ISSN 0735-2727, Radioelectronics and Communications Systems, 2016, Vol. 59, No. 5, pp. 221–228. © Allerton Press, Inc., 2016.
Original Russian Text © A.B. Kokhanov, M.Yu. Levkovskaya, 2016, published in Izv. Vyssh. Uchebn. Zaved., Radioelektron., 2016, Vol. 59, No. 5, pp. 38–46.

Single-Sideband Quadrature Angle Modulation

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Received in final form February 14, 2015

Abstract—In this article we describe a modulation technique of the angular component of the signal with the quadrature angle modulation (QAgM), which is aimed to narrow the spectrum width using the signals with single-sideband quadrature modulation as a modulation signal. This allows one to reduce the spectrum width of the signal compared to the spectrum width of the signal with QAgM.

DOI: 10.3103/S0735272716050046

The publications [1, 2] provide a theoretical justification of a modification of angular modulation, namely of the quadrature angle modulation (QAgM). This type of modulation allows one to transmit two signals instead of one using angular modulation at one carrier frequency. Orthogonally separated signals are utilized as the modulation signal. It has been demonstrated in [1] that as such signals one can utilize the signals with quadrature amplitude modulation (QAM), signals with differential QAM using phase modulation and signals with orthogonal frequency division multiplexing (OFDM).

In [2–5] the authors present the examples of practical implementation of this modulation technique in radiocommunication and digital television systems, which improves the signal-to-noise ratio by 3–10 dB compared with the commonly used angle modulation. This improvement occurs due to the constant envelope of the QAgM signal. However, in this case the spectral width of the signal with the quadrature angle modulation is doubled as compared with the commonly used angular modulation [1].

The purpose of this work is the development of a method for generation of signals with quadrature angle modulation, in the case of whose utilization the spectral width remains the same as the one for the signals with the conventional angular modulation.

INTRODUCTION

If one utilizes the signal with quadrature modulation [1, 2] for the formation of current phase of the signal, then, in the general case, the radio signal with QAgM can be represented in the following form:

$$a(t) = A_0 \cos[\omega_0 t + \beta\Theta(t) + \Theta_0] = A(t)\cos\varphi(t), \tag{1}$$

where $A_0 = \text{const}$, $A(t)$ denotes the amplitude of signal with the quadrature phase modulation, ω_0 defines carrier frequency, β stands for the modulation index, Θ_0 designates the initial phase, $\Theta(t)$ is the function of variation of the current phase of the signal, which is determined as follows:

$$\Theta(t) = A_n \cos\omega_S t + B_n \sin\omega_S t, \tag{2}$$

where ω_S denotes a subcarrier frequency of the QAM signal, $A(t) = \sqrt{A_n + B_n}$, $\cos\varphi = B_n / C_n$, A_n and B_n stand for the amplitudes of modulation signal symbols, which are specified by the rules of M-ary modulation at the symbol interval T_S, t designates time. For QAgM the variation law of current phase is determined by the signal with the quadrature modulation [1].

The spectrum of the modulation signal with QAM (2) is described by expression [6]:

$$\dot{S}(\Omega) = \frac{1}{2}\dot{A}_n(\omega_S + \Omega_S) + \frac{1}{2}\dot{A}_n(\omega_S - \Omega_S) - \frac{1}{2}\mathrm{j}\dot{B}_n(\omega_S + \Omega_S) + \frac{1}{2}\mathrm{j}\dot{B}_n(\omega_S - \Omega_S), \tag{3}$$