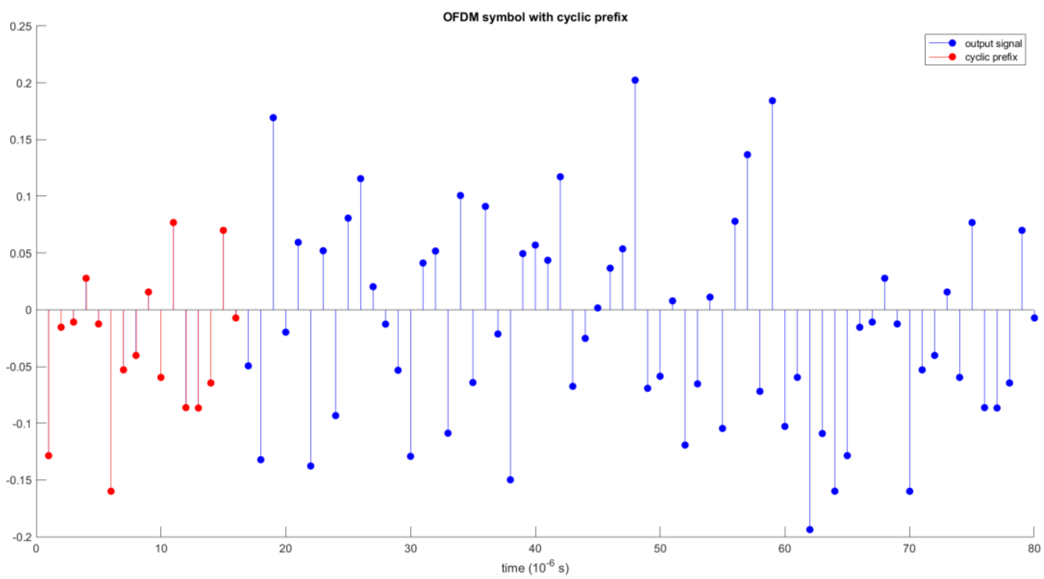
Communication Systems Lab

Lab 3: OFDM & Frame Synchronization

B11901110 電機三 陳璿吉

1. OFDM signal generation and reception
   A. Generate 1 OFDM symbol with the cyclic prefix. Plot the generated signal in the time domain right before upsampling (**a** in Fig. 1) with the x-axis in μs. Mark the cyclic prefix part. Briefly describe the figure.

      The OFDM symbol with cyclic prefix is shown in the figure below.

      We can observe that the length of the signal is 80, instead of 64 because we added a prefix to the front. The prefix is the last 16 data points of the signal, from index 65 to 80.

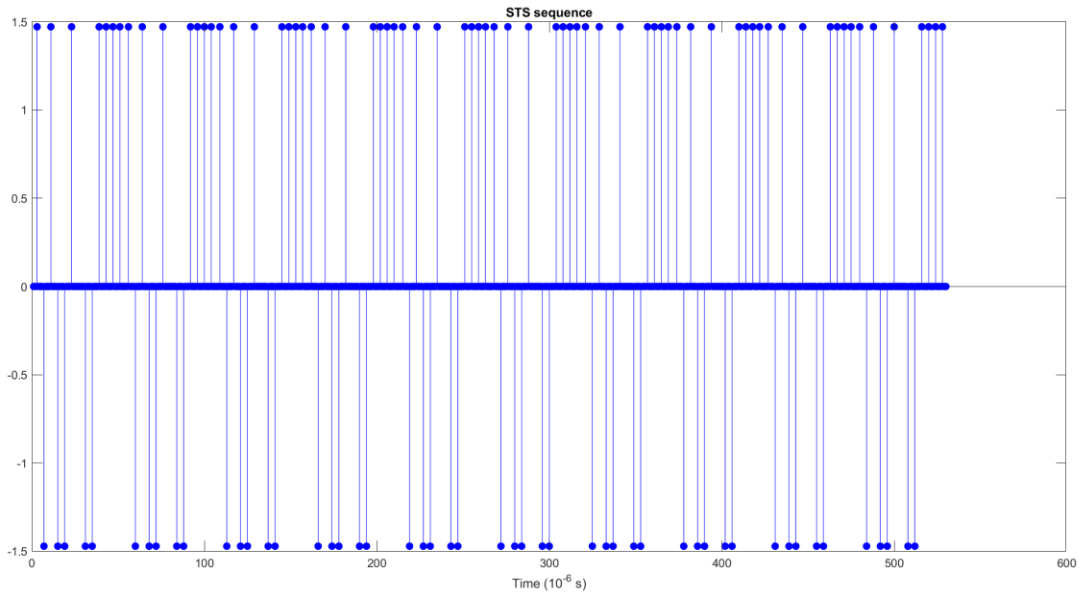
   B. Plot the OFDM signal in the frequency domain after upconversions (b in Fig. 1). The x-axis is in GHz. Briefly describe the figure.
   C. Plot the received signal in the frequency domain after the cyclic prefix is removed (c in Fig. 1). The x-axis is in KHz. Briefly describe the figure.
   D. Transmit and receive 1000 OFDM symbols with SNR = {0 dB, 5 dB, 10 dB, 15 dB, 20 dB}. Plot the BER vs SNR. Briefly describe the figure.

E. Repeat D using a modulation order of 64-QAM. Plot the BER vs SNR of 16-QAM and 64-QAM on the same figure. Briefly describe the figure.

2. STS & LTS generation and frame synchronization

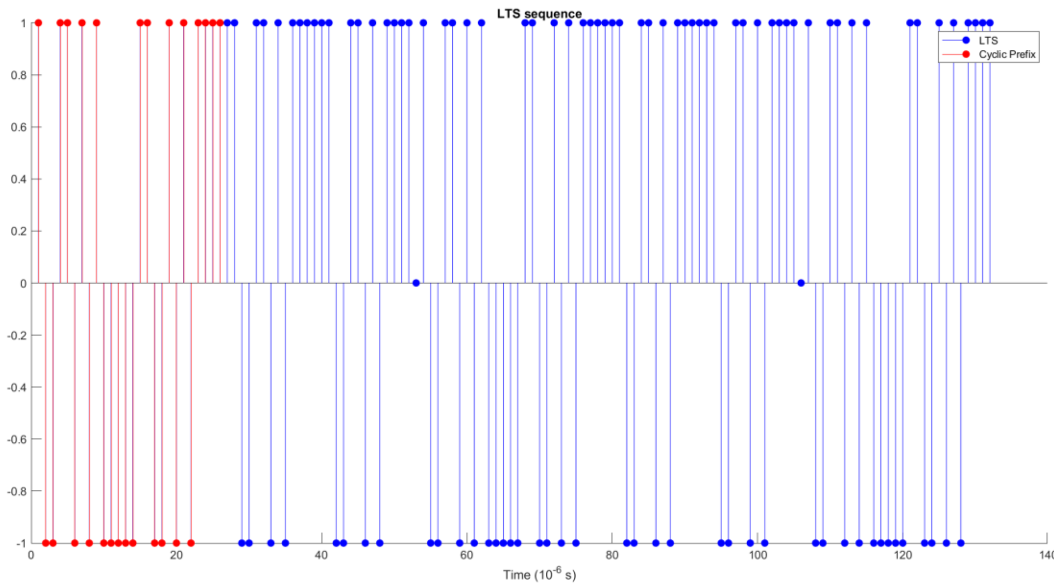
   A. Generate the short training sequence (STS). Please refer to $S_{-26,26}$ in the course slide for STS generation. Plot the STS (10 repeated) symbols in the time domain with the x-axis in μs.

      Only the real part of the STS is plotted.



B. Generate the long training sequence (LTS). Please refer to $L_{-26,26}$ in the course slide for LTS generation. Plot the LTS (2 long training symbols + cyclic prefix as in the course slide) in the time domain with the x-axis in μs.

The following figure is the LTS, where the portion in red represents the cyclic prefix.



C. Create a frame starting with STS, LTS, followed by 3 OFDM symbols (using the same procedure in part 1 with 16-QAM). Normalize the signal if needed so that the whole frame has consistent power. Plot the whole frame in the time domain with the x-axis in μs. Mark STS, LTS, and data portion in the frame.

D. Create a frame similar to the one in C but now with 100 OFDM symbols. Before upsampling,
add 30 zeros before and after the created frame (that is, the frame starts with 30 zeros, followed by STS, LTS, OFDM data, then 30 zeros). Add white Gaussian noise with 20 dB SNR. For the received signals (after downsampling), create your own matched filter based procedure to correctly determine the start of the OFDM data symbols. Plot the match filter result and briefly explain the figure

E. Explain your synchronization algorithm.

F. Process the OFDM data signals obtained in D. What is the bit error rate?

G. Use the frame created in D and vary the SNR = {0dB, 5dB, 10dB, 15dB, 20dB} (by adding white Gaussian noise with different power). For each SNR, repeat the frame transmission 100 times and calculate the probability of successful frame synchronization at the receiver (i.e., correctly determine the start of OFDM data symbols). Plot the probability of successful frame synchronization with SNR. Briefly describe the figure.