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Phase-Shift Keyed Wideband Signal against Noises Detection by Quadrature Receiver with Input Band-Pass Filter

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Abstract—In this paper we consider wideband signal against noise receiving by quadrature correlation receiver with input band-pass filter. We obtain analytical expressions of detection characteristics. We analyzed dependences of correct receiving on delay time, signal-to-noise ratio and input filter bandwidth. It is shown, that maximal probability of signal detection is obtained in case of non-zero delay time of received signal, which depends on filter bandwidth.

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At present time phase-shift keyed wideband signals (PSKWS) with phase shift keying according pseudorandom sequence (PRS) law are widely used in asynchronous address communication systems [1–4]. To select useful information during receiving of such signals with known frequency, it is necessary to define delay time of PRS begin. PRS begin is defined basing on output effect shaped by receiver. This effect is proportional to cross-correlation function (CCF) of received and reference signals. This result is compared with threshold, i.e. PRS begin is defined by operation of received signal detection [1–4]. If threshold is overcome then decision about signal presence is made and following systems is switched on and useful information selection begins.

In practice when procedure of PKWS detection by correlation receivers is considered, spectrum limitation of received signals by band-pass filters is usually is not taken into account. In the paper [5] they analyzed output effect distortion, which is made by band-pass filters, when PSKWS is received. But this consideration was carried in case of noise absence. Moreover, such signals quality essentially depends on random behavior of such signals parameters, like initial phase and amplitude. Thus, obtaining of these detection characteristics of PSKWS receiving against noise by means of quadrature receiver with band-pass filter application in case of random modification of initial phase and amplitude of input signals is practically interest.

Let band-pass filter input signal is additive mixture $x(t)=a_0 s(t-\varepsilon_0)+n(t)$, where a_0 is received signal amplitude, $s(t)=\sum_{k=1}^{N} p_k \operatorname{rect}\left[\frac{t-(k-1)\tau_p}{\tau_p}\right]\cos(w_0 t+\varphi_0)$ is PSKWS with PRS phase binary modulation and unit amplitude, $w_0=2\pi f_0$, f_0 is carrier frequency, φ_0 is random initial phase, according to uniform distribution at the inyrtval of $[-\pi, \pi]$; ε_0 is received signal delay time with regard to selected reference point; $\operatorname{rect}\left(\frac{t-(k-1)\tau_p}{\tau_p}\right)=\begin{cases}1, & (k-1)\tau_p \le t \le k\tau_p,\\ 0, & t<(k-1)\tau_p, t>k\tau_p,\end{cases}$ $k=1,\dots,N$ is PSWS elementary pulse envelope, which has rectangular shape with duration τ_p; $p_1,\dots,p_N$ are PRS code elements, which are +1 or –1, at that $p_k=P_{k\pm N}$; $n(t)$ is Gaussian stationery noise with zero mean value and correlation function of $\langle n(t_1)n(t_2)\rangle=(N_0/2)\delta(t_1-t_2)$, N_0 is noise spectral density. Further we suppose amplitude frequency response of band-pass filter has rectangular shape with bandwidth of Δw, i.e. filter pulse response is defined by relation $h(t)=k_0\frac{\Delta w}{\pi}\operatorname{sinc}\frac{\Delta w}{2}t\cos w_0 t$, $\operatorname{sinc} x=\frac{\sin x}{x}$, where k_0 is uniformity factor. In this case signal and noise components at the band-pass filter output can be represented correspondingly as

$$s_{\text{bpf}}(t)=a_0\hat{s}_{\text{bpf}}(t),$$