Calculation of the Peak-to-Average Power Ratio of Signals of OFDM Multichannel Systems

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Abstract—The analysis of the available in literature methods and results dealing with the calculation of the peak-to-average power ratio (PAPR) of baseband signals of multichannel systems using the orthogonal frequency division multiplexing (OFDM) has been performed. The correction of calculations was shown to be necessary in using the Rayleigh distribution law for the envelope of narrow-band normal random process.
The method based on the level crossing theory of random processes was proposed for calculations, and the required calculations were performed. The scattering of results for various methods was shown to amount to 0.5–2.0 dB in terms of the PAPR values and up to 100 times in terms of the probability values. The method based on using the normal law parameters proved to be most advantageous and accurate.

1. PROBLEM STATEMENT

In recent years the OFDM method has been finding the increasing application in multichannel systems. Such systems include advanced systems of mobile communication, digital TV systems, and the broadband access systems. The number of subcarrier frequencies (frequency channels) in mobile telecommunications amounts to about 200, while this number in digital TV is about 2000 or 8000.

The sufficiently full description of OFDM principles, the list of original sources, and a brief historical review are presented in paper [1]. For the first time this multiplexing method was used in US shortwave radio communication system Kineplex in 1958 [2, 3]. The US patent for this method was issued in 1970 [4]. The use of the fast Fourier transform for modulation and detection operations was proposed in 1971 [5].

The notion of peak factor (PAPR) of multichannel OFDM signal, which in the author's opinion is not quite correct, was first introduced in [8]. Paper [9] presents a somewhat different definition of PAPR.

A critical review of the technique used in [8] was performed in [10]; this paper proposed a different adequate method for determination of the multichannel signal PAPR, and new refined results were obtained.

The purpose of this study is to determine PAPR of signals in OFDM multichannel systems using the technique based on the level crossing theory of random processes and to compare the results obtained by different methods.

2. HANDLING THE PROBLEM

In case of using OFDM, channel (individual) signals represent sections of sinusoids with different amplitudes and phases. In this case the carrier frequencies of adjacent channels differ by a value of orthogonal spacing $F = 1/T_s$, where T_s is the duration of multiposition symbol.

Multichannel signal on one symbol interval T_s can be written in the form

$$S_\Sigma(t) = \sum_{k=1}^{N} \alpha_{kl} \cos\left(k\frac{2\pi}{T_s} t + \varphi_{kl} \right),$$

$$\frac{1}{T_s} = F, \tag{1}$$