 ISSN 1310-3946

A METHOD TO CALCULATE QUARTZ CRYSTAL ULTRA-HIGH FREQUENCY OSCILLATORS FOR DOMESTIC ANIMALS

МЕТОДИКА РАСЧЕТА КВАРЦЕВЫХ РЕЗОНАТОРОВ СВЧ ДЛЯ ДОМАШНИХ ЖИВОТНЫХ

Assoc. Prof. Eng. Oleksandr Orel, PhD
Tavria State Agrotechnological University,
18, Khmelnytskiy av., Melitopol, 72312, Zaporozhye region, Ukraine
E-mail: orelan2006@ukr.net

Abstract: *One of the significant problems is increase of productivity in animal husbandry while preserving and increasing the number of domestic animal which is considerably dependent on timely treatment of their injuries. Antibiotics and other medicines sometimes has any healing effect, besides, through milk and meat medicinal preparations get into a human's organism affecting it negatively. UHF therapy is related to resonant action and excitation of acoustoelectric waves within cell membranes. Purpose of the article is to calculate the power characteristics of an auto-oscillator with the usage of quartz crystal oscillators. Technique for calculating power characteristics of quartz crystal ultra-high frequency oscillators used in electromagnetic therapy devices for animals has been developed.*
KEY WORDS: *QUARTZ CRYSTAL OSCILLATOR, UHF RADIATION, AUTO-OSCILLATOR.*

1. Introduction

One of the most relevant problems the agrarian complex of Ukraine is currently facing is improving of productivity in animal husbandry while preserving and increasing the number of domestic animal which is considerably dependent on timely treatment of their injuries. As a result of injuries and their complications the productivity of sick animals is declining, they are drafted out prematurely and often die [1, 2].

Nowadays medication based therapy is mainly used to treat injuries of animals. Usage of antibiotics and other medicines sometimes has any healing effect, besides, through milk and meat medicinal preparations get into a human's organism affecting it negatively. In many countries world-wide scientists are tirelessly searching for drug-free modalities for treatment and prevention of animal illnesses [3, 4].

It is possible to achieve the goal due to usage of electromagnetic emissions of UHF and EHF ranges [5,6]. As the UHF therapy is related to resonant action and excitation of acoustoelectric waves within cell membranes, high stability UHF oscillators with output capacity up to 50 mW and frequency tuning should be used to transmit the maximum radiant energy to biological objects [7, 8].

2. Analysis of recent research and publications

An analysis of the literature has shown that absence of specialized high stability monochromatic sources of UHF emissions with frequency of 1 cm makes it quite problematic to create a low-energy electrotechnology for domestic animal treatment [9, 10].

While solving this task it is essential to conduct a theoretical analysis of the basic characteristics of a quartz crystal oscillator as well as analysis of its short-time instability depending on fluctuating parameters of auto-oscillator circuit elements [11. 12].

3. Purpose of the article (objective setting)

The purpose of the article is to calculate the power characteristics of an auto-oscillator with the usage of quartz crystal oscillators. Basic materials of the research (main part). Nowadays there is a great number of circuits of quartz crystal oscillators with frequency up to 100MHz, techniques for their calculation are various still restricted by the frequency domain. Meanwhile, engineering practice demands a quite simple method to calculate quartz crystal oscillators with frequencies ranging from 200 to 500MHz, which is possible to use with data references available or having data measured by simple methods.

Here in after we give one of the possible variants of a calculation technique that can be applied for the wide frequency spectrum and considerable output capacity. The simplified schematic diagram (Fig. 1) is used to calculate the energy relations of stationary mode, supposed that reactive components Z_{in}, Z_{out}, Z_n influence the phase relationships in the oscillator (the phase balance) and have no influence on the amplitude balance.

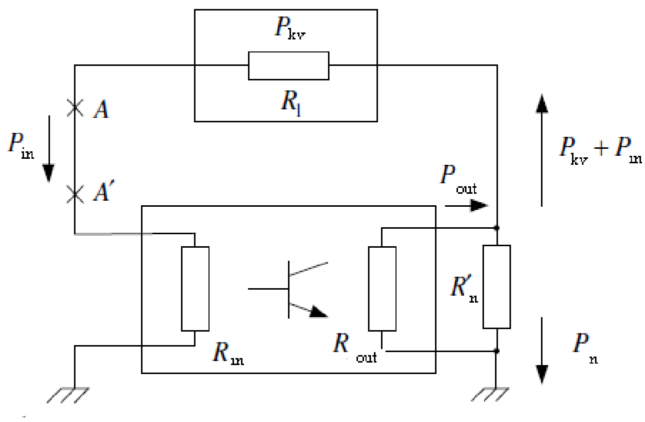

Fig. 1. *Quartz crystal oscillator equivalent circuit*

Let us consider the amplitude balance. Fig. 1 shows that power output of the transistor P_{out} is emitted while operating, a part of it goes to the base of the transistor through feedback circuit with some input power being dissipated in the quartz crystal oscillator.

$$P_{out} = P_n + P_{kv} + P_{in}. \quad (1)$$

Transistor power gain

$$K_p = \frac{P_{out}}{P_{in}} \quad (2)$$

If the coefficient of resonator Q-factor usage

$$K_Q = \frac{P_{kv}}{P_{in}} = \frac{R_1^1}{R_{in}}, \quad (3)$$

where R_1^1 is equivalent impedance of the composite oscillator.

Supposed $R_{in} = R_n^1$, the circuit on the Fig. 1 can be transformed into Fig. 2.

Connection of the quartz crystal oscillator to the points with resistance $\frac{R_1^1}{K_Q}$ lowers its Q-factor as shown

$$Q_e = Q\frac{R_1^1}{R_1 + 2\frac{R_1^1}{K_Q}} = \frac{Q_{K_Q}}{K_Q + 2}, \quad (4)$$

where: Q is unloaded Q-factor of the quartz crystal oscillator

 YEAR XXIV, VOLUME 2, P.P. 110-111 (2016)

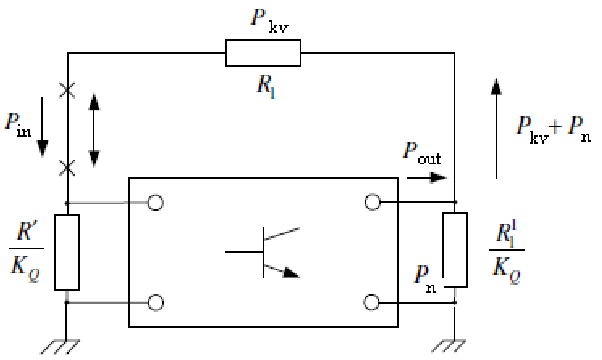

Fig. 2. *Quartz crystal oscillator equivalent circuit*

From equations (2) – (4) follows that

$$K_p = \frac{P_n + \frac{P_{kv}}{K_Q} + P_{kv}}{\frac{P_{kv}}{K_Q}} = K_Q(\frac{P_n}{P_{kv}} + 1) + 1 . \quad (5)$$

Formula (5) is a condition for generator amplitude balance in stationary mode. After the transformation (5) we get the formula for the calculation of oscillator output power fluctuations:

$$P_n = \frac{P_{kv}}{K_Q}(K_p - K_Q - 1) . \quad (6)$$

On practice usually $K_p>1>K_Q+1$. Thus, we have

$$P_n = \frac{P_{kv}K_p}{K_Q} = \frac{P_{kv}K_p}{2}(\frac{Q}{K_Q} - 1) . \quad (7)$$

Formula (6) shows that $K_p=K_Q+1$, as $P_n=0$ as all the output power is spent on self-oscillation.

Let K_{On} denote the coefficient of lowering of the oscillator Q-factor:

$$K_{Q_n} = \frac{Q_e}{Q} = \frac{K_Q}{K_Q + 2} . \quad (8)$$

Feedback network gain is equal to:

$$K_{os} = \frac{P_{in}}{P_{os}} = \frac{1}{K_Q + 1} . \quad (9)$$

Thus:

$$K_{os} = \frac{1 - K_Q}{1 + K_Q} . \quad (10)$$

Using the equation for recovery factor $G = K_{os}K_p$, it is easy to get:

$$K_{Q_n} = \frac{K_p - G}{K_p + G} . \quad (11)$$

Formula (11) makes it clear that with a specified coefficient G which is usually equal to 2, increase in K_{Q_n} can be achieved only due to increasing K_p. The same conclusion can be made after the analysis of the formula (6). If K_p is increased, the required recovery factor G can be received under lower values of P_{kv}. However, considerable decrease in Q_e has significantly adverse impact on providing maximum P_n. From this point of view, an optimal value of P_{kv} is the one, not causing non-linear effects (multifrequency oscillations) and being in the immediate vicinity to the frequency n of the oscillator mechanical overtones. This power is usually specified for type of oscillator.

For domestic 250 MHz oscillators the value P_{kv} = 0,5 mW. Regarding the aforesaid it is convenient to express P_n through K_p, P_{kv}, K_{Qn}:

$$K_Q = \frac{2K_{Q_n}}{1 - K_Q} ; \quad (12)$$

$$P_n = P_k \frac{K_p(1 - K_{Q_n}) - K_{Q_n} - 1}{2K_{Q_n}} . \quad (13)$$

Actual value of K_{Qn} can be calculated using the formula (11), next formula (13) enables to find maximum output power K_p achieved under the given P_n. Using the correlations given above it is rather easy to perform calculations for an oscillator under the given G, K_{kv} and Q_e.

Having given (measured) values $Re(Z_{in})$ and dependence $K_p(P_{in})$ it is possible to calculate the transformation ratio and phase shift and thereafter to work out an oscillator circuit.

4. Conclusion

Engineering technique for calculating basic power parameters of an auto-oscillator is simple, actionable within a wide range of frequencies and can be used for synthesis of quartz crystal oscillators with frequencies ranging from 200 to 500MHz.

5. Literature

1. Lebedev A.V., Lukyanovskiy V.A., Semenov B.S. i dr. Obschaya veterinarnaya hirurgiya. - M.: Kolos, 2000. - 488 s.
2. Gertsen P.P. Profilaktika i lechenie travm v promyishlennom zhivotnovodstve. - Kishinev: Karmya Moldovenyaska, 1981. - 354 s.
3. Veremey E.I., Eliseev A.N., Lukyanovskiy V.A. Spravochnik po primeneniyu lekarstvennyih sredstv v veterinarnoy hirurgii. - Minsk: Urodzhay, 1989. - 170 s.
4. Ulaschina V.S. Aktualnyie voprosyi elektrolecheniya i ultrazvukovoy terapii. - Minsk: Urodzhay, 1983. - 144 s.
5. Presman A.S. Elektromagnitnyie polya i zhivaya priroda. - M.: Nauka, 1968. - 288 s.
6. Devyatkov A.D., Golant M.B., Betskiy O.V. Millimetrovyie volnyi i ih rol v protsessah zhiznedeyatelnosti. - M.: Radio i svyaz, 1991. - 169 s.
7. Ismailov E.Sh. Biofizicheskoe deystvie SVCh izlucheniy. - M.: Energoatomizdat, 1987. - 144 s.
8. Kuznetsov A.P. Elektromagnitnyie polya zhivyih kletok v KVCh diapazone // Elektronnaya tehnika: Ser. 1. Elektronika SVCh. - 1991. - Vip. 7 (441). - S. 3 - 6.
9. Spravochnik po radioizmeritelnyim priboram (pod red. V.S.Nasonova). - M.: Sov. radio, 1986. - 485 s.
10. Hewlett Packard Test Measurement Catalog 1984 - 1998.
11. Malahov A.N. Fluktuatsii v avtokolebatelnyih sistemah. - M.: Nauka, 1967. - 660 s.
12. Kabanov D.A. Obobschennyiy podhod k issledovaniyu avtogeneratorov // Radiotehnika i elektronika. - 1974. - № 8. - S. 1690 - 1697.