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THE METHOD OF NONORTHOGONAL FREQUENCY-DISCRETE MODULATION OF SIGNALS FOR NARROW-BAND COMMUNICATION CHANNELS

V. I. Slyusar and V. G. Smolyar

Kiev, Ukraine

The suggested computational procedures make it possible to perform frequency-division multiplexing of narrow-band communication channels based on the nonorthogonal discrete modulation of signals.

The method of orthogonal frequency-discrete modulation of signals (OFDM), which has found wide utility in communication systems, is intended for relatively wide-band information highways. In the case of narrow-band communication channels, OFDM loses its appeal.

The purpose of this paper is to consider an alternative to the OFDM method, which consists in nonorthogonal frequency modulation of signals and permits using a denser arrangement of carriers in the spectral domain.

As in traditional OFDM, assume that at the transmitting end the shaping of the signal, in conformity with the frequency-discrete and quadrature-phase modulation (QPM) principles, is carried out with the aid of a signal processor and a digital-to-analog converter. However, as distinct from the OFDM method, the frequency shift will not be associated with the maxima of amplitude-frequency responses of the filters, which ought to be synthesized at the reception end by means of the fast Fourier transform.

The procedure of signal demodulation in the receiver of messages will be derived under the assumption that the instant of arrival of the signal burst is known exactly. With the use of the maximum likelihood method and provided that the noise is noncorrelated and has the Gaussian distribution, we set up the informational equivalent of the likelihood function for the real-valued representation of the sum of M harmonic signals

$$L = \sum_{s=1}^{S} \left\{ U_s - \sum_{m=1}^{M} a_m \cos\left(\omega_m \Delta t (s-1) + \varphi_m \right) \right\}^2 \quad (1)$$

or, if denoting $a_m^c = a_m \cos \varphi_m$, $a_m^s = a_m \sin \varphi_m$, $p_{ms} = \omega_m \Delta t(s-1)$,

$$L = \sum_{s=1}^{S} \left\{ U_s - \sum_{m=1}^{M} \left(a_m^c \cos p_{ms} - a_m^s \sin p_{ms} \right) \right\}^2 = \min, \quad (2)$$

where U_s is the signal mixture voltage in the sth time sample, a_m is the amplitude of the mth harmonic signal, S is the total number of time samples to be processed ($S \geq 2M$), s is the ordinal number of ADC reading within the signal sample, ω_m is the circular frequency of the mth signal, and φ_m is its initial phase.

Here we assume that the amplitude of the signals remains unchanged during S samplings. As for the amplitude samples, they can be obtained by solving the likelihood equations

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