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Survey and Analysis of SDR based Frame Synchronization using Barker Codes

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Abstract: With the exponential growth in the ways and means by which people need to communicate-data communications, voice communications, video communications, broadcast messaging, command and control communications, emergency response communications, etc. - modifying radio devices easily and cost-effectively has become business critical. Software defined radio (SDR) technology brings the flexibility, cost efficiency and power to drive communications forward, with wide-reaching benefits realized by service providers and product developers through to end users. Modern communications protocols are not simply streaming bits at 100% duty cycle. Instead, they use packets/frames. At the receiver, identification of frame is necessary when a new frame begins. Preamble contains a synchronization sequence that the receiver uses to detect start of frames, and it is a sequence known by the receiver beforehand. In this paper, frame synchronization using Barker Codes (BC) for various Frame Length (FL) (taken frame lengths are 3,4 and 13) by applying different modulation techniques like Binary Phase Shift Keying(BPSK) and Quadrature Phase Shift Keying (QPSK).

***IndexTerms* – SDR, BC, FL, BPSK, QPSK.**

I. Introduction

Various forms of communication have evolved over the millennia. The spoken word can be transmitted from one person, and heard or received by another. In modern times town criers hold an annual contest to discover who can shout a comprehensible message over the greatest distance. However, while the world record is for loudest crier is 112.8 decibels, it can only be understood at less than 100 meters. The desire to communicate more effectively than shouting, is old as speech itself. With modern advances in computing technologies, digital signal processing and digital communication algorithms, artificial intelligence, radio frequency (RF) hardware design, networking topologies, and many other elements have evolved modern communication systems into complex, intelligent, high-performance platforms that can adapt to operational environments and deliver large amounts of information in real-time, error-free. The latest step in communication systems technology is the software-defined radio, or SDR, which adopts the most recent advances in all fields to yield the ultimate transmitter and receiver. An SDR system is a complex device that performs several complicated tasks simultaneously in order to enable the seamless transmission and reception of data. In general, a digital communications system consists of an interdependent sequence of operations responsible for taking some type of information, whether it is human speech, music, or video images, and transmits it over-the-air to a receiver for processing and decoding into a reconstructed version of the original information signal. If the original information is analog (like audio), it must first be digitized using techniques such as quantization in order for us to obtain a binary representation of this information [R. C. Johnson and W. A. Sethares,2003; A.Priya, Rajesh, R.Muthaiah, 2013;C. Hayes, A. R. Margetts,et.al,2016;,D. Arnitz and M. S. Reynolds, 2016; Y. Zeng, B. Clerckx, and R. Zhang, 2017;,A. Forenza, S. Perlman,2015]. Once in a binary format, the transmitter digitally processes this information and converts it into an electromagnetic sinusoidal waveform that is uniquely defined by its physical characteristics, such as its signal amplitude, carrier frequency, and user of the spectrum is not using it, an SDR can borrow the spectrum and assign it to a secondary user until the owner requires it again phase This technique has the potential to dramatically increase the optimal use of available spectrum.

i. Compactness and power efficiency

The software radio approach, however, results in a compact and in some cases, a power-efficient design. As the number of functionalities increase, same piece of hardware is reused to implement multiple interfaces thus less number of different hardware components are required as well as power consumption is lowered.

ii. Ease of upgrades

In the course of deployment, current services may need to be updated or new services may have to be introduced. A flexible architecture of SDR allows improvements and addition of already existing or new functionality through software only instead of replacing the hardware platform or user terminals.

DISADVANTAGES OF SDR

i. Analogue to digital converters limit top frequencies that can be used by the digital section.
ii. For very simple radios the basic platform may be too expensive.
iii. Development of a software defined radio requires both hardware and software skills.
iv. Poor dynamic range in some SDR prototype designs.
v. It is difficult to write software to support different target platforms.
vi. SDR architecture consists of analog RF front end and digital front end. Hence it is challenging to implement interfacing between analog and digital modules or blocks.
vii. For few simple radio system designs, SDR platform may be expensive.

APPLICATIONS OF SDR

i. Mobile communications
Software defined radios are very useful in areas such as mobile communications. By upgrading the software, it is possible to apply changes to any standards and even add new waveforms purely by upgrading the software and without the need for changes to the hardware. This can even be done remotely, thereby providing considerable savings in cost .
ii. Research & development
The software defined radio, SDR is very useful in many research projects. The radios can be configured to provide the exact receiver and transmitter requirements for any application without the need for a total hardware design from scratch.
iii. Military
The military have made much use of software defined radio technology enabling them to re-use hardware and update signal waveforms as needed.
iv. SDR for Android
One of the platforms for which SDR applications have been developed is Android. The software SDR Touch turns the phone in to a SDR receiver whose range fluctuates between 50MHz and 2 GHz in AM, FM and SSB depending on the used hardware. There is also another software called Pocket HAM Bands Transceiver who allows the remote listening of SDR receivers.
v. Amateur Radio
Radio hams have very successfully employed software defined radio technology, using it to provide improved performance
vi. Commercial applications

II. BARKER CODE

In communication technology, a Barker code, or Barker sequence, is a finite sequence of digital values with the ideal autocorrelation property. It is used as synchronising pattern between sender and receiver.

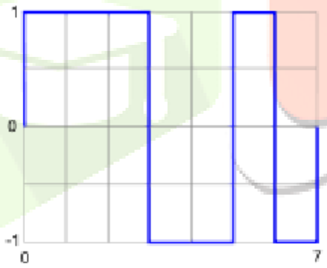

Fig.1 Graphical Representation of Barker Code

Barker codes are named after their inventor R.H. Barker, who examined 6000 different polynomials in a study published in1953. This resulted in the list of the 9 known Berker codes.(simple negations or inversions of the pulses sequence would also be possible but are faded out here).later computer-aided investigations investigated pulse sequence up to a code length of $n=4.10^{33}$,but found no other code sequences to which this requirement also applies.

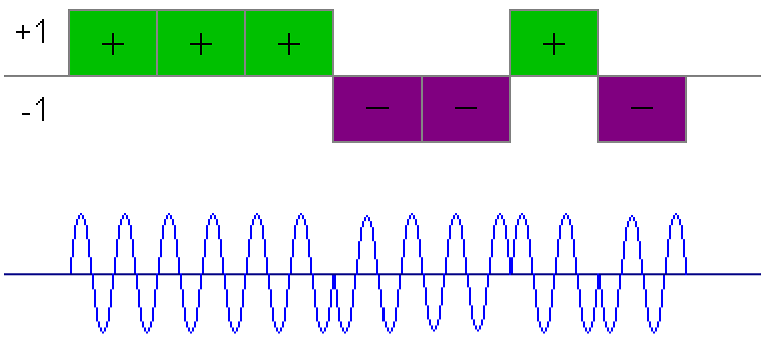

Fig.2 Representation of Barker Code

III. FRAME SYNCHRONIZATION USING BARKER CODES

Use a length 13 Barker code frame preamble for frame synchronization of data bits.

Based on detection of a Barker code preamble, the model performs frame synchronization on frame bits. To load the model and to configure the runtime preamble setting, call back functions are used. For more information, see model call backs (Simulink).

i. When loading the model, a Post Load call back initializes the preamble value of the preamble detector block.

ii. For runtime execution, call back gets the runtime setting for the preamble from the Barker Code Generator block.

The Barker Code Generator block outputs a bipolar (-1,1) signal that must be converted to unipolar (0,1) for transmission as the preamble of BPSK signal frame. After modulation signal is root raised cosine (RRC) filtered, then a fixed delay and AWGN impairments corrupt the signal and its timing. [R. Heath, 2012; A. Hussain, B. Por Einarsson,et.al, 2015;W. Tranter,2004; National Instruments,2015; K.-U. Schmidt and J. Willms, 2015] After adding impairments, the model applies RRC filtering to the received signal. To align the output signal with a valid clock reference, the Symbol Synchronizer block corrects the clock skew between the transmitted and received symbols**.**

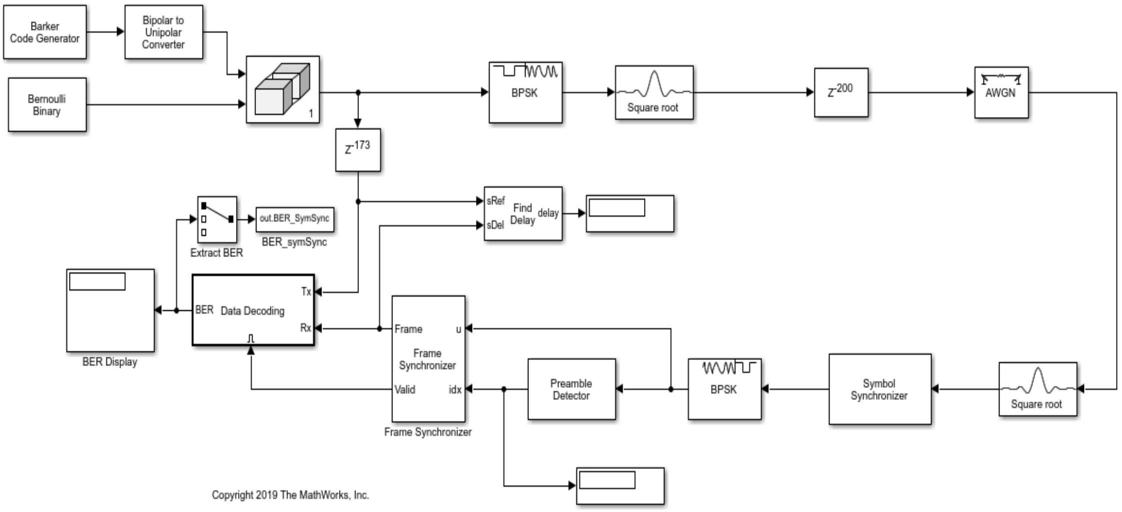

Fig.3 Block Diagram of Barker Code

To align the bit stream along correct frame boundaries and to determine valid frame indicators in the demodulated bit stream, the Frame Synchronizer block uses the start of packet index detected by the Preamble Detector block. The BER Data Decoding subsystem calculates the bit error rate (BER) and stops the simulation when 100bit errors are counted. The model displays the BER achieved.

IV. RESULTS AND DISCUSSION

In this paper, the study of frame synchronization is observed at the receiving end where SDR is applied. The observations are Baker code frame length of 3,4 and 13 by applying modulation techniques like BPSK and QPSK.

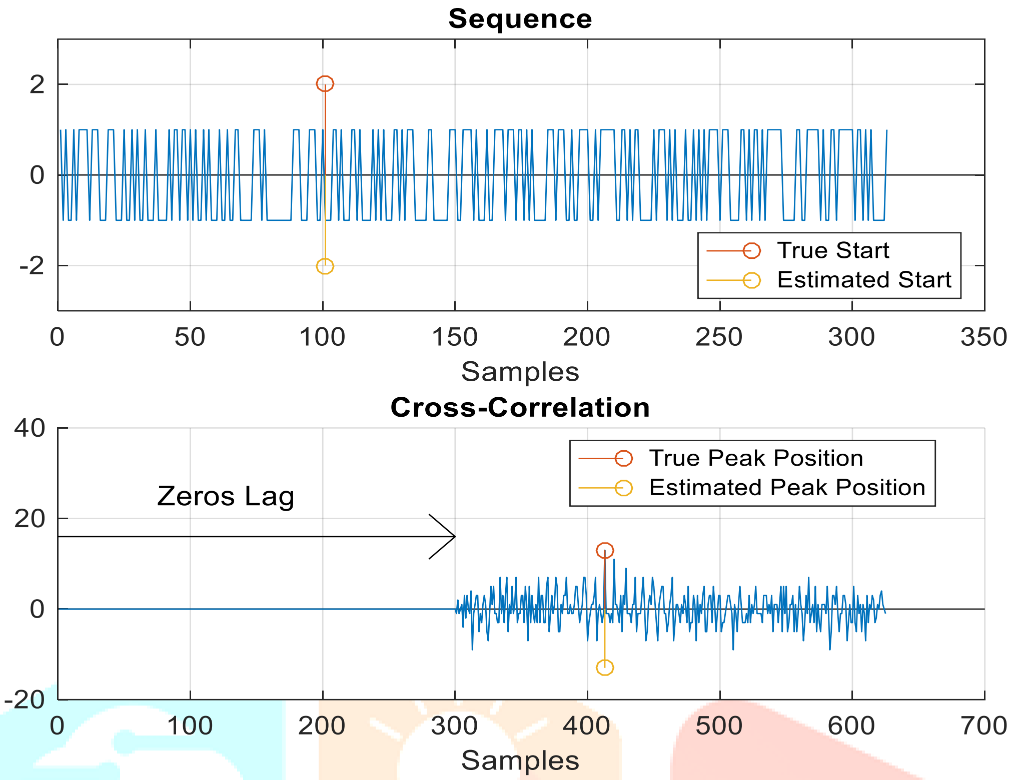

Fig.4 Observation of cross correlation using sequence length 13

The performance of the system using Cross correlation is observed for Barker code by taking Sequence Length 13.The simulation is done using MATLAB16.

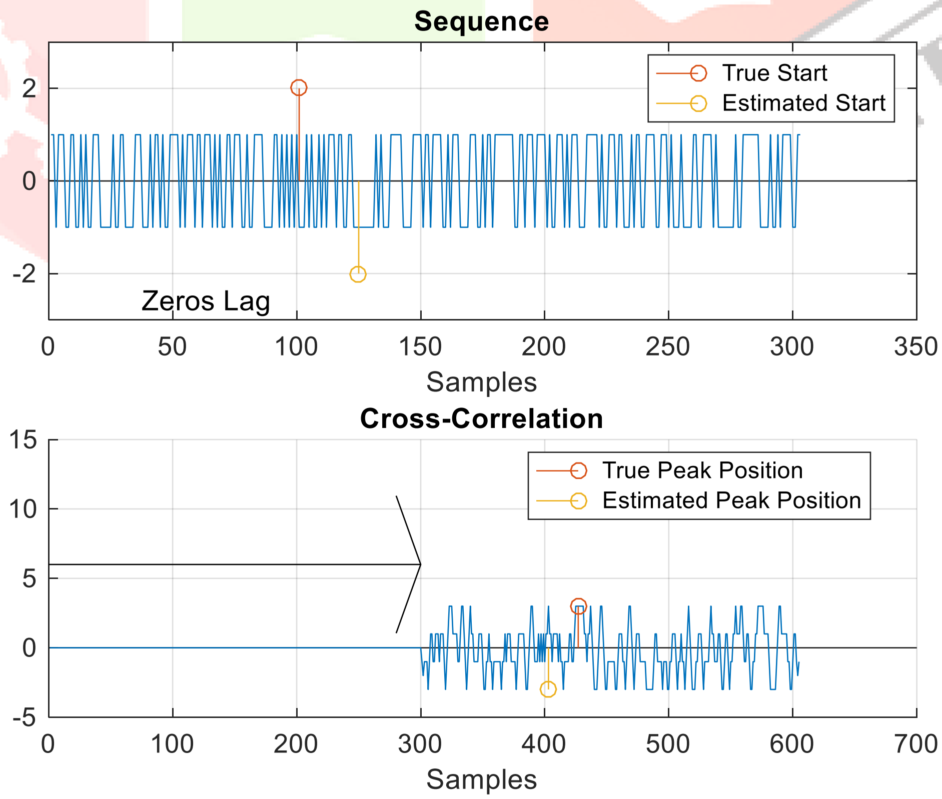

Fig.5 Observation of cross correlation using sequence length 3

The performance of the system using Cross correlation is observed for Barker code by taking Sequence Length 3. The simulation is done using MATLAB16.

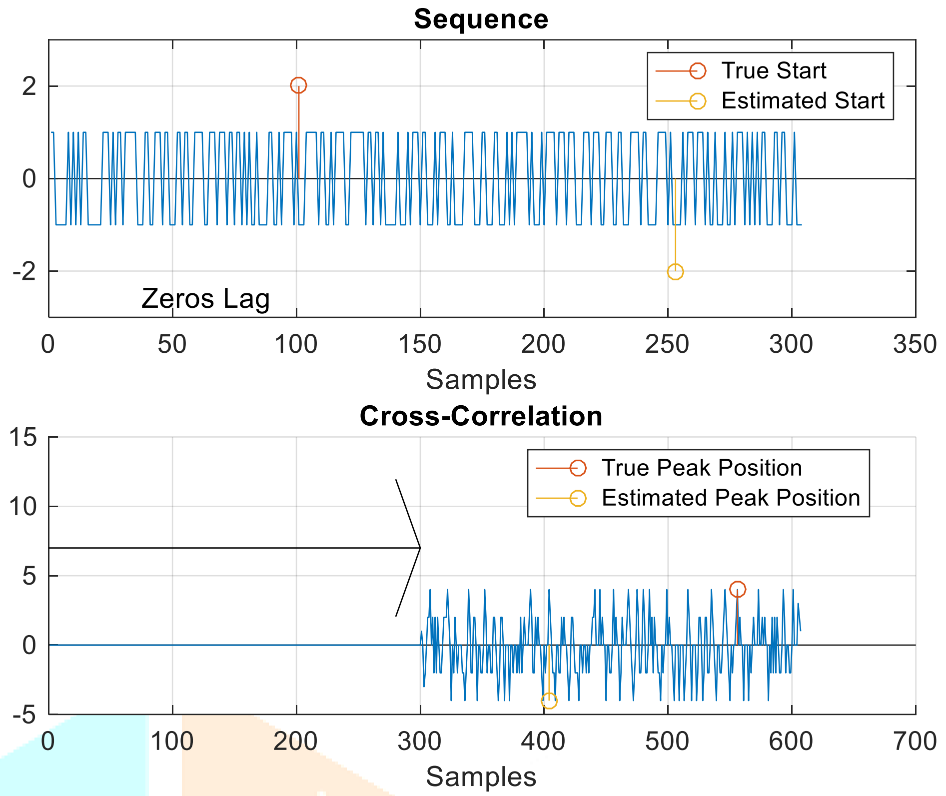

Fig.6 Observation of cross correlation using sequence length 4

The performance of the system using Cross correlation is observed for Barker code by taking Sequence Length 4. The simulation is done using MATLAB16.

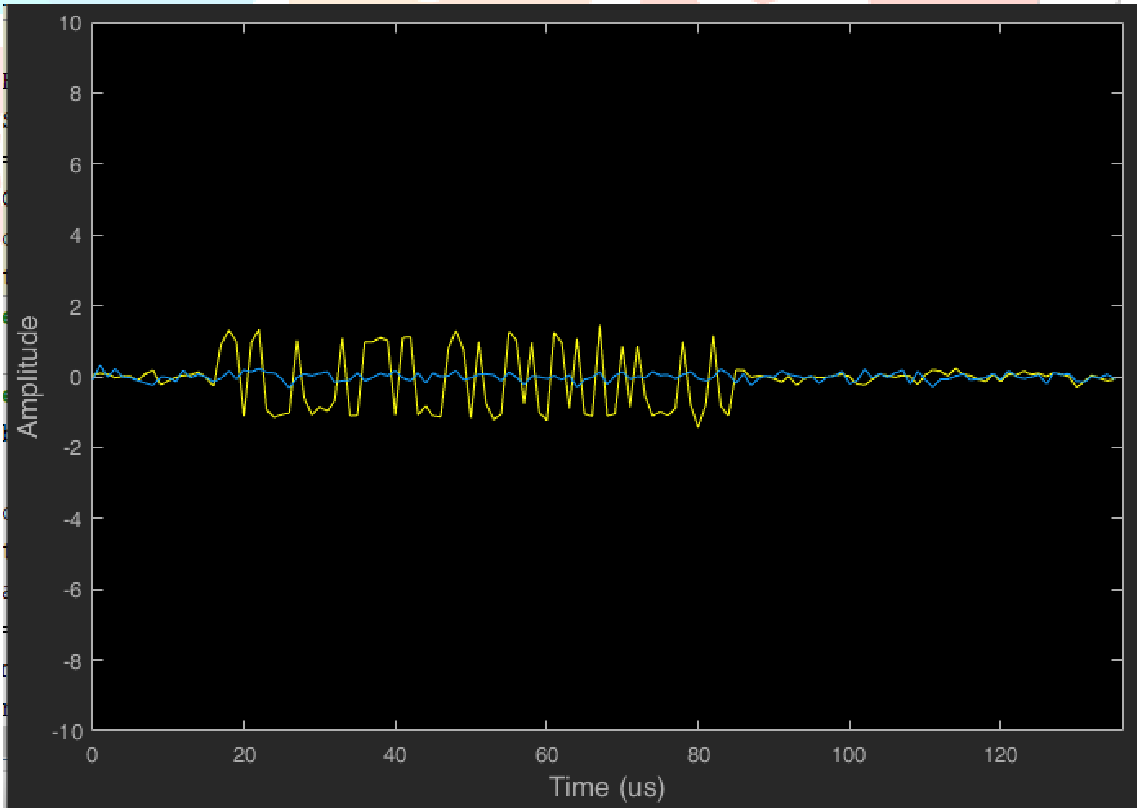

Fig.7 Observation of frame synchronization for sequence length 13 for BPSK

The frame synchronization of the system is observed for Barker code by taking Sequence Length 13. The observation is done by applying BPSK modulation technique.

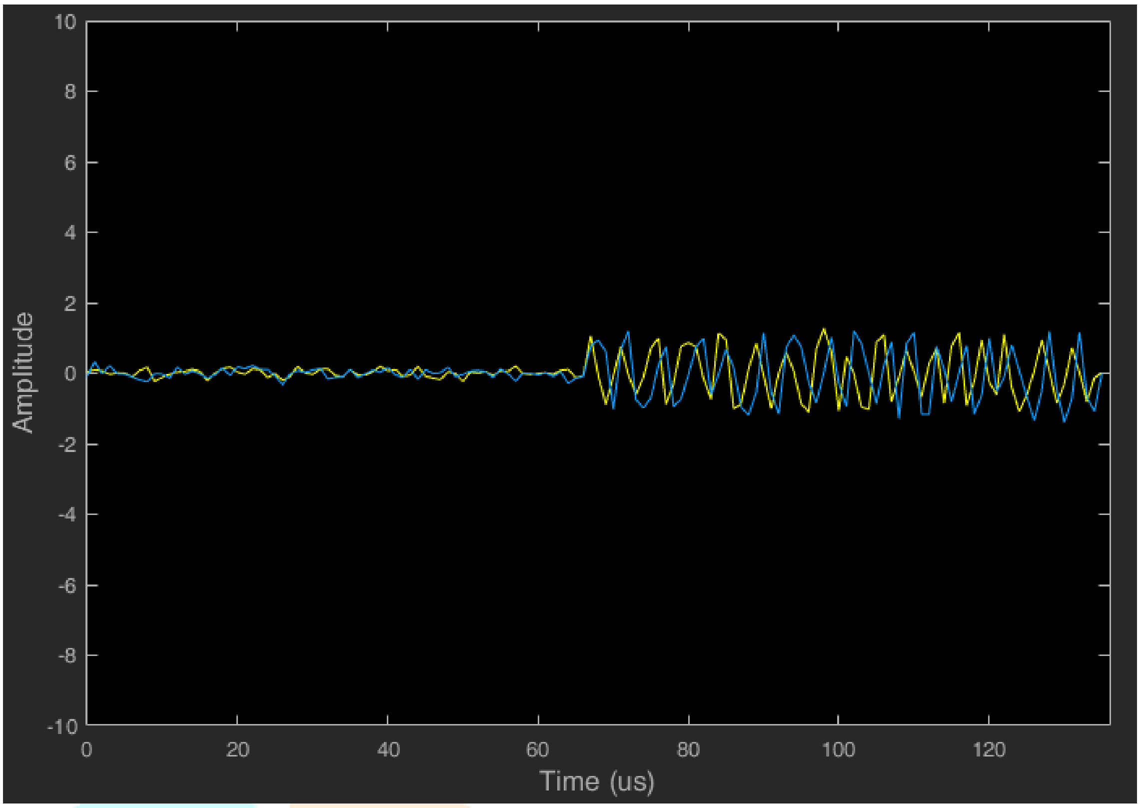

Fig.8 Observation of frame synchronization for sequence length 13 for QPSK

The frame synchronization of the system is observed for Barker code by taking Sequence Length 13. The observation is done by applying QPSK modulation technique. From the result it is observed that as modulation technique changes there is a change in the frame synchronization.

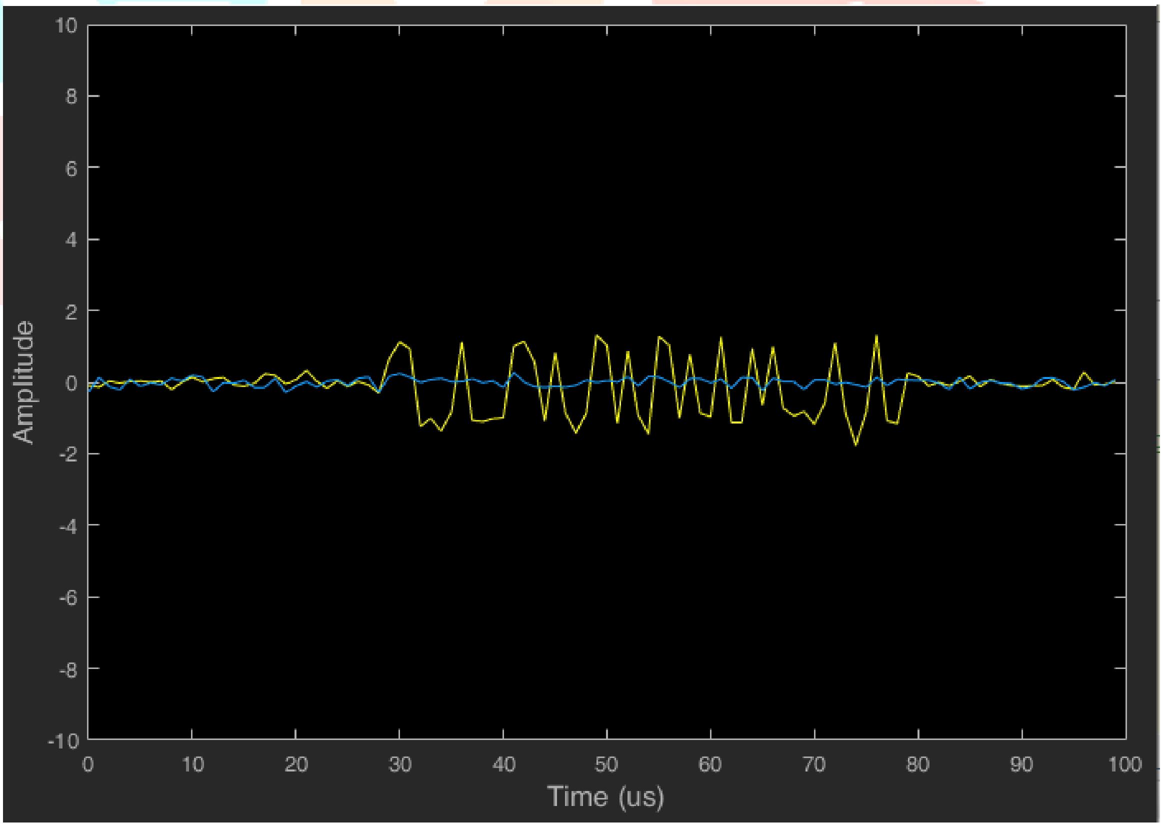

Fig.9 Observation of frame synchronization for sequence length 4 for BPSK

The frame synchronization of the system is observed for Barker code by taking Sequence Length 4. The observation is done by applying BPSK modulation technique.

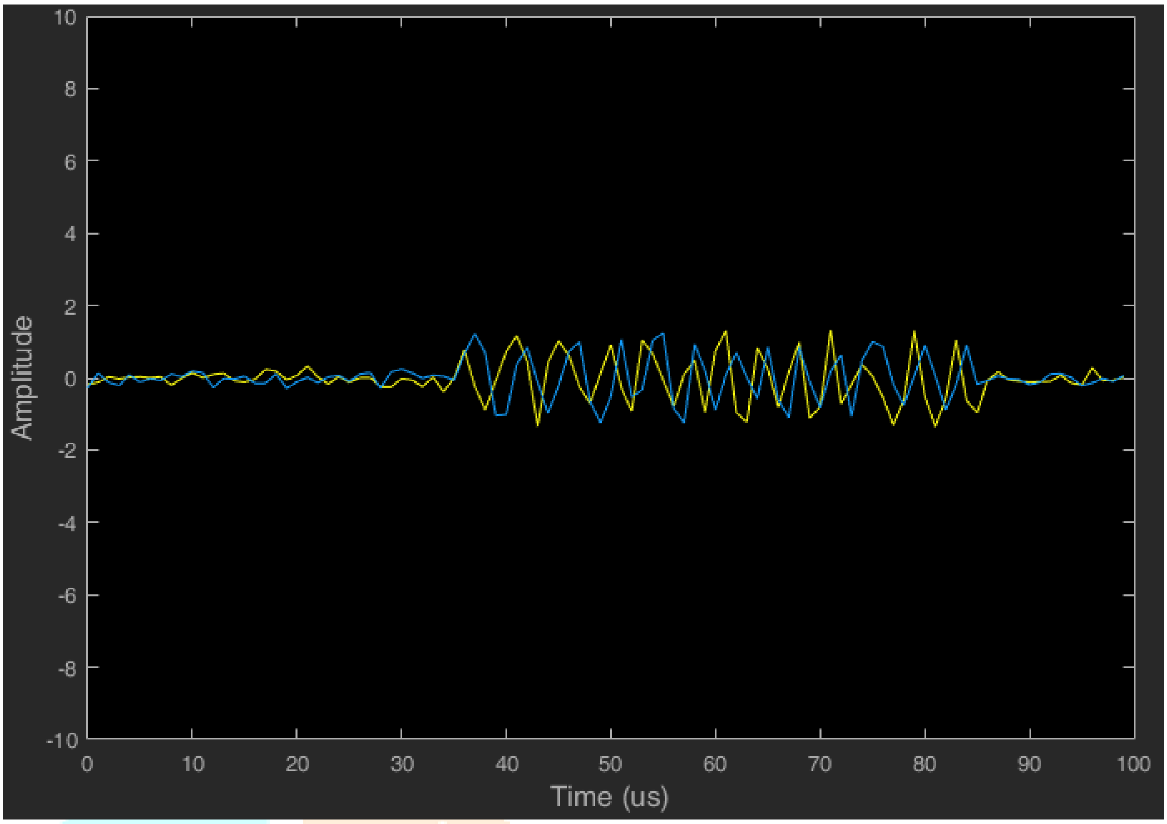

Fig.10 Observation of frame synchronization for sequence length 4 for QPSK

The frame synchronization of the system is observed for Barker code by taking Sequence Length 4. The observation is done by applying QPSK modulation technique. From the result it is observed that as modulation technique changes there is a change in the frame synchronization. Frame synchr

V. Conclusion

In this paper, the study of frame synchronization is observed. The observations are for Baker code frame length of 3,4 and 13 by applying modulation techniques like BPSK and QPSK. Cross correlation and frame synchronization is observed for various lengths. From this observation, there is change in frame synchronization as modulation techniques changes.

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