Frame Synchronization

Frame synchronization is the process of aligning the reception at the receiving end of a communication system with the corresponding transmission end as the transmissions occur. For example, you transmit a series of frames; however there may be gaps in between frame transmissions. At the receiver side you need to know where each frame actually starts in order to decode the data. Thus, you will need to implement frame synchronization to do this.

Frame synchronization involves the following steps:

In the first step, the transmitter injects a fixed length symbol pattern, called a marker, into the beginning of each frame to form a marker and frame pair, which is known as a packet. Packets are then converted from symbols into a waveform and transmitted through the channel. The receiver detects the arrival of packets by searching for the marker, removes the markers from the data stream, and recovers the transmitted messages.

Marker detection is the most important step for frame synchronization. In this experiment you are going to use MATLAB to implement a system that uses a 13-bit barker code for frame synchronization and eventually incorporate the USRP into it.

Barker code

A barker code is a sequence of N values $a_j \in \{\pm 1\}, j = 1, \dots, N$ such that:

$$\left| \sum_{j=1}^{N-t} a_j a_{j+t} \right| \leq 1, \qquad \forall 1 \leq t < N$$

Barker codes are commonly used for frame synchronization in digital communication systems. Barker codes have a length of at most 13 and possess low correlation side lobes. A correlation side lobe is the correlation of a code word with a time-shifted version of itself.

Table 1

Code Length	Barker Code
1	[−]
2	[−+]
3	[− − +]
4	[− − +−]
5	[− − − + −]
7	[− − − + + − +]
11	[− − − + + + − + + − +]
13	[− − − − − + + − − + − + −]

1) Why would we need a code with low correlation side lobes?
2) Write a function in Matlab that getting two digital input sequences, outputs their correlation.
3) Use this function to calculate the autocorrelation of the Barker codes as listed in Table 1.
4) Provide the resulted plots below and describe what you notice in all of the plots.
5) Based on these plots, can you define sidelobe level ratio in dB for Barker codes of different lengths?
6) Based on your answers, what do you think is the reason for the popularity of this code in Frame synchronization for example in IEEE 802.11?
7) In the USRP system, we append a Marker sequence built of Barker code with length 13 to the beginning of each data frame for the frame synchronization purposes.

   Based on the autocorrelation properties of this Barker sequence explored so far, how do you think we are going to find the beginning of the frames? Please explain your method based on the correlation function that you wrote in the first step and assume that the Barker code is available at the receiver as well.
8) Why do you think we are using the Barker code of length 13?
9) Maximum Length Sequences (generated with Linear Feedback Shift Registers) include significantly longer sequences than Barker codes and have similar correlation properties. Find two popular use cases of these sequences and explain the reason for using them instead of Barker codes in them. (*Hint: analyze your answers to Questions 3, 4 and 7*).