A Method For Creation Of An Autonomous Synchronization With Forecasting Of Random Fluctuations Of The Delay Of Radiocommunication Systems With Frequency Hopping Signaling

Antonio Andonov [1]

Abstract - This paper presents a new frequency synthesizer to realize coherent communication in frequency hopping spread spectrum and algorithm for the synchronization.

Keyword- Spread spectrum communication systems

I.COHERENT RADIOCOMMUNICA-TION SYSTEMS FREQUENCY HOPPING SIGNALING

If a sinusoidal signal of frequency f is transferred through the device, the gain and phase shift are given by [1]:

$$G = \exp\left\{-n\varepsilon\left[1-\cos\left(\frac{2\pi f}{f_c}\right)\right]\right\}$$

and

$$\nabla\theta = -n\varepsilon\left\{\left(\frac{2\pi f}{f_c}\right)-\sin\left(\frac{2\pi f}{f_c}\right)\right\} \quad (1)$$

where ε is the transfer inefficiency of CCD and f_c is the clock frequency.

The proposed synthesizer consists of a standard signal source, a CCD delay line and a switching circuit.

The proposed method gets the signal with different angle frequency from the standard signal with the same angle frequency ω_0. Many signals (called primitive signals) with the same angle frequency of the standard signal and the phases shifted θ-sequentially are prepared. These primitive signals are guided to the output through a switching circuit in the phase shifting order. The circuit is synchronized to one of the primitive signals and switching after each *k* cycle of the primitive signal is done.

Let T_s, called sampling interval, be the time interval between switching. The synthesized signal s(t) is expressed by (2):

$$s(t) = \sum rect(t-kT_s)\sin(\omega_0 T + k\theta) \quad (2)$$

For simplicity, the amplitude of the synthesized signal is unity. The phase difference between the synthesized signal and standard signal increases by θ per time T_s. Therefore the synthesized signal through this method can approximate the signal with angle frequency $\omega_{0+}\theta/T_s$. Let ω_d be the object angle frequency of desired signal, then sequential phase shift amount θ should be determined by (3):

$$\omega_d = \omega_{0+}\theta / T_s \quad (3)$$

Especially when θ= 2π/N, N=2,3,4,… synthesized signal can be maintained for arbitrary timelength by using N primitive signals iteratively.

Since -2π<θ<2π, the synthesizable angle frequency satisfies (4):

$$\omega_0 - \frac{2\pi}{T_s} < \omega_d < \omega_0 + \frac{2\pi}{T_s} \quad (4)$$

The synthesized signal has a type of distorted wave. Through Fourier expansion, the desired signal component has calculated. Supposing θ=2π/ N, the period T_d of synthesized signal s(t) is equal to Nt_s and its Fourier expansion is given by (5):

$$s(t) = \sum_{k=1}^{\infty} a_k \sin\frac{2k\pi}{T_d} + \sum_{k=1}^{\infty} b_k \cos\frac{2k\pi}{T_d} \quad (5)$$

In synthesized signals, only frequency components corresponding to k=(K+1)N±1, 1= 0, ±1, ±2,…. exist [1]. Their angle frequency $\omega^{\pm}_1$ is expressed by (6), using θ=2π/ N, $T_d=NT_s$, $\omega_0 T_s=2k\pi$;

$$\omega_1^{\pm} = \frac{2\pi}{T_d}k = \frac{2\pi}{T_d}KN \pm \frac{2\pi}{T_d}IN = \omega_0 \pm \frac{\theta}{T_s} + \frac{2\pi}{T_d}I \quad (6)$$

Substituting I=0, ω_0 equals the desired angle frequency ω_d. Then, the amplitude of the desired signal included in the synthesized signal A_d is evaluated by (7), [1]:

[1] Antonio Vladimirov Andonov is witch the Higher School of Transport, Geo Milev Str.158, 1584 Sofia, Bulgaria, e-mail : a.andonov@infotel.bg

$$A_d = \sqrt{a_{KN+1}^2 + b_{KN+1}^2} = \frac{\sin(\theta/2)}{\theta/2} \qquad (7)$$

The phase of the synthesized desired signal φ is determined by the phase of primitive signal at the synthesis start time.

$$\varphi = arctg\left(\frac{b_{KN+1}}{a_{KN+1}}\right) = \frac{\theta}{2} \qquad (8)$$

The phase of the desired signal can be varied by starting synthesis using a primitive signal with the corresponding phase. Letting the phase of a primitive signal be nθ, the phase of the desired signal φ also is shifted by nθ,

$$\varphi = \left(n - \frac{1}{L}\right)\theta \qquad (9)$$

Since a switching circuit is synchronized to one of primitive signals, the desired signal with the same phase is obtained every time the synthesis start. Thus this method can control the phase of the synthesized desired signal, freely and always reproduces the phase. An interval $1/T_s$ exist between the desired signal and each spurious component. If T_s is small enough, the spurious components are put out of the communication channel band. That is, T_s should be set satisfying (10):

$$T_s < 1/F \qquad (10)$$

Thus no spurious components are considered to exist within the communication channel band.

Let the delay time be m cycle of primitive signal, $2m\pi/\omega_0$, m=1, 2, 3,….., and N taps be placed at an equal interval. If m and N are prime to each other then all the N waves of primitive signals satisfying $\theta = 2\pi/N$ an be obtained. If m and N have common divider except for one, duplication exists among N waves of primitive signals. Especially if m=IN±1, (I=0, 1, 2,..), the shifting order of primitive signals by θ and the tab sequence order agree.

Using all these primitive signals sequentially, a desired signal with angle frequency θ_d satisfying (2) can be synthesized. If every other primitive signal is selected, then each phase is shifted by 2θ. The angle frequency in this case differs by θ/T_s from the former case. In general, if primitive signals are selected so that each phase is shefted by nθ , then the angle frequency of synthesized signal ω_d I, trough (3), evaluated by (11):

$$\omega_d = \omega_0 + \frac{n}{T_s}\theta \qquad (11)$$

II. ALGORITHM FOR THE SYNCHRONIZATION IN RADIO COMMUNICATION SYSTEMS

The described algorithm is applied in publication [2]. On the basic of Markov-theory of optimal non-linear filtration a problem is set and being researched for the estimation and maintenance of autonomous synchronization in the system for radio communication among remote moving objects.

REFERENCES:

[1] Andonov A. The problem of functional stability of the systems of mobile radioconnections. Sofia, VTU, 1996

[2] Andonov A., V.Kadrev Algorithm for the synchronization in radio-communication systems with coherent discontinuous variation of the working frequency. ICEST 2002