1. In this assignment, you are required to design a baseband transmitter of 802.11a. You may need to refer to the IEEE 802.11a specs reference. The Tx adopts 64 subcarriers OFDM system with 48 data tone, 4 pilot tone, and 12 null tones. The message $M(k)$, $k=0,1,\ldots,47$ are assigned to subcarrier index according to Eq. (1). Then the IFFT assignment is as defined in the specs as shown in Fig. 1(a). In order to simplify the design, only modulation and OFDM signal with cyclic prefix in the transmitter is considered. The data is transmitting with channel bandwidth of 20MHz.

$$M(k) = \begin{cases} 
  k - 26 & 0 \leq k \leq 4 \\
  k - 25 & 5 \leq k \leq 17 \\
  k - 24 & 18 \leq k \leq 23 \\
  k - 23 & 24 \leq k \leq 29 \\
  k - 22 & 30 \leq k \leq 42 \\
  k - 21 & 43 \leq k \leq 47 
\end{cases}$$

Eq. (1)

Let the transmitting message signal $M$ be (in the sequence of $t_0 t_1 t_2 \ldots$) 0000010011001000001010111011001001101111110110010011011111010 and then repeat periodically. Here we assume the four pilot tones are always sending the same symbol of $1+j$ and the pilot insertion is indicated in Fig. 1(b). The IFFT outputs are I and Q signals. In real implementation, I and Q are sent to a D/A converter and modulate with carrier to RF band.

![Fig. 1 (a)](image_url)
(1) Use 16-QAM as shown in Fig. 2 to modulate the message and find the modulated signal stream of the first OFDM symbol. (30%)

(2) What is your data rate? (10%)

(3) Find the time domain signal for the first OFDM symbol. (30%)

(4) Find the time domain cyclic prefix for the first OFDM symbol. (30%)

Please write a report on your result and submit your result with your source code.
You may use Matlab with floating point for the design.