Title: Comparing performances of BPSK, QPSK and π/4-QPSK Modulation formats in an AWGN channel

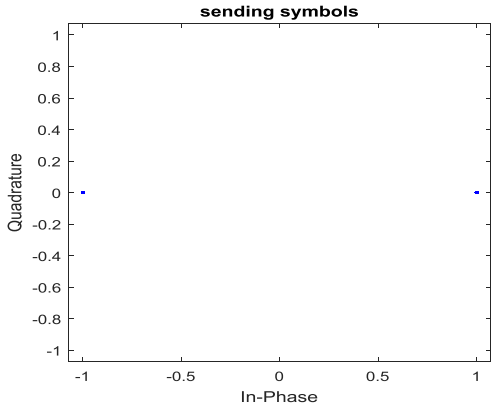
A stream of data was generated by MATLAB coding. To simulate a real channel, it is common to consider an additive white Gaussian noise (AWGN). Therefore, we added AWGN to our desired signal. In our simulation, we varied signal to noise ratio (SNR) from -15 dB to 35 dB.

In this project, the performances of different modulation formats such as BPSK, QPSK and π/4-QPSK considering the bit error rate (BER) are compared in an AWGN channel.

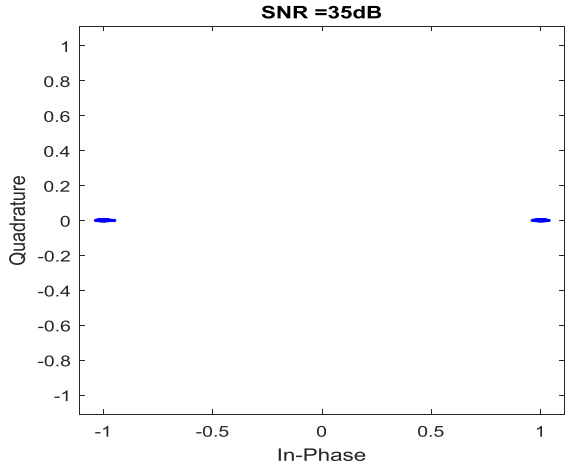
The following observations were made as a result of simulations conducted in MATLAB.

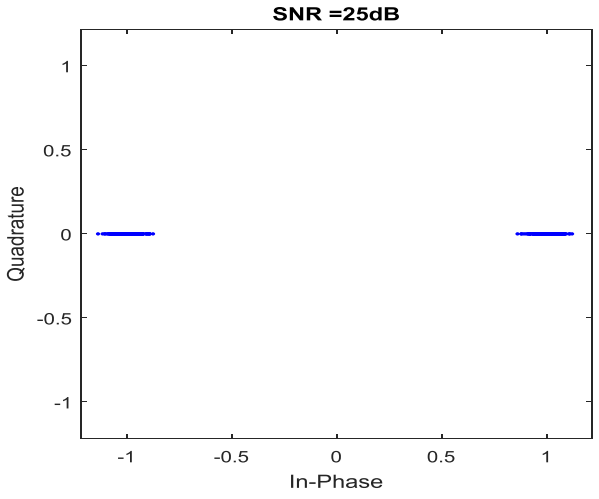
BPSK modulation:

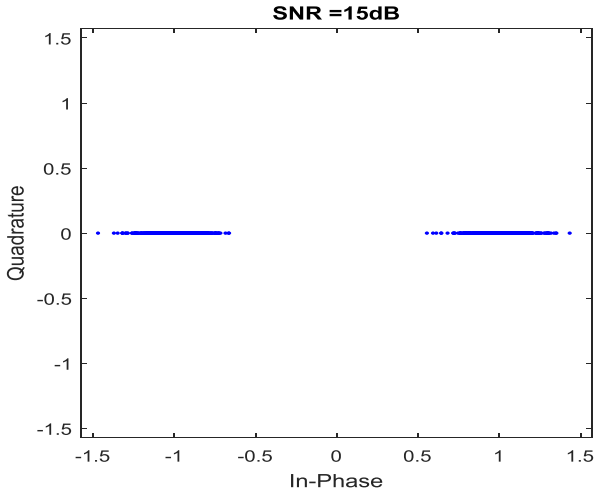
In this case, signal was modulated based on BPSK modulation format as shown in the following figure:

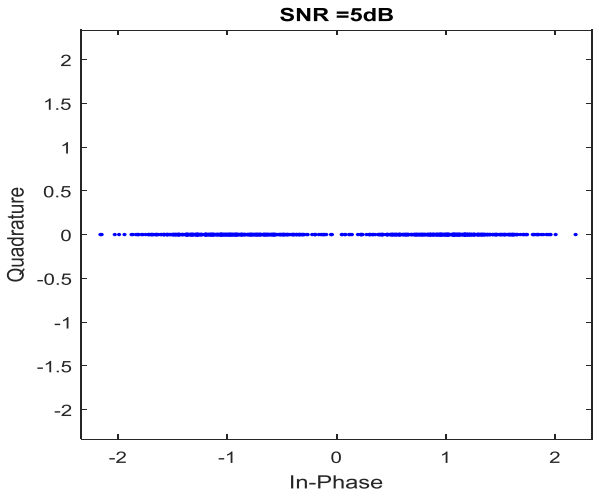


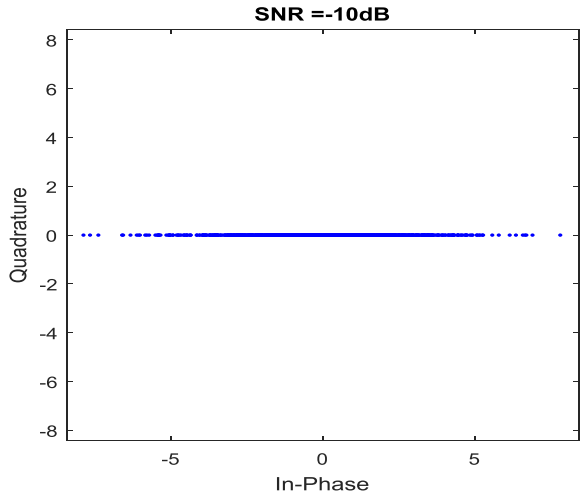
The constellation diagrams of output signals of AWGN channel for different SNRs are given as below:



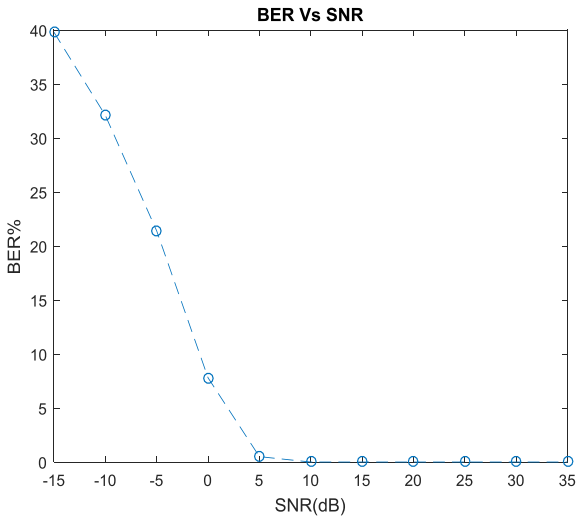

SNR =25dB
Quadrature
In-Phase
1
0.5
0
-0.5
-1
-1
-0.5
0
0.5
1


SNR =15dB
Quadrature
In-Phase
1.5
1
0.5
0
-0.5
-1
-1.5
-1.5
-1
-0.5
0
0.5
1
1.5


SNR =5dB
Quadrature
In-Phase
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2
-1
0
1
2

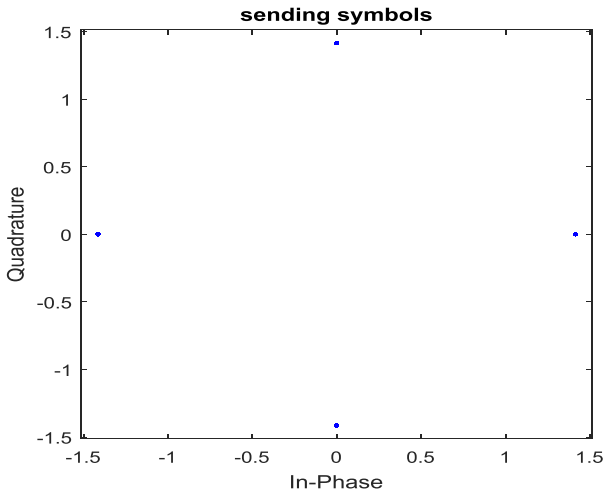


So finally, bit error rate (BER) vs. SNR variations is plotted:

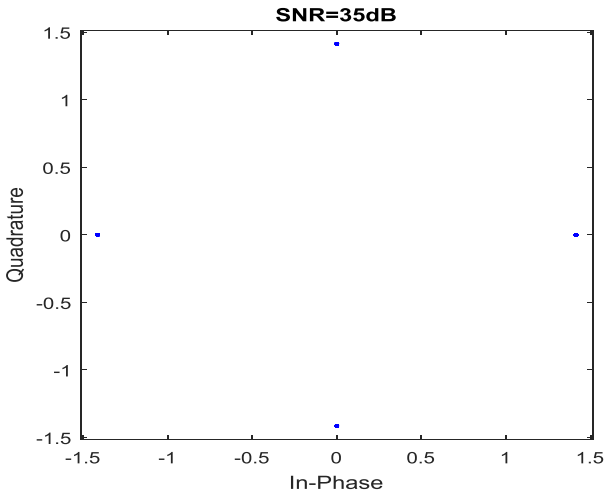


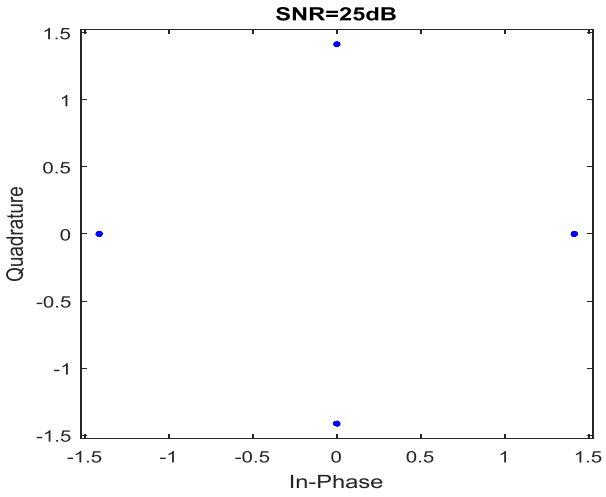
QPSK modulation:

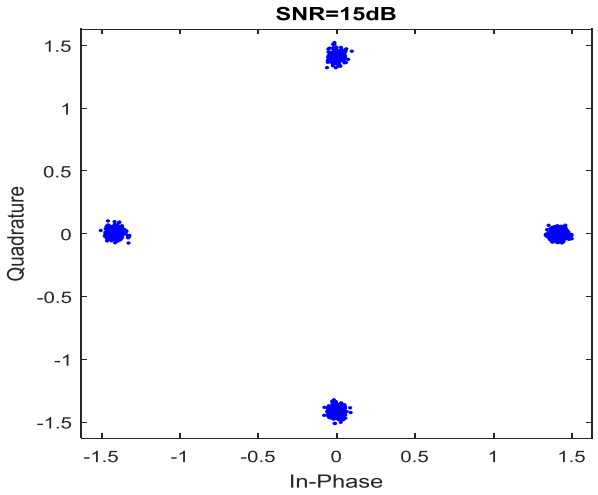
We also examined the performance of QPSK signal in an AWGN channel. The constellation diagram of sending symbols is illustrated as following:

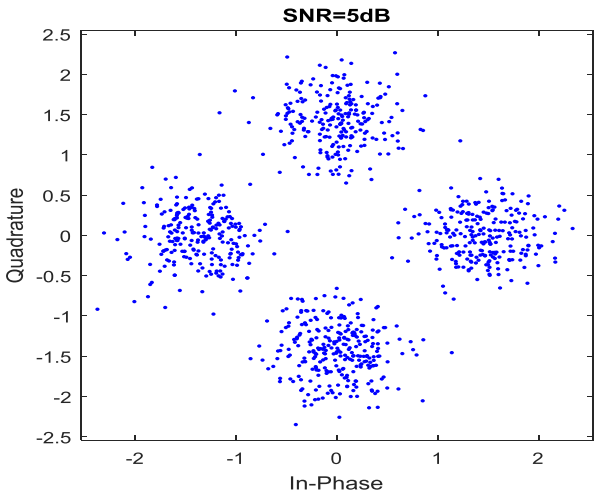


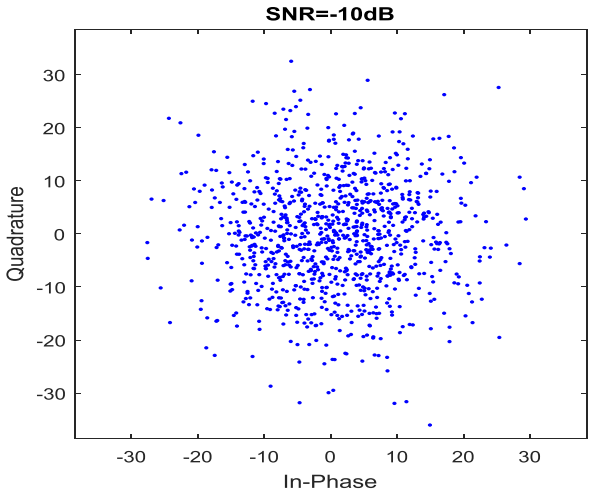
As a result, the constellation diagram of output signals of the AWGN channel for different SNRs can be seen as below:



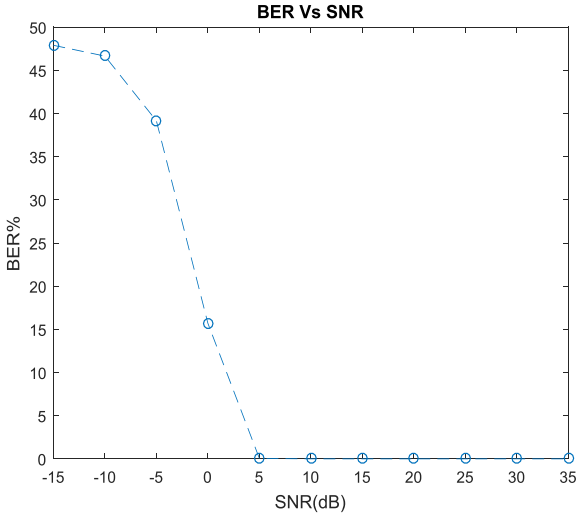

SNR=25dB
Quadrature
In-Phase
1.5
1
0.5
0
-0.5
-1
-1.5


SNR=15dB
Quadrature
In-Phase
1.5
1
0.5
0
-0.5
-1
-1.5


SNR=5dB
Quadrature
In-Phase
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5

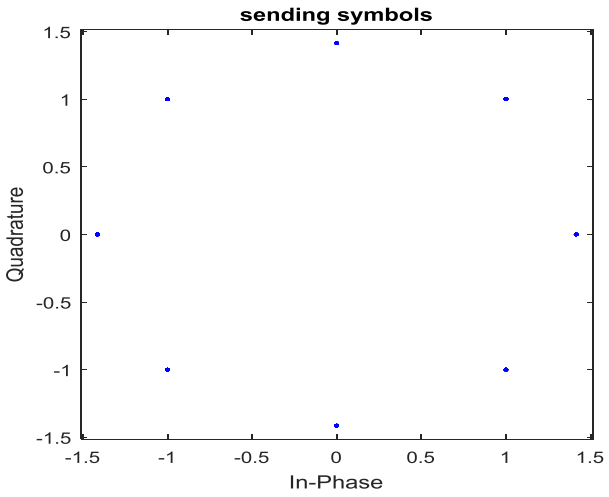


BER vs SNR is plotted as well:

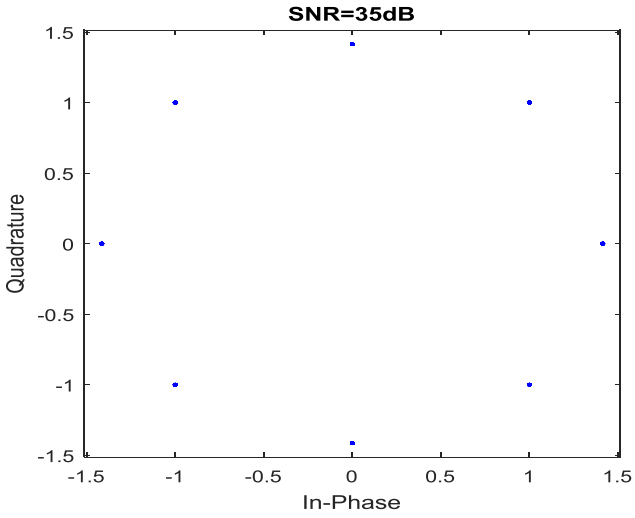


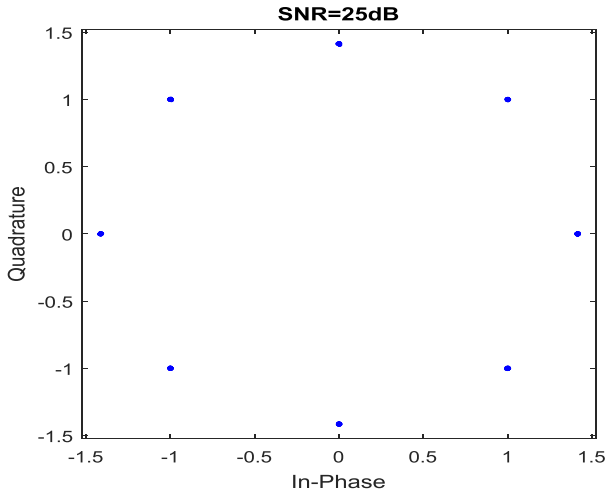
π/4-QPSK modulation:

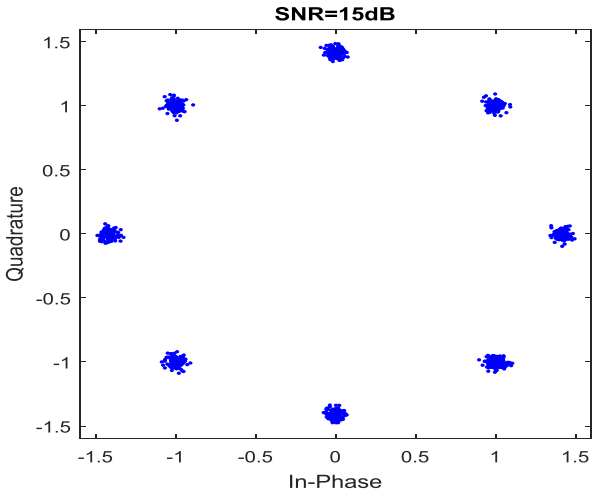
In this part, signal was modulated considering the π/4-QPSK modulation format. We can also see the constellation diagram of sending symbols:

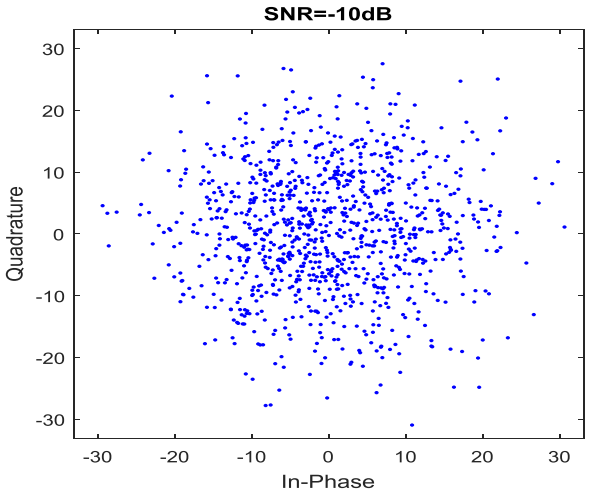


What follows is the constellation diagram of output signals of AWGN channel for different SNRs:

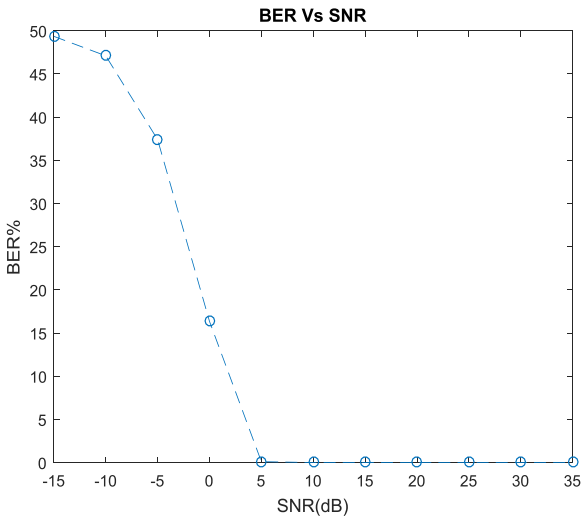



SNR=25dB
Quadrature
In-Phase
1.5
1
0.5
0
-0.5
-1
-1.5


SNR=15dB
Quadrature
In-Phase
1.5
1
0.5
0
-0.5
-1
-1.5

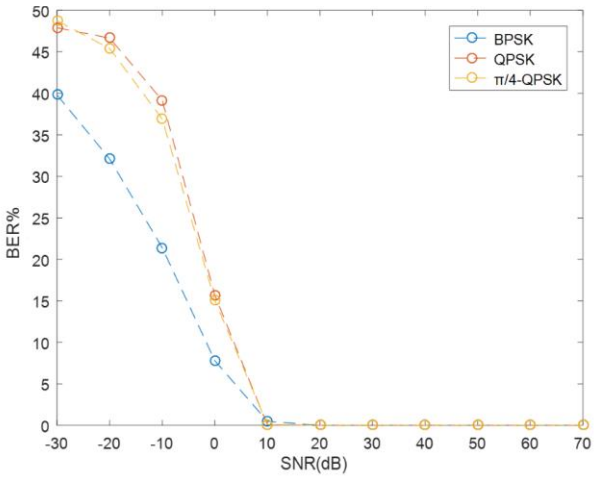

SNR=-10dB
Quadrature
In-Phase
30
20
10
0
-10
-20
-30

And BER vs. SNR is given here:



- **Conclusion**

In this simulation, the performances of BPSK, QPSK and π/4-QPSK Modulation are compared and summarized in the following picture. It is found that BPSK modulation has better performance in term of BER in comparison to the others at a given SNR. The BER of QPSK is better than π/4-QPSK for a fixed SNR. However, between QPSK and π/4-QPSK, π/4-QPSK is preferred due to its lower out of band leakage in frequency domain.



It is also concluded that by increasing SNR, BER decreases. In addition, from the constellation diagrams, it can be seen that at lower SNRs, constellation points are noisier, and formed a cloud around the central symbol.