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Phase Recovery of the Coherent Carrier Frequency Using Digital Phase Filter

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Abstract—This paper considers a phase recovery method for the coherent carrier frequency of the signal received by a digital receiver using a unit of digital recovery of the coherent carrier phase. The use of digital phase filter makes it possible to do without the application of traditional phase-locked loop frequency control. The paper also presents a technique for deriving a transfer function of the specified digital filter and considers the issue of its robustness in relation to self-excitation. In addition, the paper presents a functional diagram of this filter.

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Nowadays the problem of exact phase recovery of the coherent carrier frequency of received signal for the purpose of its subsequent processing and detection is topical in many fields such as radio communications, radio location, radio astronomy, radio navigation, radio measurements and other sectors of radio electronics and automatics. Synchronous detection [1–3] makes it possible to ensure high-quality detection of the signal received and secure a gain of 3 dB in terms of the signal-to-noise ratio that is especially important in case the weak or noisy signals come to the receiver input.

Papers [1–3] describe the technique of building a unit for the recovery of the received signal coherent carrier for the subsequent construction of synchronous detectors. However, the results presented in these papers are suitable for the analog signal processing. The construction of digital circuits on the basis of the theory of discrete systems is not always possible while using the specified results.

The purpose of this paper is to determine the complex transfer function (CTF) of a digital phase filter (DPF) and construct functional diagram of the device for digital phase recovery of the coherent carrier (DPRCC) on the basis of digital filtering methods.

Discrete signal $x(nT)$ can be obtained from the initial analog signal by using the filtering properties of delta function $\delta(t)$ [4]. In this case it can be presented as a convolution of delta function with weighting factors equal to samples $x(kT)$ of the initial analog signal $x(t)$ at points kT:

$$x(nT) = \sum_{k=-\infty}^{\infty} x(kT)\delta(nT - kT), \tag{1}$$

where $n = 0, 1, 2, \ldots$, T is the sampling period. Since the real input signal due to its cause-and-effect relations is measured from the specific value of time t that can be equated to zero, relationship (1) with due regard for the time normalization can be written in the form:

$$x(n) = \sum_{k=0}^{\infty} x(k)\delta(n - k). \tag{2}$$

Let the input analog signal at the input of the high-frequency amplifier (HFA) of the receiver (in-phase signal) be described as follows:

$$S_s(t) = U(t)\sin[2\pi ft + \theta(t)], \tag{3}$$