Entropy of Noise Signal

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Abstract -**The estimation of quantity of information which is contained in radioelectronic elements own noises is proposed.**
Keywords - **Flicker-noise, Relaxation time, Informational entropy of noise signal.**

I. INTRODUCTION

In general the noises of radioelectronic elements are considered as an obstacle which should be diminished to the minimum. However own noises of elements represent the processes which take place inside the elements. Therefore they can be considered as informatinal signals which contain certain information about an element. For example, in thermal noise there is an information about the temperature of element, flicker-noise (FN) contains information about particularities of inner structure of element.

II. PERFORMED INVESTIGATIONS

Spectral density of noises power (energy spectrum of noises) of radioelectronic elements presented in [1]:

$$S(f) = \frac{1}{P_H} \cdot 4kq \ , \qquad (1)$$

where κ – Boltzmann constant, θ - temperature of element, P_H - probability of element's fluctuations (noises).

Logarithm of expression (1) contains two components:

$$\log S(f) = \log \frac{1}{P_H} + \log 4kq \ . \qquad (2)$$

Probability P_H is determined as [1] $P_H = \frac{\exp(f \cdot t) - 1}{\exp(f \cdot t)}$, where τ - relaxation time of element, f - frequency of fluctuations (noises of element).

Component $\log \frac{1}{P_H}$ can be interpreted as informational entropy of noise signal ($\log \frac{1}{P_H} = H(f,t)$) as it defines the quantity of information contained in the noise signal on the frequency *f*.. In general case dependance of informational entropy $H(f,t)$ on the fluctuations frequency f means the relativity of quantity of information that can be found out using noises of element. During measuring of noises on low frequencies ($f \to 0$) the quantity of information that can be found out by noises of element increases. During measuring of noises elements on high frequencies ($f \to \infty$), the quantity of information that can be found out decreases.

Informational entropy is also the function of time of element relaxation time τ . If element is in equilibrium state ($\tau = \infty$) so the quantity of information contained in his noises $H(f,t) = 0$ (the only information that is possible to find out noises of such element is his temperature θ). If examined radioelectronic element is in non-equilibrium state ($\tau < \infty$) so the quantity of information that can be found out his noises increases: the quantity of information increases if value τ decreases.

Quantity of information contained in noise signal can be defined by formula:

$$I = \int_{f_1}^{f_2} \log \frac{\exp(f \cdot t)}{\exp(f \cdot t) - 1} df \ , \qquad (3)$$

where f_1 and f_2 - lower and upper frequencies of noise spectrum of the investigated element.

From (3) the quantity of information depends on the range of frequencies in which the own noise of element is measured and also on the parameter τ. Analysis of expression (3) also shows that quantity of information contained in element's noises in the range of middle and high frequencies is minimal ($I \to 0$). Maximal quantity of information is in element's noises in the range of low frequencies moreover the quantity of information increases if value τ decreases. The conducted researches present that relaxation time τ depends on the defects location of element's structure (well-organized (regular) location and chaotic (irregular) location of the same defects), on the sizes of structure defects, on the distance between them and on their amount. It means that information contained in the noise signal (3) of radioelectronic element characterizes the state of his inner structure. In general the definition of quantity of information of noise signal (3) can be used for evaluation of informing saturation of different sources of continuous casual signals about the state of their structure.

III. CONCLUSION

Noises of radioelectronic elements can be treated not only as obstacle but as the signals that contain useful information about investigated object. Quantity of information contained in the noises of real element can be evaluated using informational entropy of noise signal. Informational entropy depends on the parameters of the element (relaxation time τ) as well as on the range of frequencies used for its noise measuring. Using informational entropy of noise signal it is possible to find out the quantity of information of noise source.

REFERENCES

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