C_0 - C_V) - \omega^2 C_0 (2 C_V L + C_0 L + C^2 R_{equ}^2 - C_0 R_{equ}^2 C_1) - C_0 = 0 \quad (15)$$

For the fundamental resonance frequency dependent inductance IDN calculated by the emitter current, which is shown in Figure 2. As can be seen from the graphs, with increasing inductance of the emitter current increases, which leads to a decrease of the resonance frequency.

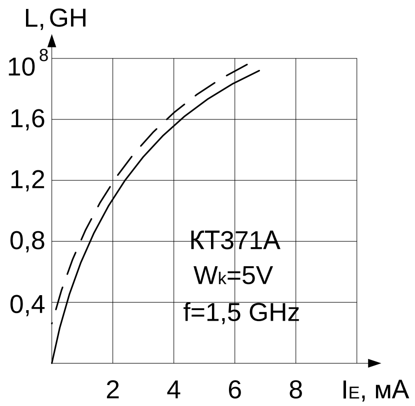

Figure 2. dependence of current of emitter from inductance

In accordance with the expression (1) Dependence of capacity varicap from power supply . Comparison of these results shows, that with minor changes in voltage varicap caused by instable of power supply, lead to a change in capacity varicap, this change of 90% offset by a change in inductance IDN.

from the frequency we have to calculate the full equivalent resistance oscillator circuit

$$R_{equ} = \frac{\left[\omega^2 L(C_0 - C_V) - 1\right]\omega^2 C_V C_0 R + \omega R (C_V + C_0)\omega C_0 (\omega^2 C_1 L - 1)}{\omega^4 C_V^2 C_0^2 R^2 + \omega^2 C_0^2 (\omega^2 C_B L - 1)^2} \quad (16)$$

where full resistance on frequency generation is zero, given that the expression for the oscillation frequency can be written as:

$$\omega_{1,2} = \pm\left\{\frac{C_0 L(2C_V - C_0) + \left[C_0^2 L^2 (2C_V + C_0)^2 + 4L^2 C_0 C_V (C_0 - C_1)\right]^{1/2}}{2L^2 C_0 C_V (C_0 - C_V)}\right\}^{1/2}$$

$$\omega_{2,3} = \pm\left\{\frac{C_0 L(2C_V - C_0) + \left[C_0^2 L^2 (2C_1 + C_0)^2 + 4L^2 C_0 C_1 (C_0 - C_1)\right]^{1/2}}{2L^2 C_0 C_1 (C_0 - C_1)}\right\}^{1/2} \quad (17)$$

CONCLUSIONS.

1. Proposed method for compensation instability of frequency of frequency modulator (FM) in the absence of modulating signal (control signal), based on depend of inductance of IDN on the voltage on the emitter.

2. Obtained Expressions for calculating the oscillation frequency given its dependence on the physical parameters of the equivalent circuit of the transistor.

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