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# OVERVIEW OF SYNCHRONIZATION TECHNIQUES IN ULTRA-WIDEBAND COMMUNICATION SYSTEMS

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*The main synchronization methods for ultra-wideband communication systems are described, the principle of each method to identify the system weaknesses is explained and the requirements for the design of highly stable ultra-wideband telecommunications systems are formulated.*

Trends in the development of ultra-wideband (UWB) communication systems are given due to the presence in them of a number of advantageous factors to narrowband telecommunication systems. Among the advantages the following should be noted: high secrecy link (thanks to the low power spectral density of a UWB signal), high subscriber capacity, the ability to achieve high data rates, good noise immunity [1-2]. Furthermore, due to attenuation of the broadband the short-pulse signal is sufficiently small in different environments [2].

An important factor that contributes to the correct operation of UWB systems is to synchronize the transmitter and receiver. In UWB radiolocation devices the synchronization task is not a technical complexity, because the structure of such systems usually involves placing the transmitter and receiver in a single general corps or the chassis, depending on the structural elements. The transmission clock signal in this case is provided by a standard wireline. But in telecommunications systems, the receiver and transmitter are away from each other at some distance. It is necessary to synchronize them using a wireless communication channel. Today, there are several ways to solve this problem. Thus it is necessary to analyze the existing approaches in order to create optimal criteria for high-precision and stable synchronization in the construction of the UWB communication systems.

**Using two independent channels** (Fig. 1). The essence of the acquisition process is to use two independent radio channels - radio UWB or wideband (WB) with frequency-modulated (FM) and phase-modulated (FM) radio signals, which concurrently uses, for example, a code sequence clock signal. Moments phase changes or frequency of WB radio signal should correspond to the time windows UWB radio signal at the center of each time window. The synchronization acquisition and maintaining it at regular intervals of time, during which the UWB radio signal does not go beyond the time window for all destabilizing factors, are provided by WB radio channel. In the intervals between the clock signals WB radio can transmit other information. Isolation moments phase changes or frequency WB radio signal are carried out in its amplification processes, conversion to an intermediate frequency and to digital form by an analog-to-digital converter (ADC) and the subsequent processing of the wavelet filter [3].

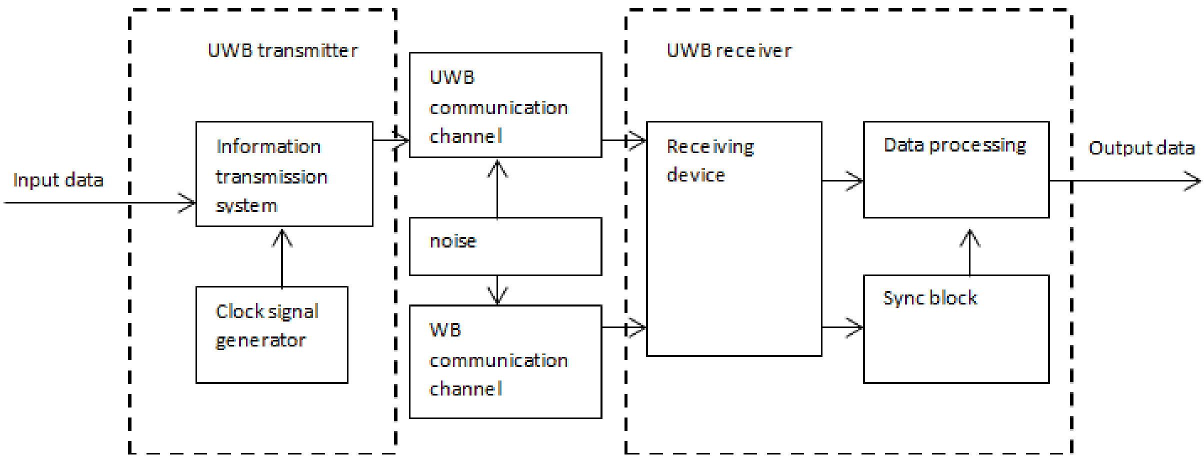


Fig. 1. A generalized block diagram of the UWB communication system with two transmission channels

The disadvantage of this system is the only operation in the absence of multipath in the WB radio channel [4].

**Correlation processing code sequence in the multipath propagation.** Unlike the previous method, the system uses one common channel for UWB communication and data synchronization. The essence of the synchronization acquisition process is to use any part of the code sequence multipath UWB signal [5]. Due to the increased pulse stream, multipath correlation processing operation is carried out with a model pulse stream and, in the case of coincidence of system, synchronization is acquired. When thresholding of at least one part of the reflected multipath after checking for synchronization, the system performs rapid capture. Thus, the method of synchronization is to receive the pulse signal, the measurement model (copies) of the pulse stream, finding a pulse signal due to the shift up pulse stream until they match.

The disadvantage of this system is non-functionality in a mobile version as well as the fact that the condition of multipath unexpectedly varies depending on the distance and the relative position of the receiver and the transmitter [3].

**Method of fast synchronization.** The method for identifying an input UWB signal phase involves several steps: receiving input pulses of UWB signal pulses which arrive adjacent at fixed intervals; local generation of pulses in the UWB receiver; correlation with the local pulse input pulses and receiving the correlation function; determination of the maximum of the correlation function for each shift of local pulses in the UWB receiver, determining a first maximum in the first phase interval, the analysis of the correlation function to find the second pulse which exceeds the first peak; search intervals around the second peak around the second phase interval and determine whether it is indeed the second maximum [3, 6].

**Method of fast synchronization with a floating threshold.** The method consists of receiving the input UWB signal, formation of copies in the UWB receiver, analyzing the input UWB signal and comparing with its copy with a predetermined threshold, receiving the comparison result, a shift input copy when the analysis result is larger than the predetermined threshold, changing the threshold value, repetition of these comparisons, the input offset copies [3, 7].

The disadvantage of the above two methods in the efficiency of the system is only high signal / noise ratio at the receiver input.

**Synchronization with increased accuracy and synchronization stability** (Fig. 2). The structure of this system includes at least two radio stations each of which has a common transmitting (Tx) and reception (Rx) side. The transmitter of the first radio station emits at each interval Tx clock and data signals, and the receiver of the second station receives these signals and using a local digital frequency synthesizer (DFS) based on the pulse-system phase locked loop (PSPLL) tunes and synchronizes its Rx slots at intervals of Tx first radio station to an accuracy of the phase. Increased accuracy is achieved by the fact that the first radio transmitter and receiver of the second station begins to work from one reference oscillator to the first station. Similarly, the second radio transmitter radiates in each interval Tx clock and data signals, the first radio station and the receiver receives these signals, and using the first radio DFS synchronizes their slots Rx Tx intervals of the second station up to the phase. As a result, two PSPLL synchronous systems are formed, each running on its own reference oscillator. The synchronization is saved for all the destabilizing factors and in the high-speed mobile devices [4].

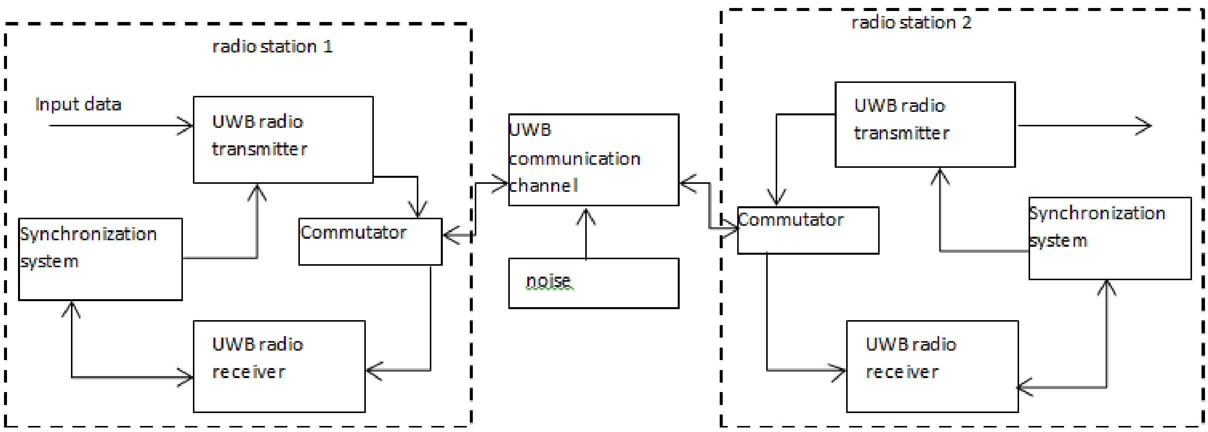


Fig. 2. A generalized block diagram of a UWB communication system with improved accuracy and stability of synchronization

The disadvantage of this method is increasing costs at the time of synchronization acquisition.

As a result of the analysis of the methods, the following general requirements for the device synchronization, when designing a highly stable UWB communication system, were formed: the ability to work in the mobile version of multipath signal propagation, low probability of de-synchronization, high noise immunity, high degree of synchronization accuracy (up phase) in order to minimize data loss on the receiving side and the minimum time of synchronization acquisition.

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