EE477 Homework 1

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I. MATLAB

A. BPSK

Binary Phase Shift Keying (BPSK) is a two phase modulation scheme, where the 0's and 1's in a binary message are represented by two different phase states in the carrier signal: $\theta = 0°$ is used for binary 0 and $\theta = 180°$ is used for binary 1.
These phase angles can easily be seen on figure 1. On figure 2.1 one can see the different symbols 0 and 1. The left half of the diagram on figure 2.1 represents 0. The right half of the diagram on figure 2 represent 1. The given stream is modulated using these symbols on figure 2.2. One can check bit by bit easily.

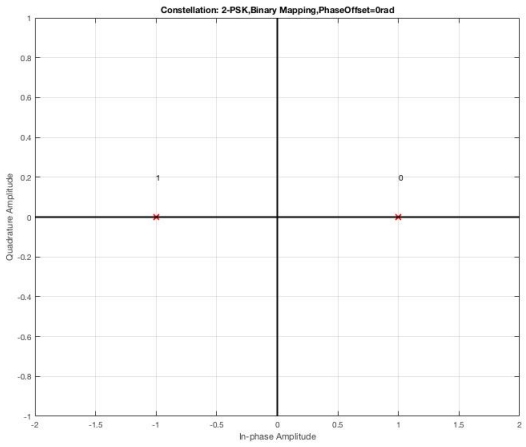

Fig. 1: constellation diagram of BPSK

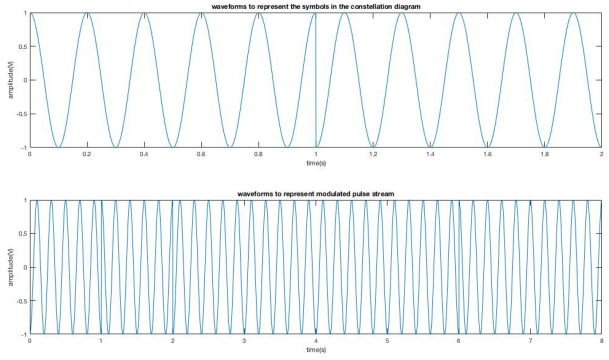

Fig. 2: BPSK symbol signals and modulated signal

Fig. 3: constellation diagram of QPSK

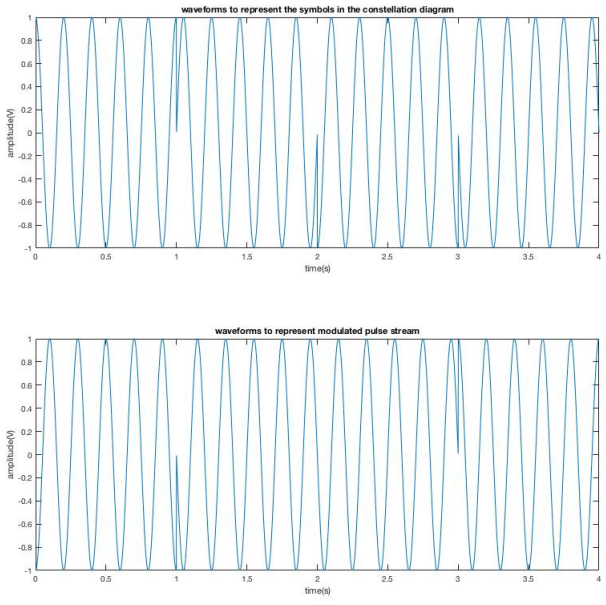

Fig. 4: QPSK symbol signals and modulated signals

B. QPSK

Quadrature Phase Shift Keying (QPSK) is a form of Phase Shift Keying in which two bits are modulated at once. Selecting the phase offset 0, one should expect that the dots on constellation diagram to be found at $\theta = 0, \pi/2, \pi, 3\pi/2$. This expectation is confirmed looking at the constellation diagram. The binary codeword 0 corresponds to $\theta = 0$, 1 corresponds to $\theta = \pi/2$, 2 corresponds to $\theta = \pi$, 3 corresponds to $\theta = 3\pi/2$. One can see the phase shifts between 4 symbols on Figure 4.1. The order of symbols on Figure 4.1 is [0,1,2,3]. The given stream corresponds to [2,3,3,0] in QPSK. On Figure 4.2 it is expected to see symbols in this order and one can confirm easily this assumption.

C. 4-PAM

PAM-4 is a modulation technique whereby 4 distinct pulse amplitudes are used to convey the information. This is confirmed looking at constellation diagram on figure 5. Each dot has different amplitude. The leftmost dot corresponds to 0 and the rightmost dot corresponds to 3.
The order of symbols on Figure 6.1 is [0,1,2,3]. The given stream corresponds to [2,3,3,0] in 4-PAM. On Figure 6.2 it is expected to see symbols in this order and one can confirm easily this assumption.

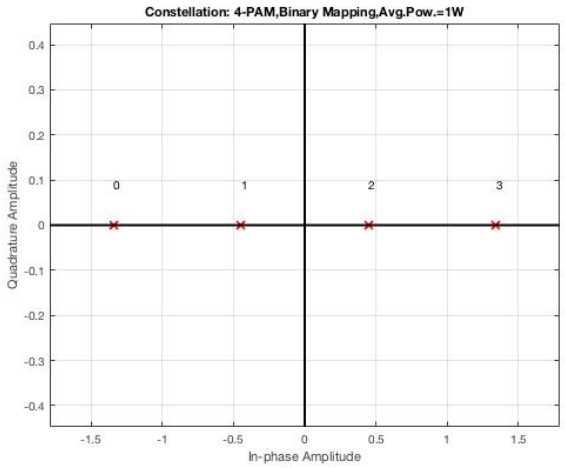

Fig. 5: constellation diagram of 4-PAM

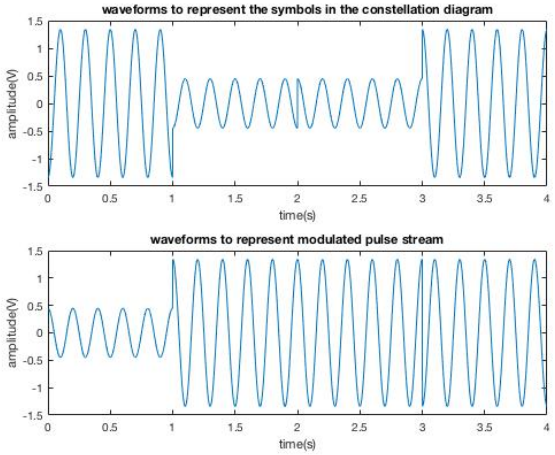

Fig. 6: 4-PAM symbol signals and modulated signals

D. 16-QAM

This modulation technique is a combination of both Amplitude and phase modulation techniques. There are 4 different phase levels and 4 different amplitude levels. The output is a combination of these levels. Therefore the message signal is grouped in 4 bits corresponding to 16 different symbols. One can see the phase and amplitude differences on constellation diagram figure 7 easily.
The order of symbols on Figure 8.1 is [0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15]. The given stream corresponds to [11,12] in 16-QAM. On Figure 8.2 it is expected to see symbols in this order and one can confirm easily this assumption.

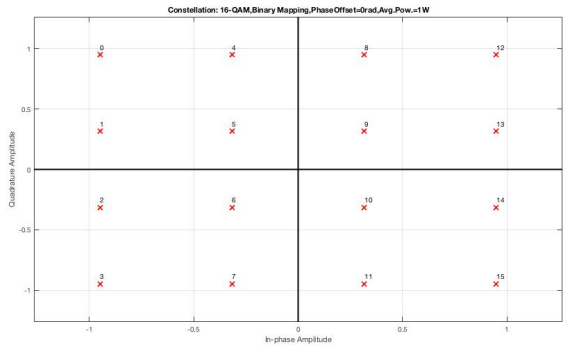

Fig. 7: constellation diagram of 16-QAM

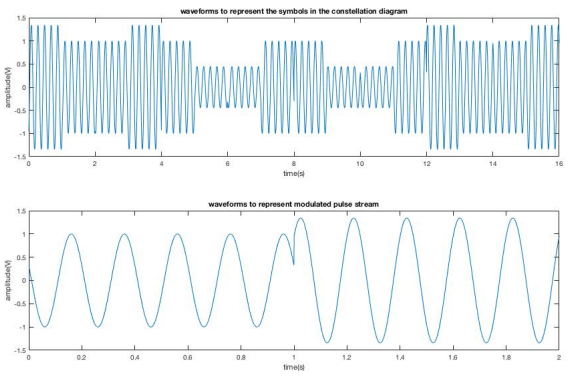

Fig. 8: 16-QAM symbol signals and modulated signals

E. BFSK

The dots on constellation diagram differ in frequency. The frequency difference is 1 Hz, because the symboling period is 1 second. Looking at the figure 10, one cannot see easily the frequency difference between two distinct symbols, because the frequency difference is not too much. But if you take a look more carefully you see the difference.
The 0-bit has a frequency 5 Hz, and the 1-bit has a frequency of 6 Hz. The given stream can also be confirmed on figure 10.2.

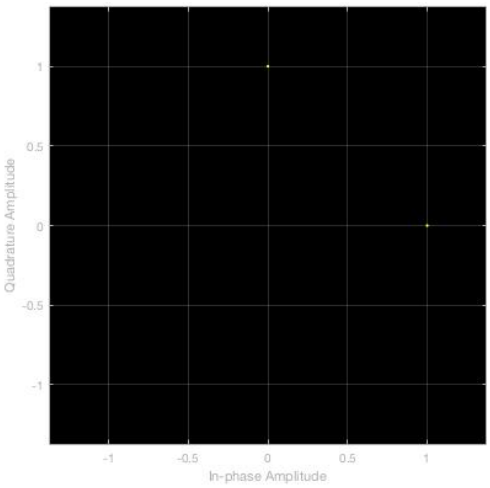

Fig. 9: constellation diagram of binary FSK

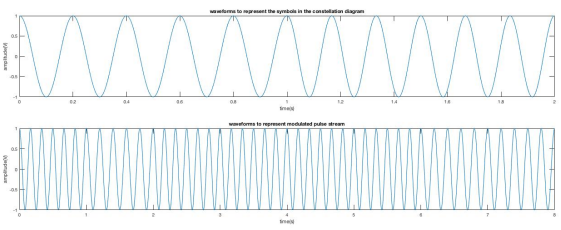

Fig. 10: binary FSK symbol signals and modulated signals

II. PART 2

The answers and the explanations can be found in matlab file as comments and variables.