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Methods for Improvement of Noise Stability at Reception of Messages in Radio-Engineering Systems of Remote Control and Monitoring

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Abstract—The paper considers the possibility for optimization of the envelope shape of spectrum-effective APM-signals using the criterion of maximum rate of decline of the energy spectrum of a random keying sequence.

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A number of important theorems in the theory of communications and information dwell on the assumption that the channels have a strictly limited passband. This means that outside the passband the signal power equals zero.

Thus we face a dilemma: the signals with a strictly limited band cannot be realized, since they must have an infinite duration, while the signals with a limited duration are easily realizable, but also unsuitable, because they bear energy at relatively high frequencies. Clearly, for all spectra with a limited band the signals are unfeasible while for feasible signals the absolute bandwidth is infinitely large.

All the above leads to the following assertion: the smoother is a signal in the time domain, the faster its Fourier transform diminishes. The smoothness of a function can be expressed in the simplest manner through the number of times of its differentiability. When we select signals in channels with a limited passband, we must first of all set as narrow band of frequencies as possible, and a level of off-band radiation low enough.

In addition, we have to ensure a small difference between the peak and average power of the radiated oscillation. In the acting communication systems the transmitted power levels and signal characteristics have an insufficient reserve for their optimization, while the methods of coding-decoding of signals are still far from their theoretical potentialities. Thus, in order to improve the energetic and spectral effectiveness of signals, new methods are to be introduced: special types of modulation—quadrature-amplitude (QAM), amplitude-phase (APM), frequency with continuous phase (FMCP); effective methods of formation of sequences—introduction of intersymbol interference (ISI), extension of channel alphabet, application of dependent signals, when the signal shape, corresponding to a given information symbol, depends on signals previously transmitted; application of various methods for diminishing the oscillation amplitude at the instants of phase jumps of the high-frequency filling, replacement of phase jumps themselves by their smooth variations, elimination of phase changes equal to 180°; going to signals, whose duration exceeds their repetition period; usage of spectrum-effective codes; digital realization of signal processing methods, etc.

There are several physical reasons for hampering the use of the existing types of signals: rectangular shape of pulsed signal trajectories resulting in jumps of amplitude, phase, or frequency and, hence, in expansion of the signal spectrum; non-optimality arising from empirical choice of envelope shape due to simplicity of such shaping (TRFM, PKFM, MKS, APM-ISI of the type $\sin(x)/x$); usage of filters at signal shaping (GMMS, Feyer's CPM).

When the low-frequency signals are shaped with the use of filters, not all shapes of envelopes are realizable. On the other hand, an increase in transmission speed leads to emergence of uncontrollable ISI, growing peak-factor of the oscillations, and to energy loss. Moreover, for each of several types of keying we must use a "peculiar" optimal filter, or some keying filter "averaged" for different modes of transmitter's operation. Thus the problem of selection of envelope's optimal shape is a matter of importance.