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Review on Synchronization of Timing Offset for UWB-IR Receivers

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Abstract— The engrossment of Ultra wideband is growing rapidly and its growth has been tremendous specially in short-range wireless communications in the past few years for a various range of applications. Ultra wideband (UWB) has significance for both high-data-rate (HDR), and low-data-rate (LDR) short range communications. IN wireless communication for high data rates Ultra Wide Band technology is a reliable transmission scheme. In this paper for single user in IEEE 802.15.4a channel data aided (DA) synchronization is used for both coherent and Non-coherent UWB-IR receivers. Before every transmitted sequence random timing offset using Walsh codes is estimated which further act as pilot sequence to achieve timing synchronization. To perform correlation of received bit stream sliding correlation window of appropriate length is used. For a peak value at an instant, Autocorrelation of Walsh code is performed. This instant of peak is estimated as symbol boundary. In order to show the performance of pilot sequence, Error variance Vs SNR (dB) and its BER performance is plotted for different lengths of pilot sequences in different environments. It can be further helpful to mitigate the negative effects of timing offset.

Keywords—Ultra-wide band Impulse radio (UWB-IR), IEEE 802.15.4a channel model, Sliding correlation window, Walsh code, Error variance.

I. INTRODUCTION

The growing of capacity in wireless communication requires a new type of method, which does not interfere with current systems. UWB is the new technology that fulfils those requirements and is growing fast especially in the short range indoor wireless communication, for example, in wireless personal area networks (WPAN). These properties of UWB give rise to fine time resolution, rich multipath diversity, low probability of detection, enhanced penetration capability, high user-capacity, and potential spectrum compatibility with existing narrowband systems.

Impulse radio UWB are baseband pulses of very short duration. However, one of the most critical challenges in enabling the unique benefits of UWB transmissions is timing synchronization, because the transmitted pulses are narrow and have low power density under the noise floor. Frequency up-conversion and down-conversion is not required in the transceiver due to carrier less nature of IR-UWB. This nature of signal reduces the complexity and power consumption of transceiver. It further makes IR-UWB suitable for low-complexity and low power wireless sensor network applications. It can be used with high bandwidth in short data transmission range. Between the received signal and a transmit-waveform template timing synchronization in wireless communication systems depends on the sliding correlator .

Power spectral density for these devices is -41.3 dBm/MHz, or 75 nW/MHz. Transmission systems in UWB has 500 MHz as its instantaneous spectral occupancy or more than 20% of fractional bandwidth. In UWB short data pulses are transmitted. It is immune or invulnerable from problems such as sensitivity, fading or multipath effects, due to extremely short duration of pulses which the existing systems now days suffer. The information here is encoded in baseband signal and does not require a continuous carrier frequency, due to which UWB does not suffer from problems including sensitivity to multipath propogation.

UWB consists of very short duration in order of nanoseconds. These pulses called monopulses. The signal energy here is expanded consistently. The energy of these narrow pulses are widened over a few gigahertzes, due to which the signal becomes ultra wideband. Monopulse pulses are spaced consistently in time having pulse duration near about few hundred to a thousand times, due to which the pulse further are considered as pulses with train of low-duty-cycle. The power consumed by an Impulse Radio depends on the duty cycle. UWB pulses consist of very small duty cycle. The need for extremely large data rate at very low power spectral densities over short distances can be fulfilled by UWB technology. In applications such as radar, communications, and geolocation, UWB is becoming more and more attractive.

II. LITERATURE REVIEW

Anshul tyagi et al. data aided synchronization is used for both coherent and non coherent receivers. Synchronization can be achieved easily in coherent receiver in low SNR environment as compared to non-coherent receiver. Also BER performance

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of synchronised coherent receiver is better than synchronised noncoherent receiver in different environment[6]. Ashish Thakre and Amol Dhenge et. al For UWB performance evaluation different types of pulse shaping and modulation schemes are used. By using Bit Error Rate effects of modulation technique and pulse shaping techniques are investigated in the presence of UWB technology [9].

III. SYNCHRONIZATION BLOCK DIAGRAM

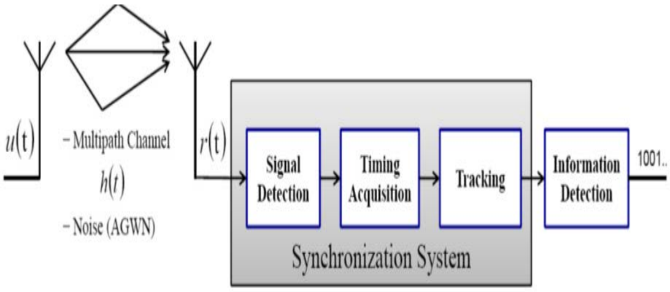

Fig.1: SYNCHRONIZATION SYSTEM BLOCK DIAGRAM

From above fig, the synchronization block is divided into three parts: signal detection, timing acquisition and tracking. The first part is Signal Detection, for deciding if the signal received is desired UWB signal or noise only. Timing Acquisition is the second block, which is also known as coarse synchronization. It is employed to find the approximate initial point of the each symbol being received and also used to reduce the timing error of UWB pulse duration. Tracking is the third step. It is used to maintain and lock the satisfactory synchronization in the presence of timing offset.

IV. PULSES USED FOR UWB

For UWB communications usually the pulse shapes are the Gaussian pulse, the first derivative of Gaussian pulse also called Gaussian monocycle and the second derivative of the Gaussian pulse known as Gaussian doublet. There are also other pulse shapes available such as the Laplacian pulse, the Hermite pulse, the Rayleigh pulse and the Gaussian pulse. Basicaly the pulses can be of any shape whose spectrum satisfies FCC spectral mask for UWB signals. Gaussian pulse of Higher-order derivatives are the most popular pulse shapes. In UWB technology pulse shape is an important lineup for as its spectrum is determined by the pulse shape and pulse width. There are two factors comprising UWB. Firstly the energy in expanded in frequency to minimize the interference and the power spectral density. Secondly in order to maintain the antenna radiation efficiency dc component is avoided.
The different types of monopulse shapes are:

- Gaussian first derivative,
- Gaussian doublet which is also known as Rayleigh monocycle or Scholtz monocycle,
- RZ Manchester
- In above three pulses dc component are not present and consist of wide 3-dB bandwidths. They also have balanced positive and negative excursions.

V. MODULATION TECHNIQUES FOR UWB

In communication to prevent system from interference modulation techniques are used. There are different types of modulation schemes used for UWB system. The modulation techniques used are as follow:

- pulse position modulation (PPM)
- on-off keying (OOK)
- binary phase shift keying (BPSK)

All the modulation schemes used above are digital. Adaptive modulation techniques such as QAM can also be used for UWB communication.

VI. UWB SIGNAL MODELLING

An impulse radio UWB-IR system is to be considered, here every symbol that consists of N_F pulses over N_F frames i.e one pulse per frame are transmitted over T_S period. Every frame of duration T_f contains N_c chips.
The symbol waveform of duration $T_s := T_f N_f$ is

$$p_T(t) = \sum_{j=0}^{N} p(t - j T_f - c_j T_c)$$

where, $p_T(t)$ denotes un ultra-short pulse and
$T_c := T_f/N_c$ is nothing but the the chip duration with pseudorandom time-hopping (TH) codes.
We consider that the symbol waveform has unit energy

$$\int p_T^2(t)dt = 1$$

By considering the pulse amplitude modulation (PAM), where symbols s[n] $\in\{\pm 1\}$ containing the information are fashioned as binary independent and are uniformly distributed with energy which is expanded over N_f frames. The transmitted UWB waveform is then given by

$$u(t) = \sqrt{\mathcal{E}_s} \sum_{n=0}^{\infty} s[n] p_T(t - nT_s)$$

where signal u(t) propogates through multipath channel.

VII. UWB SIGNAL DETECTION

At the receiver, detection of the received signal r(t) and identifying the symbol-level offset n_s takes place. The detection symbol identification are achieved by using the dirty template data-aided (DA) algorithms. In DA method fixed length bits are sent in each transmitted frame. The performance is analyzed in IEEE 802.15.4a channel.

VIII. TIMING ACQUISITION AND ESTIMATION

Basically timing synchronization is the main problem in UWB. Timing synchronization includes Timing Offset Acquisition and Tracking.

A. Acquisition

Timing acquisition is the difficult task in the UWB systems mainly due to following problems

- Low transmitted power
- High-resolution multipath, making decision much more complex .

Further Imperfect synchronization degrades the reliability of transmission and affects the performance of UWB-IR
To minimize this difficulty of synchronization, DA method is adopted, in which fixed length pilot bits are sent prior to each transmitted frame. This pilot sequence has good auto correlation property, which help in estimating the symbol boundary.

As DA synchronization is performed in this paper, so to analyze its performance in IEEE 802.15.4a channel, Error variance of timing offset estimation is calculated with increasing SNR (dB) for different preamble length. Error variance VS SNR and its BER performance in different channel models are two measures that are analyzed and discussed.

B. Timing Offset Estimation

Timing offset acquisition and tracking (fine synchronization) are further parts of timing synchronization. Here we have performed DA algorithm using IEEE 802.15.4a Channel mode. In this algorithm a predefined preamble sequence is sent prior to each data sequence.
The diagram for transmitted frame structure is as given below in Fig.(1)

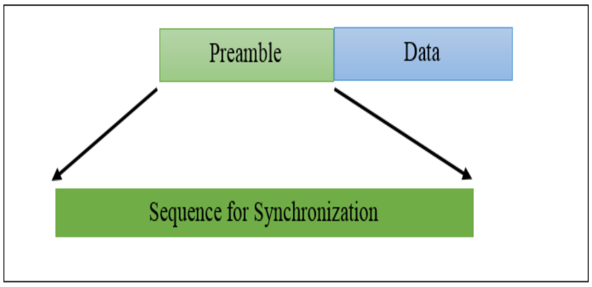

Fig.1: frame structure of each symbol

A physical layer standard for low-data-rate (LDR) systems has been developed by IEEE 802.15.4a group. The application set includes e.g., management, sensor networks for process control, asset tagging and supervision of storage halls.

The procedure to estimate the symbol boundaries is clearly shown in Fig.(2). Here received bit stream are correlated with sliding window. After this a peak value at an instant is obtained by autocorrelation of Walsh code. This instant of peak is estimated as symbol boundary.

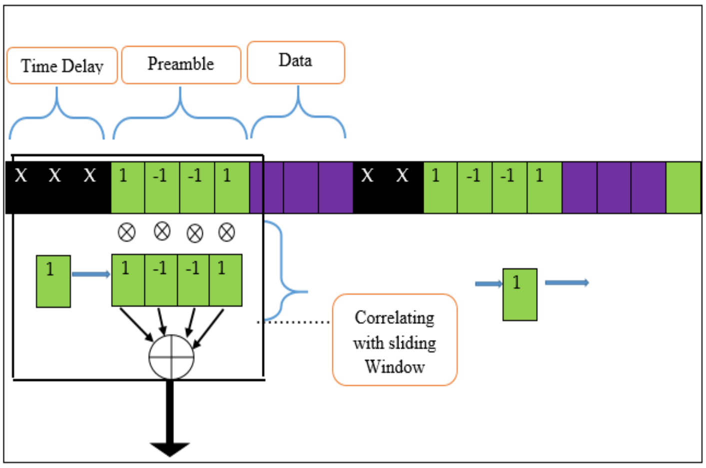

Fig.2: Diagram indicating Correlation of received bit stream with 4 bit Walsh code

C. Tracking

After detecting UWB signals and estimating the timing offset, next target is the maintenance of synchronization between the receiver and the signals to be received. In order to alleviate the effects of timing offset variations due to transmitter receiver motion (Doppler effects) and to maintain the transmission quality, tracking unit is used. For tracking purpose, we will use Delay-Locked Loop (DLL) approach which is considered as structural tracking technique for spread-spectrum devices and UWB communication. For improving the tracking performance in UWB systems several DLL schemes have been proposed. It further enables timing offset variations in the received signals and also used to enhance the BER performance.

IX. CONCLUSION

After literature survey it has been observed that by using DA algorithm, synchronization can be achieved easily in coherent receiver in low SNR environment as compared to non-coherent receiver.Also BER performance of synchronised coherent receiver is better than synchronised noncoherent receiver in different environment.

Further by using adaptive modulation techniques higher throughputs and better spectral efficiency can also be achieved.

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