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Single Sideband Quadrature Amplitude Modulation

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Abstract—A new modulation scheme — single sideband quadrature amplitude modulation (SSB QAM) is proposed. This scheme allows to decrease the spectral width of the transferred signal by two times as opposed to the traditional quadrature amplitude modulation, while maintaining its spectral efficiency. This allows transmitting the modulated signal with the spectral width, which is equal to the spectral width of the modulating signal, and providing an energy gain of about 3 dB.

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INTRODUCTION

The quadrature amplitude modulation (QAM) is widely used in contemporary modems [1–3]. In the QAM signal modulator the digital information bitstream with the time interval T_b is transformed into a symbolic stream $T = mT_b$, m is an integer number. It is then transmitted in the form of two information blocks (symbols A_n and B_n) during the symbolic time interval T on two orthogonal carriers with frequency ω_0 [3].

The disadvantage of such transmission method lies in the existence of two sidebands in QAM signal spectrum: upper sideband (USB) on the frequencies $\omega_0 + \omega$ and lower sideband (LSB) on the frequencies $\omega_0 - \omega$. The information, which is transferred through A_n and B_n symbols, is conveyed in both USB and LSB. In such a way, there is a redundancy in the spectrum of the transmitted signal.

If the subcarrier frequency ω_0 is used like a QAM signal carrier frequency in the transmitting system during the signal formation, then we obtain QAM signal without carrier frequency. The carrier frequency does not provide any useful information and leads to additional expenditure of energy. The described type of modulation is called carrierless amplitude phase modulation (CAP). CAP modulation was developed and patented by GlobeSpan Inc. The disadvantage of such method lies in the absence of standardized demodulation procedures, which are not published by the patent owners. The access to such information is possible through licensing. The second disadvantage of CAP is in the simultaneous use of USB and LSB.

The single sideband 4-level phase modulation [2, 4, 5], which coincides with 4-QAM, is a more efficient solution. However, this method is not applicable for multilevel phase modulation or multilevel QAM, because the solution of the problem of phase modulation is carried out only for the four levels of signal amplitude.

The purpose of this paper is the development of modulation and demodulation scheme of the single sideband QAM signal (SSB-QAM) to eliminate the information redundancy in the spectrum of the transmitted signal.

1. FORMING QAM SIGNAL WITH SINGLE SIDEBAND

The SSB QAM is a signal, which contains only a single sideband with frequencies $\omega_0 + \omega$ (for USB) or $\omega_0 - \omega$ (for LSB). Let us assume, that there is a signal supplied to the first in-phase input of the SSB QAM modulator and to the input of the first Hilbert filter HF1 [6]:

$$S_s(t) = A_n \sin(\Omega t). \tag{1}$$

Then the following signal is formed on the filter output

$$\widehat{S}_s(t) = A_n \cos(\Omega t), \tag{2}$$

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