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Dynamics of Temperature-Frequency Processes in Multifrequency Crystal Oscillators with Digital Compensations of Resonator Performance Instability

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Abstract—Design and construction peculiarities of multifrequency crystal oscillators technically invariant to temperature effects have been considered. The analysis of thermodynamic characteristics of multifrequency temperature-compensated crystal oscillators was performed in conditions of nonstationarity of the thermal behavior of piezoelectric resonator. The volume density of heat source was determined during the excitation of quartz crystal resonator. Thermodynamic processes occurring in multifrequency crystal oscillators were investigated at the stage of settling of quartz crystal resonator oscillations. The need of taking into account the thermodynamic component during the investigation of high-speed thermal processes taking place in quartz crystal resonators was proved. The efficiency of using a multifrequency-algorithmic approach for ensuring the invariance of piezoresonance devices was estimated. It was shown that the use of this approach makes it possible to essentially reduce the temperature instability of crystal oscillators and reduce the up time of these devices due to a more exact compensation of initial frequency drifts.

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INTRODUCTION

The augmentation of temperature stability of crystal oscillators (CO) and CO-based devices is usually associated with the use of design and manufacture methods, where thermostating occupies the leading place [1–3], and with the use of classical function-compensation methods based on identification of disturbing effects by using individual sensors spaced apart from the area of excitation of piezoelectric element (PE) oscillations [4–6].

However these methods come into contradiction with the requirements of microminiaturization (elements of surface-mounted devices SMD), reproducibility of characteristics, reduction of power consumption, enhancing the reliability and improvement of operating ability. For example, the use of resonators-thermostats is not always justified both form the perspective of energy and mass-dimensional indicators and due to a large time of reaching the regime of thermostabilization (up time) required for the stabilization of thermal processes in quartz crystal resonators (QCR) [7].

The use of mutifrequency-algorithmic approach for ensuring the invariance of piezoresonance (quartz) devices (PRD) is an effective solution of the specified problem in PRD; this approach is based on representing PRD as a dynamic object with natural redundancy in the frequency basis (multifrequency) and the current identification of reversible destabilizing factors. In this case the temperature relationships of difference components of the output spectrum of the multifrequency crystal oscillator (MCO) are used at the first stage, while the functional methods of instability compensation of the thermal behavior of QCR piezoelectric plate are used at the second stage [8–11].

The purpose of this study is to analyze the thermodynamic characteristics of multifrequency temperature-compensated quartz crystal oscillators in conditions of nonstationarity of the thermal behavior of piezoelectric resonator.