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УСКОРЕНА СИНХРОНИЗАЦИЯ В СИСТЕМИ СЪС СИГНАЛИ С РАЗШИРЕН СПЕКТЪР С ОПТИМИЗИРАНА СТРУКТУРА

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ACCELERATED SYNCHRONIZATION IN SYSTEM WITH SSS (SPREAD SPECTRUM SIGNAL) WITH OPTIMIZED STRUCTURE

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Abstract: *In the systems with spread spectrum signal the quasi-coherent acceptance can not be made without prior synchronization, because in the real conditions the phase, position of time and Doppler shift frequency are unknown.*

For the purposes of processing of quasi-coherent SSS should make the introduction of tracking devices in step with an accuracy determined by the area of the grip devices.

The accuracy of determining the frequency and the delay of the received signal must be determined by the appropriate intervals of the correlation of the signal.

To minimize the time for initial synchronization, the signal should be changed so that the autocorrelation function at each stage to be agreed with the necessary increase in aposteriority density.

Keywords: *synchronization, quasi-coherent acceptance.*

Introduction

As it is known, the development of aviation and space equipment led to the creation of compatible multi-functional radio communication systems.

It measuring of parameters of the movement of the controlled object, two-role synchronization and transmission of information are merged within a single radio engineering system, based on the multipurpose use of signals SSS a carrier of information.

As such a signal is used SSS.

The multiple roles allow simplifying on-board and ground equipment to reduce weight, dimensions and power consumption.

This is because SSS is typical for the presence of discrete and continuous parameters.

However in the high criteria in aviation-space systems on the quality of transmission of information increase the importance and role of the optimal methods for forming and processing of signals.

At the present time, coherent radio links are those that allow their properties to almost reach the conditions for optimal signal reception, but this is related to solving one of the most difficult problems the establishment of synchronization.

In conjunction with SSS systems the receiver does not know of two major parameters of the signal. This is the time of the initial phase of the code sequence and frequency of the carrier and each of them must be set before the start of the work in the receiver mode of reception information.

This work deals with this issue.

Initial conditions

In the transmission of analog messages λ (t) signal structure is known to the receiver and is not changed, so the optimal quasi-coherent reception of such signals materializes in rules, arising in particular from the results of the theory of nonlinear filtration.

In the case of discrete messages and dependence of SSS ever changing parasitic parameters (phase, delay) devices for quasi-coherent reception are significantly complicated.

Transmitted messages reflect random events or processes that determine their probability description.

If the message is determined at any moment of time, it describes a r andom process.

Broad class processes are random processes Markov, asked by the stochastic differential equations of the type:

(1) $$\frac{d\lambda(t)}{dt} = K_1(\lambda,t) + \sqrt{K_2(\lambda,t)}\xi(t),$$

where ξ(t) is white noise with unit spectral density K1 and K2 are the coefficients of transmission and diffusion process.

In the simplest type of expression (1) has type:

(2) $$\frac{d\lambda(t)}{dt} = -a\lambda(t) + n_\lambda(t),$$

who describing the process, formed by white noise $n_\lambda(t)$ in its passage through the RC filter.

The value of $\alpha = 1/RC$ is determined by time constant filter $T = RC$

From the choice of T depends on the width of the spectrum of the process $\lambda(t)$ and time correlation $\tau_k = 1/\lambda$.

Correlation function of the process $\lambda(t)$ is determined in this case by:

$R_A(\tau) = \sigma_\lambda^2 \exp\left(-\frac{\alpha}{\tau}\right)$, where σ_λ^2 is the dispersion process.

The Markov process described by equation (1) may be compared to the probability density equation:

(3)
$$\frac{\partial w(\lambda,t)}{\partial t} = \frac{\partial}{\partial \lambda}\left[K_1(\lambda,t) + w(\lambda,t)\right] + 0{,}5\frac{\partial^2}{\partial \lambda^2}\left[K_2(\lambda,t) + w(\lambda,t)\right] = L_{pr} w(\lambda,t)$$

Here L_{pr} is denoted by the operator of Fokker-Planck-Kolmogorov.

When describing the more complex messages accordingly using more complex models of processes Markov, but in this case is compounded only type of operator $L_{pr.}$

Modulation of information communications systems SSS can be implemented in any of the known methods.

In the case of Phase shift keying (Phase manipulation) SSS for the time period specified by pseudorandom sequence (PRS), the signal can be represented as:

(4)

$$s(t) = a_0 \sum_{k=1}^{N} rect\left[\frac{t-(k-1)\tau_i}{\tau_i}\right] \sin(\omega_0 t + \varphi_k),$$

where φ_k phase is receive discrete values in accordance with the law of the following symbols of the PRS.

In the case of binary phase manipulation signal (4) adopt kinds:

(5) $s(t) = a_0 g(t) \cos(\omega_0 t + \varphi_0),$

where g (t) is binary PRS described should cocoa

$$g(t) = \sum_{k=1}^{N} \nu_k rect\left[\frac{t-(k-1)\tau_i}{\tau_i}\right]; \nu_k = \pm 1$$

The phase shift keying SSS with phase modulation and analog message $\lambda(t)$ can be described by:

$$s(t) = a_0 g(t) \cos(\omega_0 t + \mu\lambda(t))$$

This signal is formed on the transmitting side

Initial synchronization in systems with SSS

In systems with SSS having base B >> 1 quasi-coherent acceptance can not be made without prior / home / base synchronization. In real terms in connection with the entry, the time position, phase, Doppler shift frequency of SSS are unknown.

It is therefore necessary to carry out a search in the space of SSS specified parameters, i.e. starting synchronization of the system. Search process requires significant resources of time and equipment, especially in a large a priori uncertainty. In connection with these issues and demand determination of SSS is an important task, which is independent in deciding the processes of synchronization in systems with SSS.

This is because the establishment of synchronous mode of receiver, you first need to decide the task of initial synchronization following the initial uncertainty of the frequency and time of reception of the signal.

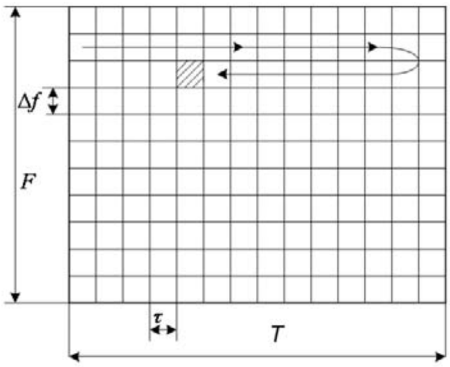
For the purposes of processing of quasi-coherent SSS should make the introduction of tracking devices in step with an accuracy determined by the area of the grip device.

Normally systems with SSS it is less than the area of uncertainty of the parameters of the signal, suggesting demand for SSS in the field of uncertainty.

The accuracy of determining the frequency and the delay of the received signal must be determined by the appropriate intervals Δf_k, $\Delta\tau_k$ of the correlation of the signal, limiting the area of grip.

So the whole area of uncertainty on the time-frequency plane can be divided into elementary rectangular final cell with number of countries $\Delta f = 1/2T$ and $\Delta\tau = 1/2F$, where T and

F are respectively the signal length and the breadth of its spectrum.
The search task is to recognize the M signals. The value of M to determine the number of cells in the area of uncertainty (Fig.1).



Фиг.1

Optimal rule of recognition to maximize the probability of correct decision is the calculation of the correlation integrals for all anticipated values of the parameters and decision in accordance with the maximum of them.

In the optimization of search criteria based on minimum time specified in the search for the correct detection probability of the signal, or most likely at this time of the search set.

Most long is the process of seeking a delay in SSS.

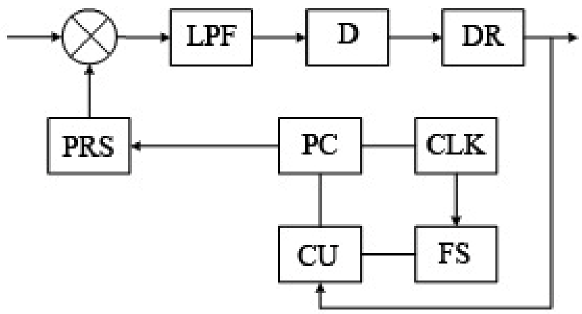
The most simple search on the delay is built on the basis of Single circuit containing pseudorandom sequence generator (PRS), multiplier, low-pass filter (LPF) detector (D), a decision device (DD), Fig.2.

In view of the delay control signal to supporting the scheme includes a control unit (CU), pulse counter (PC) device rejection (DR). Clock (CLK) generates a sequence which does count in determining the number of stroke to reside in a cell search.

After the expiry of the time of analysis $T_a = NT_i$, the meter is filled and submitted to the command in structure for management, which together with the device for rejection reject the required number of clock pulses, which change pseudorandom sequence delay.

Consequently, the timing of demand is determined by the number of cells analyzed and the time for analysis of each step.

The time required to search for signals with large base, such as SSS is great, especially in small relations signal noise.



Фиг.2

In this connection, using different procedures, acceleration of demand in late SSS: statement of purpose procedures, multi-search, use of composite sequences, use of special signals for starting synchronization and others.

The purpose of the proposed work is to establish requirements for the structure of SSS that under limited resources, minimizing initial synchronization time of the radio communication systems (RCS) for the transmission of information.

Requirements for the structure of SSS to accelerate the process of initial synchronization.

During an initial synchronization is necessary to remove the uncertainty of parameters λ.

In order to quantify the uncertainty, to apply the entropy of the probability density aposteriority.
Since aposteriority density depends on the realization of the disturbances, it is convenient to consider ensemble average in the implementation of aposteriority density, which depends on the type of signal.

Entropy of the average density is determined by the expression:

$$(6)\ H(t) = -\int_{\lambda} \langle w(t,\lambda)\rangle \ln\langle w(t,\lambda)\rangle > d\lambda ,$$

where

$$(7)\quad \langle w(t,\lambda)\rangle = k\langle w(t-T,\lambda)\rangle\ \langle F(t,\lambda)\rangle ,$$

k – нормиращ множител (...........FACTOR)
T – Time of observation

If we consider λ unenergetic parameter (time), and disturbance – white noise with spectral density $N_0/2$, function $\langle F(t,\lambda)\rangle$ may be presented as:

$$(8)\quad \langle F(t,\lambda)\rangle = \exp[qR(t,\lambda)] ,$$

where

$$(9)\quad q = \frac{F}{N_0}$$

is the ratio of signal energy to the spectral density of the disturbance.
$R(t,\lambda)$ – normalized autocorrelation function of signal

$$(10)\quad R(t,\lambda) = \frac{1}{E}\int_{t-T}^{t} s(t)s(t,\lambda)dt ,$$

Of (1) follows the expression for the rate of change of entropy.
(11)

$$\frac{dH(t)}{dt} = -\int_{\lambda}\frac{\partial\langle w(t,\lambda)\rangle}{\partial t}\ln\langle w(t,\lambda)\rangle d\lambda - \int_{\lambda}\langle w(t,\lambda)\rangle\frac{\partial \ln\langle w(t,\lambda)\rangle}{\partial t}d\lambda$$

The second integral in the above expression is zero because the function at any moment of time satisfies the condition for normalization.
Indeed, if a derivative $\frac{\partial \ln\langle w(t,\lambda)\rangle}{\partial t}$, we obtain
(12)

$$\int_{\lambda}\langle w(t,\lambda)\rangle\frac{1}{\langle w(t,\lambda)\rangle}\frac{\partial\langle w(t,\lambda)\rangle}{\partial t}d\lambda = \frac{\partial}{\partial t}\langle w(t,\lambda)\rangle d\lambda = 0$$

If we logarithmic right side of expression (7) and put it in expression (11), we obtain:

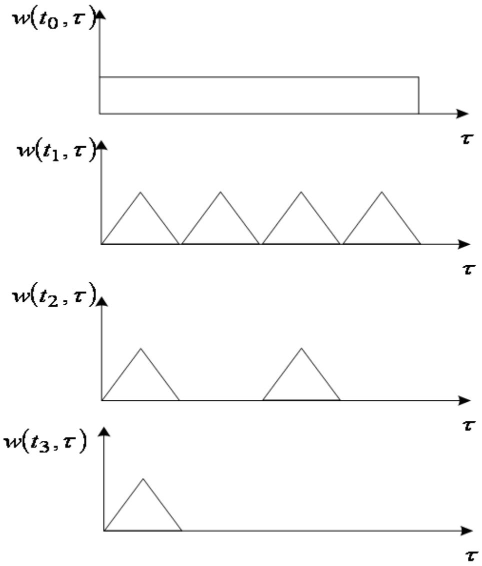
(13)

$$\frac{dH(t)}{dt} = -\int_{\lambda}\frac{\partial\langle w(t,\lambda)\rangle}{\partial t}\ln\langle w(t-T,\lambda)\rangle d\lambda - \int_{\lambda}\frac{\partial\langle w(t,\lambda)\rangle}{\partial t}qR(t,\lambda)d\lambda$$

To formulate requirements for the correlation function $R(t,\lambda)$, based on the conditions for changing the maximum entropy.

Requirements are implemented, if the relationship is satisfied:

$$(14)\ q\int_{\lambda}\frac{\partial\langle w(t,\lambda)\rangle}{\partial t}R(t,\lambda)d\lambda = \max R(t,\lambda)$$



Фиг.3

Expression (14) can be seen as a necessary condition for maximizing the rate of change of entropy. In accordance with the inequality of Schwarz-Bunyakovski can record:

(15) $$R(t,\lambda)=C_w\frac{\partial\langle w(t,\lambda)\rangle}{\partial t},$$

where C_{w_i} is a normalize factor and don`t depend on λ.

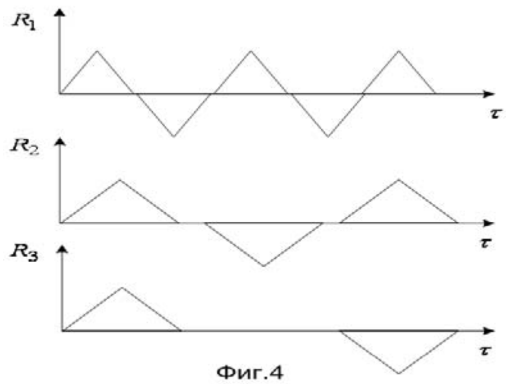
When the λ represents delay τ signal, it provided that autocorrelation function of the signal in the interval t_i, t_i+T does not change, we may write

(16) $$R_i(\tau)=C_{w_i}\left[\langle w(t_i+T,\tau)\rangle-\langle w(t_i,\tau)\rangle\right],$$

where C_{w_i} is a normalize factor for i stage.

Above ratio makes it possible to establish a link between the correlation function signal and the necessary law changing aposteriority density parameter τ in the transition from the stage of observation i to stage i +1.

As is known, the optimal receiver calculated aposteriority probability density of $w(t,\tau)$ in order to determine its maximum, which may be effected by means of a matched filter or multi correlation receiver.



Фиг.4

Determining the maximum of probability density aposteriority possible to use values consistent policy of calculating the $w(t,\tau_j)$, where τ_j accepts a final number of values at each stage. If the limit at each stage of binary solutions, i.e. implement phased division of the field of parameter uncertainty in half, then using the two-correlator can be found uncertainty to $log\frac{\Delta\tau}{\partial\tau}$ stages, where $\Delta\tau$ is the initial area of uncertainty, and $\partial\tau$ is the required final accuracy of determining the parameters.

Conclusions

The results show that the requirements in order to minimize the time for initial synchronization, the signal should be changed so that the $R_i(\tau)$ autocorrelation function at each stage to be agreed with the necessary increase in aposteriority density $w(t,\tau)$. This is possible through the implementation of SSS variable basis, the value of which doubled in the transition from one stage to another synchronization to achieve the desired value.

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