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RESEARCH OF MODERN DIRECTIONS OF RADIO JAMMING

Radio jamming is the deliberate blocking of or interference with wireless communications. Noise interference is often used to suppress the channels of radar stations. Usually, this interference is used in combination with other types of interference: diverting, intermittent (flickering), imitating, signal-like and others. During the creation of signal-like interference, the active jamming station emits an additive mixture consisting of the simulating interference $s_s(t)$ and the masking component $s_m(t)$

$$s_i(t) = s_s(t) + s_m(t) \quad (1.1)$$

Such interferences are called combined simulating and masking interferences (CSM-interference).

The masking component $s_m(t)$ in the form of noise is added to the signal (1.1) to complicate the recognition of the simulating interference on the receiving side in a suppressed radar station. This is due to the fact that during the formation of simulating interference, it is not always possible to reliably «fake» a useful signal. Therefore, the noise component is also included in the structure of interference, which complicates the operation of devices for recognition and selection of simulating interference. The portion of masking additive $s_m(t)$ is small and strictly dosed. This is necessary in order to prevent the possibility of switching the automatic tracking system by direction, for example, to tracking a source of noise interference.

The formation of the simulating component of CSM-interference jamming takes place in active jamming stations by means of amplitude, phase and frequency modulation of the reconstructed signal of the radar station. In order to obtain the maximum effect from the effect of CSM-interference, the envelope of the noise component, which can also be formed using the reconstructed signal, should ensure the creation of masking interference with the greatest masking properties in the space of the information parameter of the signal of the suppressed radar station.

When such a parameter is amplitude, the largest uncertainty is provided by intentional interference such as white or quasi-harmonic noise

$$s_m(t) = s_m(t) \cos[\omega_c t + \psi_n(t)]$$

whose envelope has the Rayleigh distribution

$$\rho(s_m) = \frac{s_m}{\sigma^2} \exp\left(-\frac{s_m^2}{2\sigma^2}\right), \quad (1.2)$$

where $s_m \geq 0$; σ – the root mean square value of the signal amplitude.

Therefore, the device for forming the interference envelope must form a digital image of the envelope $s_{md}(t)$ in the form of a sequence of numbers whose values correspond to the (1.2). In a digital device for storing and reproducing signals, distribution (1.2) can be implemented using a random number generator.

Since the simulating interference is emitted from one strictly fixed point, in which the antenna of the active jamming station is located, the distribution of the masking noise envelope according to (1.2) contributes, in addition to masking the simulating interference, to the creation of the effect of signal re-reflection by a collection of a large number of bright points. Such a set serves as a good statistical model for describing the effective scattering surface of a complex target, which is used in the processing algorithms of modern radar stations for signal detection and recognition.

A high degree of immunity to modern radio-electronic devices for various purposes is achieved primarily by the use of radio signals with complex frequency and phase modulation in combination with adaptive control of the power of the emitted signals. A clear example of such signals is complex frequency-modulated and phase-manipulated signals used in radar, radio navigation, and communication devices to increase the stealth of operation.

The use of radio signals with complex modulation, especially such as pseudo-random pulse sequences, has significantly reduced the effectiveness of suppression of radio electronic means by traditional noise and simple impulse interference. This prompted the development of a new direction of suppression of radio-electronic means, based on the use of signal-like interference. A distinctive feature of such interference is that their phase-frequency-time, spatial and polarization structure is practically no different from the similar structure of even the most complex radio signals of suppressed radio electronic means.

A prerequisite for the creation of highly effective signal-like interference is a detailed investigation of the signal structure of radio electronic devices, memorization of their information and associated parameters with the aim of subsequent reproduction at specified time intervals of corresponding copies of the output radio signals endowed with the necessary interference modulation. In modern active jamming station, this difficult task is most effectively solved with the help of two-channel amplitude-phase digital devices for memorizing and

reproducing signals. These devices allow to memorize the structure of any radio signals with a specified accuracy and reproduce it with a high degree of reliability at the right time, regardless of the type and complexity of the laws of amplitude and phase modulation of the output signal.

Despite the use of wide-band types of modulation, the radio signals used today are still mostly narrow-band, that is, quasi-harmonic.

A narrowband signal can be represented as the sum of two quadrature components:

$$s_c(t) = s_{cs}(t) + s_{ss}(t), \quad (1.3)$$

where

$$\begin{aligned} s_{cs}(t) &= s_{cs}(t) \cos \omega_0 t, \\ s_{ss}(t) &= s_{ss}(t) \sin \omega_0(t). \end{aligned}$$

In practice, in a digital device for memorizing and reproducing signals, the selection of quadrature components $s_{cs}(t)$ and $s_{ss}(t)$ occurs in the process of transferring the spectrum of the input radio signal $s_c(t)$ to the low-frequency region - to the frequency range of ± 125 MHz during theoretical consideration or in band 0...250 MHz in reality. For this transfer, two balanced mixers (multipliers) are used, which receive mutually orthogonal high-frequency $\omega_r \approx \omega_0$ reference oscillations, shifted in phase by $\pi/2$.

Since the received signal $s_c(t)$ is high-frequency and narrow-band, it can, in addition to representation (1.3), also be written in the form

$$s_c(t) = S_c(t) \cos \psi_c(t), \quad (1.4)$$

where $S_c(t)$ and $\psi_c(t)$ are, in the general case, random functions of time describing the envelope and high-frequency phase of the signal:

$$S_c(t) = \sqrt{S_{cs}^2(t) + S_{ss}^2(t)}; \quad \psi_c(t) = \arctg \frac{S_{ss}(t)}{S_{cs}(t)}.$$

Two forms of signal notation (1.3) and (1.4) allow us to propose two schemes of its digital processing. To represent (1.3) in the case of digital processing, it is necessary to form and process discrete samples of two quadrature components $s_{cs}(t)$ and $s_{ss}(t)$ in parallel. According to (1.4), both the envelope $S_c(t)$ and the phase $\psi_c(t)$ are discretized before digital signal processing. Thus, during sampling of narrowband radio signals for their digital processing, two samples can be taken at each reference point of the time scale. From here, the possibility of two-channel processing appears.