Signal-Code Constructions with the Use of Amplitude Modulation of Many Components

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Abstract —**In this work the new variety of signal modulation – amplitude modulation of many components (AMMC) was considered. The bit error rate of this modulation was explored. The possibility of use of AMMC in case of design of signal-code constructions was shown. The possibility of use of AMMC in the modern data transmission telecommunication systems and networks for the increase the speed of data transmission and rise the efficiency of such systems and networks was considered.**

Keywords: amplitude modulation of many components; bit error rate; telecommunication system; telecommunication network

I. INTRODUCTION

The modern informative society every year needs the transmission of larger quantity of information. Now an overwhelming majority of information is transmitting in the digital kind, that is why among the telecommunication systems and networks especially developed the data transmission telecommunication systems and networks, to which belong the earth and cosmic telecommunication systems, systems of the remote sensing of Earth, telephone networks, world computer network Internet, local, corporate and regional computer networks and others.

For providing a transmission of growing quantity of information it is necessary to increase a speed of data transmission in the telecommunication systems and networks. Also very important to attain a high efficiency of such systems and networks.

On the speed of data transmission and efficiency of the telecommunication systems and networks have influence the methods of forming and processing of signals. During a forming of signals carry out the modulation and correcting coding, and during a processing of signals – demodulation and correcting decoding. In a number of cases apply the trellis modulation, that is based on the use of signal-code constructions, which is formed as a definitely choose combination of concrete method of modulation and method of correcting coding. Type of apply modulation, correcting coding or signal-code construction in the whole have considerable influence on the speed of data transmission and efficiency of the telecommunication system or network.

Some of modern methods of modulation, correcting coding and trellis modulation was considered in [1, 2]. On the basis of made researches it was set, that it is possible to increase the speed of data transmission and efficiency of the data transmission telecommunication systems and networks by the use of modernized known and offer new methods and facilities of forming and processing of signals. That is why there is actual the modernization of known and offer the new high efficient methods and facilities of forming and processing of signals.

Aim of this work there is a research of characteristics of offer variety of modulation – AMMC and research of possibility of its use in the modern data transmission telecommunication systems and networks for the increase of speed of data transmission and rise of efficiency of such systems and networks.

II. AMPLITUDE MODULATION OF MANY COMPONENTS

For the rise of efficiency of the data transmission telecommunication systems and networks it is expediently to use the author offered the new variety of modulation – AMMS, in obedience to which form a modulate signal as a sum of N harmonic components, that differ by the initial phases φ_n [3]:

$$u_{AMMC}(t) = \sum_{n=1}^{N} U_0 a_n u_{m_n}(t) \cos(\omega_0 t + \varphi_0 + \varphi_n), \quad (1)$$

where U_0 – amplitude of carrier; a_n – proportion coefficients for the n-s channels of modulator, that are the parameters of modulator; $u_{m_n}(t)$ – modulating signals on the n-s inputs of modulator; ω_0 - angular frequency of carrier; φ_0 - initial phase of carrier; t – time.

This modulation in common (with the exception of case, when $N = 2$ and $\varphi_1 - \varphi_2 = \pi/2$) is belonging to the class of orthogonal amplitude-phase modulations. Signal constellations of some AMMC-signals was shown on figure 1. On figure 1 the symbol d is mean a minimum possible distance between the near-by points of signal constellation (distance of Evklid).

III. RESEARCH OF THE BIT ERROR RATE IN THE TELECOMMUNICATION SYSTEM IN CASE OF USE THE AMPLITUDE MODULATION OF MANY COMPONENTS

For the calculation of probability of bit error in case of use in the telecommunication system the AMMC-signals the author suggested to use the following formula [4]:

$$P_{b\,AMMC} = \frac{n_{mid} \cdot Q_1\left(\sqrt{K_E \cdot \log_2(M_{eff}) \cdot \frac{E_{b_{mid}}}{2N_0}}\right)}{\log_2(M_{mid})}, \quad (2)$$

where n_{mid} – middle quantity of near-by points, that are round one of points of signal constellation; $Q_1(x)$ –

Gaussian function; K_E – coefficient, equal to the ratio of minimum difference of energies of two symbols, that belong to near-by points of signal constellation, to the middle energy of all symbols, that belong to non repeat points of signal constellation; M_{eff} – effective quantity of symbols in alphabet of modulated signal; $E_{b_{mid}}$ – middle energy of bit; N_0 – spectral density of power of additive white Gaussian noise.

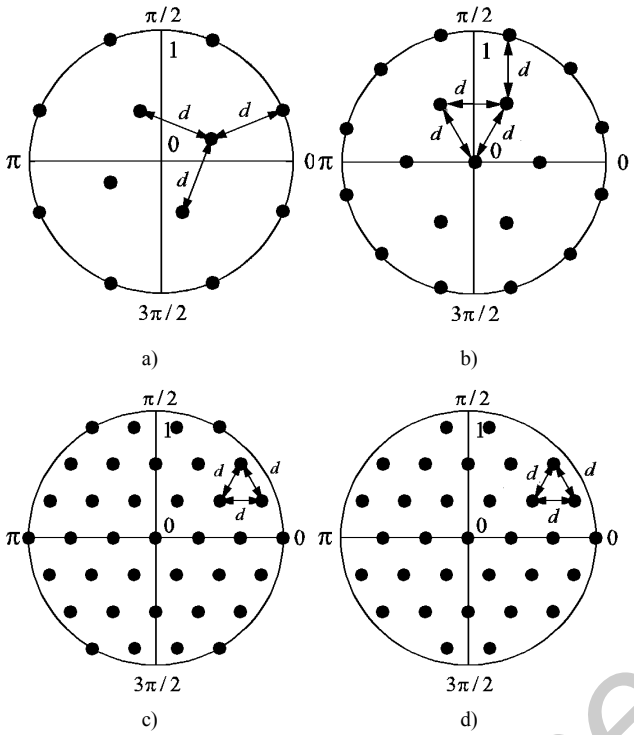

Figure 1. Signal constellations: a) 12-AMMC; b) 19-AMMC; c) 37-AMMC; d) 32-AMMC

Such formula can be using for the calculation of bite error rate in case of use in the telecommunication system not only AMMC-signals, but also PSK- and QAM-signals.

The results of computation of bit error rate in case of use in the telecommunication system the QAM- and AMMC-signals shown in table 1.

TABLE I. BIT ERROR RATE IN CASE OF USE IN THE TELECOMMUNICATION SYSTEM THE QAM- AND AMMC-SIGNALS

Modulation	Bit Error Rate
32-QAM	$3.135 \cdot 10^{-6}$
36-QAM	$1 \cdot 10^{-5}$
32-AMMC	$1.140 \cdot 10^{-6}$
36-AMMC	$4.325 \cdot 10^{-6}$
37-AMMC	$3.106 \cdot 10^{-6}$

The calculations carried out in case of ratio of middle energy of bit to the spectral density of power of white Gaussian noise $E_{b_{mid}} / N_0 = 15.93$ dB.

As a result of calculations evidently, that a bit error rate in case of use the 37-AMMC is smaller in 3.2 time by comparison to 36-QAM, and in case of use the 32-AMMC is smaller in 2.75 time by comparison to 32-QAM.

In such case an energy efficiency of the telecommunication system in case of use the 37-AMMC is higher from use the 36-QAM on 0.5 dB.

IV. SIGNAL-CODE CONSTRUCTIONS

In the modern telecommunication systems and networks for providing a high efficiency use signal-code constructions. Thus apply PSK or QAM with the double quantity of signal points of signal constellation by comparison to quantity of points, which are necessary for the transmission the information, and correcting coding with the code rate $(n_k - 1)/n_k$ (n_k – quantity of bits in the code word) [2]. This provides a code efficiency within the limits from 3 to 6 dB without expansion of stripe of admission of the telecommunication system. So far as it sets, that AMMC characterizes by the higher efficiency by comparison to QAM with the identical quantity of signal points on the signal constellation, expediently in place of QAM to use AMMC (for example, in place of 32-QAM to use 32-AMMC), that will rise the efficiency of the data transmission telecommunication system or network.

V. CONCLUSION

In this work the new variety of signal modulation – AMMC was considered. As a result of researches it was set, that a bit error rate in case of use the AMMC is smaller by comparison to QAM at the identical quantity of points of signal constellation. A frequency efficiency of the telecommunication system in case of use the AMMC is higher by comparison to QAM. The possibility of use of AMMC in case of construction of signal-code constructions was shown. Thus, offering by author the AMMC expediently to use in the modern data transmission telecommunication systems and networks for the increase the speed of data transmission and rise the efficiency of such systems and networks.

[1] Simon M.K. Bandwidth-Efficient Digital Modulation with Application to Deep-Spase Communications / M.K. Simon. – California : Jet Propulsion Laboratory, California Institute of Technology, 2001. – 228 p.

[2] Скляр Б. Цифровая связь. Теоретические основы и практическое применение : [пер. с англ.] / Б. Скляр. – 2-е изд., испр. – М. : Издательский дом "Вильямс", 2004. – 1104 с. : ил.

[3] Горбатий І.В. Амплітудна модуляція багатьох складових / І.В. Горбатий // Зб. наук. пр. (Ін-т проблем моделювання в енергетиці ім. Г.Є. Пухова НАН України). – К., 2009. – Вип. 50. – С. 186–190.

[4] Горбатий І.В. Системи дистанційного зондування Землі з космосу : монографія / І.В. Горбатий. – Львів : СПОЛОМ, 2011. – 612 с.