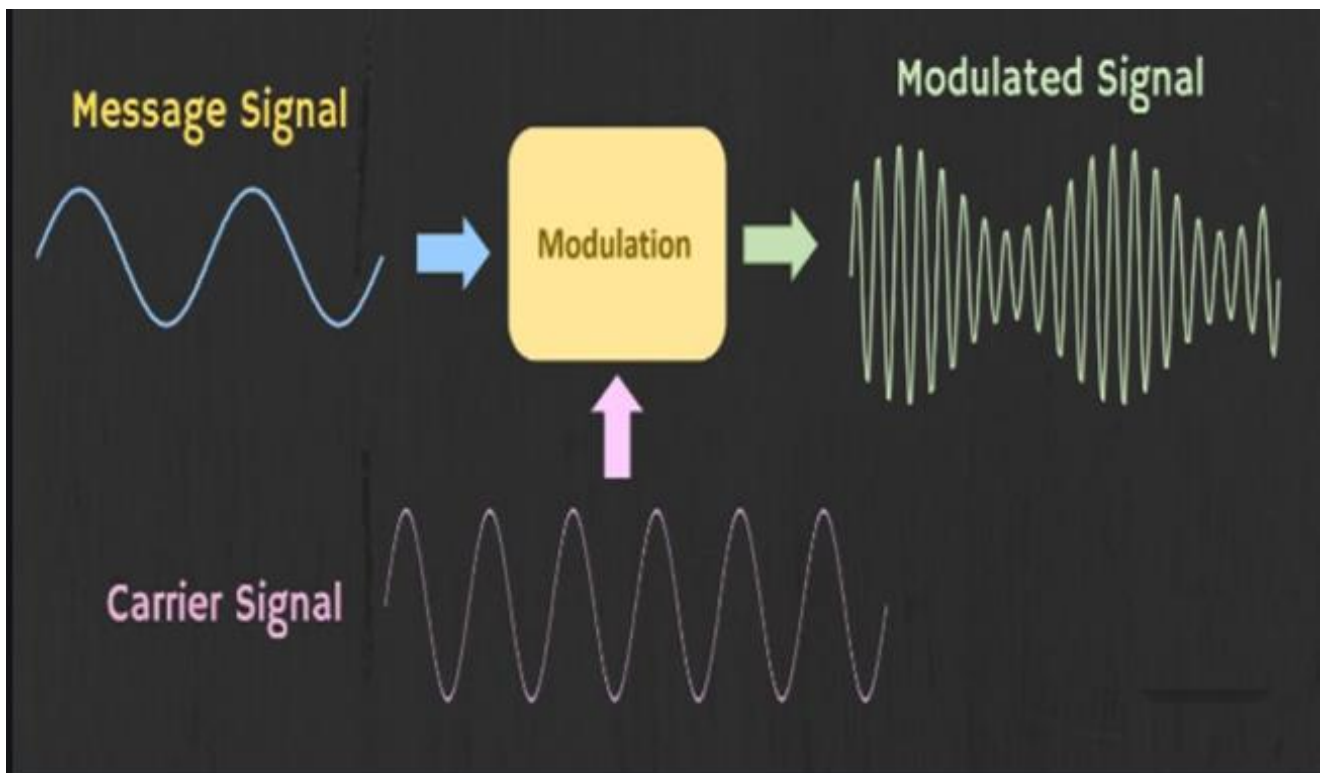


BSc (Hons.)/BEng (Hons.) Ordnance, Munitions and Explosives

ACDA5008 – Level 5 Digital Signals Processing and Communications Assignment



[1]

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Abstract

This report investigates the different types of signal data modulation, both analogue and digital, but mainly focuses on digital modulation schemes, as could be used in communication applications. Different types of digital modulation and de-modulation schemes, Amplitude-Shift Keying (ASK), Phase-Shift Keying (PSK) and an advanced variant of PSK, Quadrature Phase-Shift Keying (QPSK) are built in MATLAB Simulink with a Bernoulli Random Binary Generator as a signal source, which is then introduced to varying amounts of noise by way of Additive White Gaussian Noise (AWGN). The de-modulated signal is then compared with the original signal and a Bit Error Rate (BER) produced. BER is plotted against an increasingly noisy Signal to Noise Ratio (SNR). This allowed the performance of the three modulation schemes to be compared. Research into the different modulation schemes allows predictions to be made: The PSK scheme should produce the best performance as an increasingly noisy channel is produced. It was then shown that the simulations carried out did indeed support the predictions made and further considerations and possibilities for further investigation have been made in the conclusions section.

Contents

Front cover	1
Abstract	2
Contents	3
1. Introduction	4
2. Background information	4
2.1. Digital modulation/de-modulation scheme performance predictions	5
3. Simulation models	7
3.1. Amplitude-Shift Keying (ASK) Simulation model	7
3.2. Phase - Shift Keying (PSK) Simulation model	8
3.3. Quadrature Phase - Shift Keying (QPSK) Simulation model	9
4. Results	10
4.1. ASK Plot:	10
4.2. PSK Plot:	10
4.3. QPSK Plot:	11
4.4. Comparative Plot:	11
5. Discussion	12
6. Conclusion	13
7. References	14

1. Introduction

A report is required, critically comparing the performance of Amplitude-Shift Keying (ASK), Phase-Shift Keying (PSK) and Quadrature Phase-Shift Keying (QPSK) modulation/de-modulation schemes. Data will be obtained through simulations built in Simulink via MATLAB R2021A. The simulation models will have a data source from a Bernoulli Random Binary Generator, which is then transmitted, modulated and sent through a noisy channel by way of adding Additive White Gaussian Noise (AWGN) and then demodulated at the receiver. The Bit Error Rate (BER) as compared between the original signal and demodulated signal will be measured against the Signal to Noise Ratio (SNR) and the results plotted in MS Excel. The amount of noise added will be dependent on whether the system is considered to have failed, this point will be when the error rate is greater than 0.5 or greater than 50% of the bits transmitted are errors e.g. 6/11 bits are errors. [2]

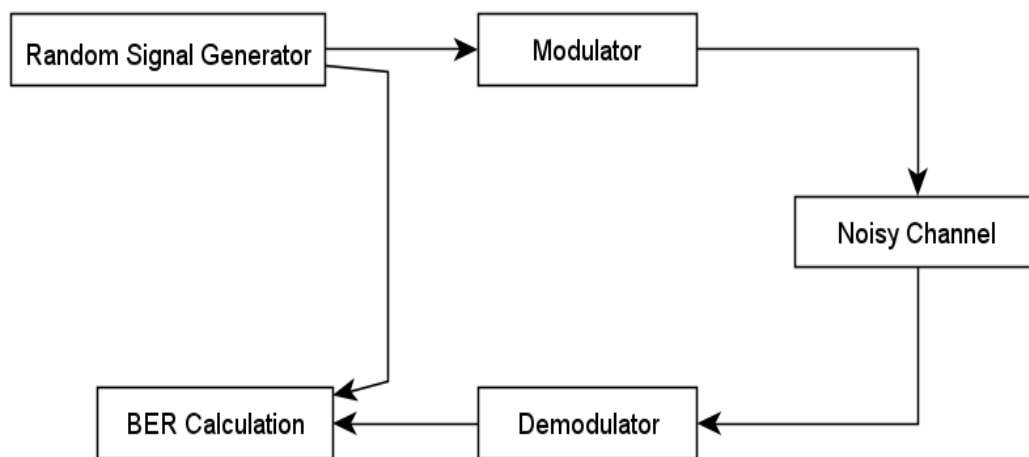


Figure 1. From ACDA5008_sem1_CW1_2020_21 (By Steve Mosey) [2]

2. Background information

According to Carritech.com... *“Modulation is the process of encoding information from a message source in a way that is suitable for transmission. This is achieved by altering the characteristics of a wave. By superimposing a message on to a high frequency signal known as a carrier wave (or sinusoidal signal), video, voice and other data can be transmitted.”* [3]

There are two main types of modulation used, these are Analogue and Digital. This report is only looking at the outputs and comparison of types of digital modulation. The types of digital modulation schemes are as follows:

- Frequency Shift Keying (FSK)
- Amplitude Shift Keying (ASK)
- Phase Shift Keying (PSK)

This report will be looking at the latter 2, ASK, PSK and an advanced variant of PSK, QPSK or Quadrature Phase-Shift Keying.

Digital modulation schemes use a carrier wave to transmit data, the data is transmitted and received as a binary square wave. As binary has two discrete values 0 and 1, therefore each scheme must have a way of transmitting a 0 and 1 for example:-

Frequency-Shift Keying (FSK) – Uses high frequency sections of signal to designate a 1 and an area of low frequency signal as a 0.

Amplitude-Shift Keying (ASK) - will alter the amplitude of the signal to designate 0 = low amplitude and 1= as a higher amplitude. An example of which can be seen on the front cover. [1]

Phase-Shift Keying (PSK) – represents a 1 as an in phase Sine wave and a 0 as an anti-phase version i.e. a Cosine wave. [4]

Modulation and de-modulation schemes or systems have been utilised in many ways for many years, they are used in radio communications such as Amplitude Modulation or AM Radio, as well as Frequency Modulation or FM Radio, these are examples of analogue modulation/de-modulation systems. Digital modulation is used for many different means of communication for example: -

Digital modulation techniques can be used in wide range of data transmission systems for example, broadcasting and cable TV or in high performance communications networks. [5] [6]

2.1. Digital modulation/de-modulation scheme performance predictions

Based on the following research carried out into the relevant modulation and de-modulation schemes or systems, there are some observations that can be made and therefore predictions made, these are as follows:

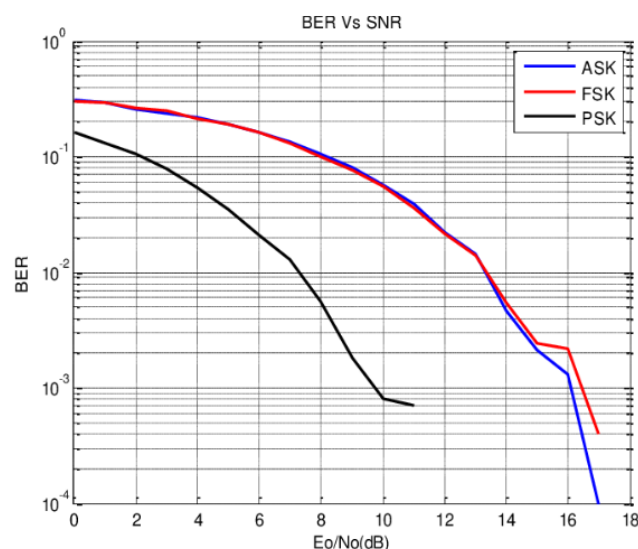


Figure 1: Shows a comparison of performance of ASK and PSK systems when introduced to a noisy channel [7]

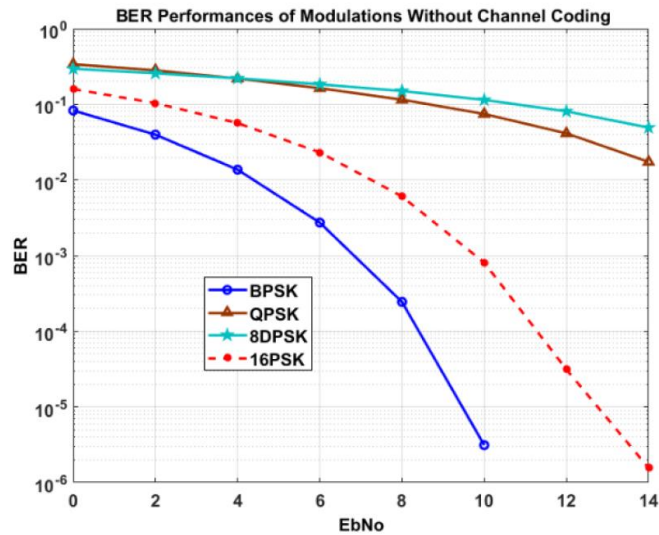


Figure 2: Shows a comparison of performance of PSK and QPSK systems when introduced to a noisy channel [8]

From observing the data compiled and graphically displayed above in figures 1 and 2 it can be seen that when a signal is applied to a noisy channel such as that provided by AWGN, that out of the three modulation systems being critically compared ASK, PSK and QPSK, PSK performs the best (as shown by the red line in Fig. 2 or black line in Fig. 1). The respective plot lines for PSK show a curve which has generally a steeper gradient and is shifted more to the left, meaning that PSK is more capable of sending an accurate signal through a noisier channel, as the BER remains lower than ASK and QPSK as more AWGN is added. It should be noted that the above plots also show that ASK while not as good at filtering the AWGN still provides a better performance than QPSK, which has a very high BER for very clean signals.

The predictions for performance therefore would be that PSK will perform best, giving a comparatively good performance in producing a cleaner signal in the environment of an increasingly noisy channel, followed by ASK and QPSK having a relatively poor performance with high BER even for relatively clean signals, with low or no noise.

3. Simulation models

The following are the simulation models which have been made to allow the simulation of a data signal and carrier wave which are then introduced to noise by way of Additive White Gaussian Noise (AGWN).

3.1. Amplitude-Shift Keying (ASK) Simulation model

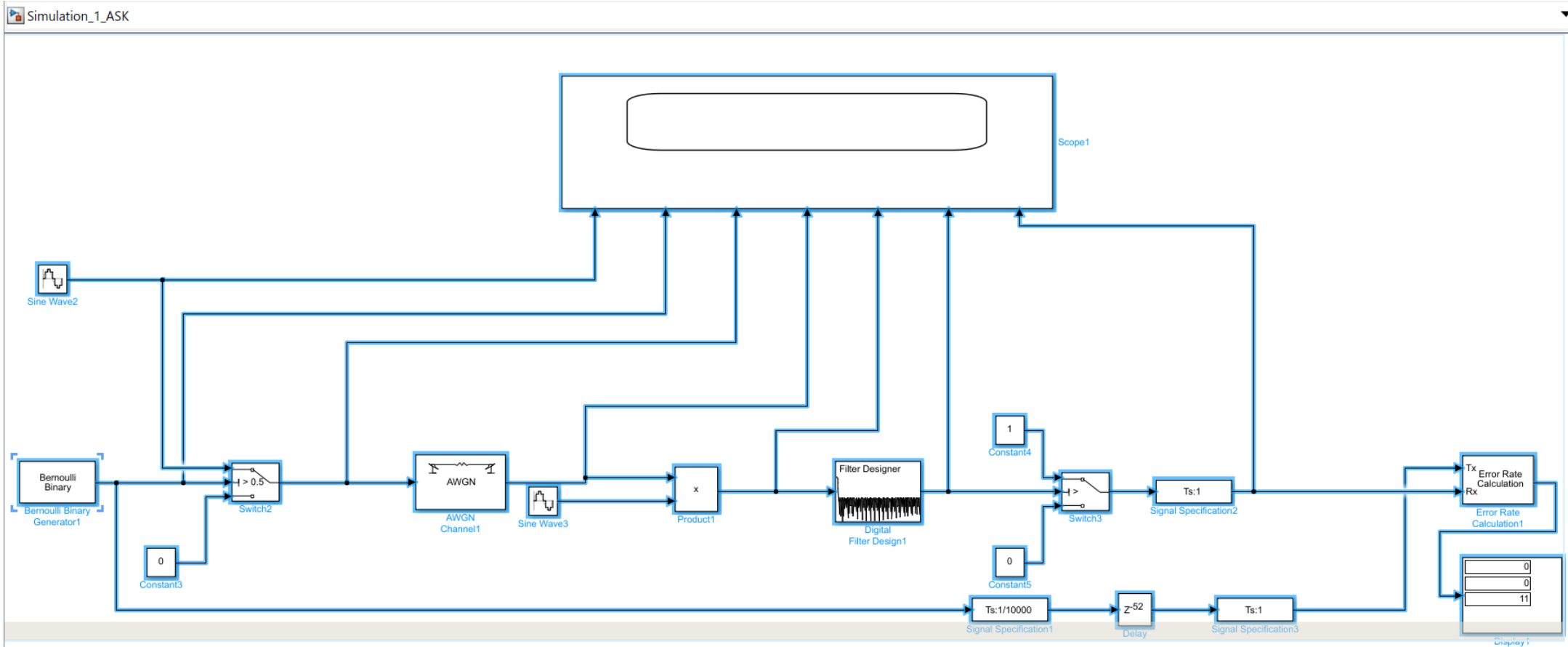


Figure 3: ASK Simulation set up on Simulink – MATLAB (by Author)

3.2. Phase - Shift Keying (PSK) Simulation model

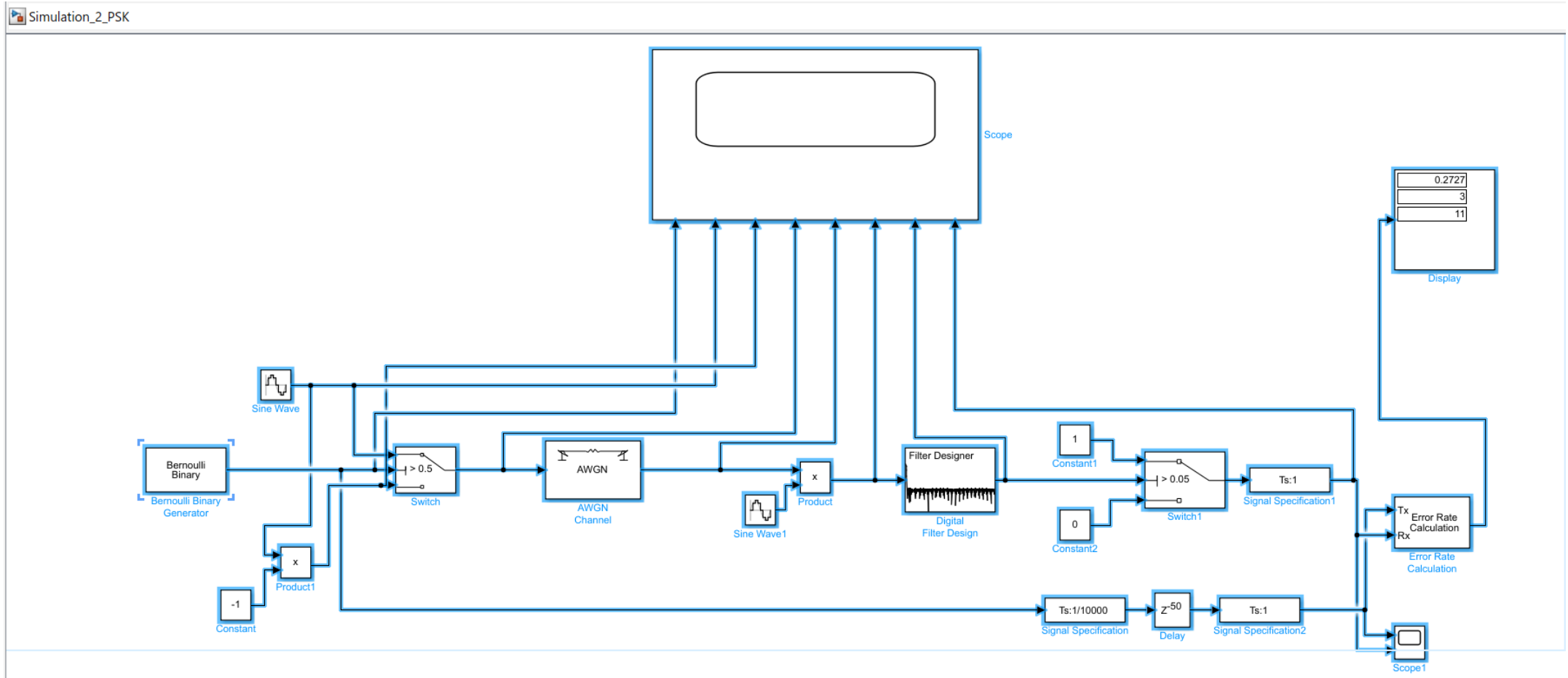


Figure 4: PSK Simulation set up on Simulink – MATLAB (by Author)

3.3. Quadrature Phase - Shift Keying (QPSK) Simulation model

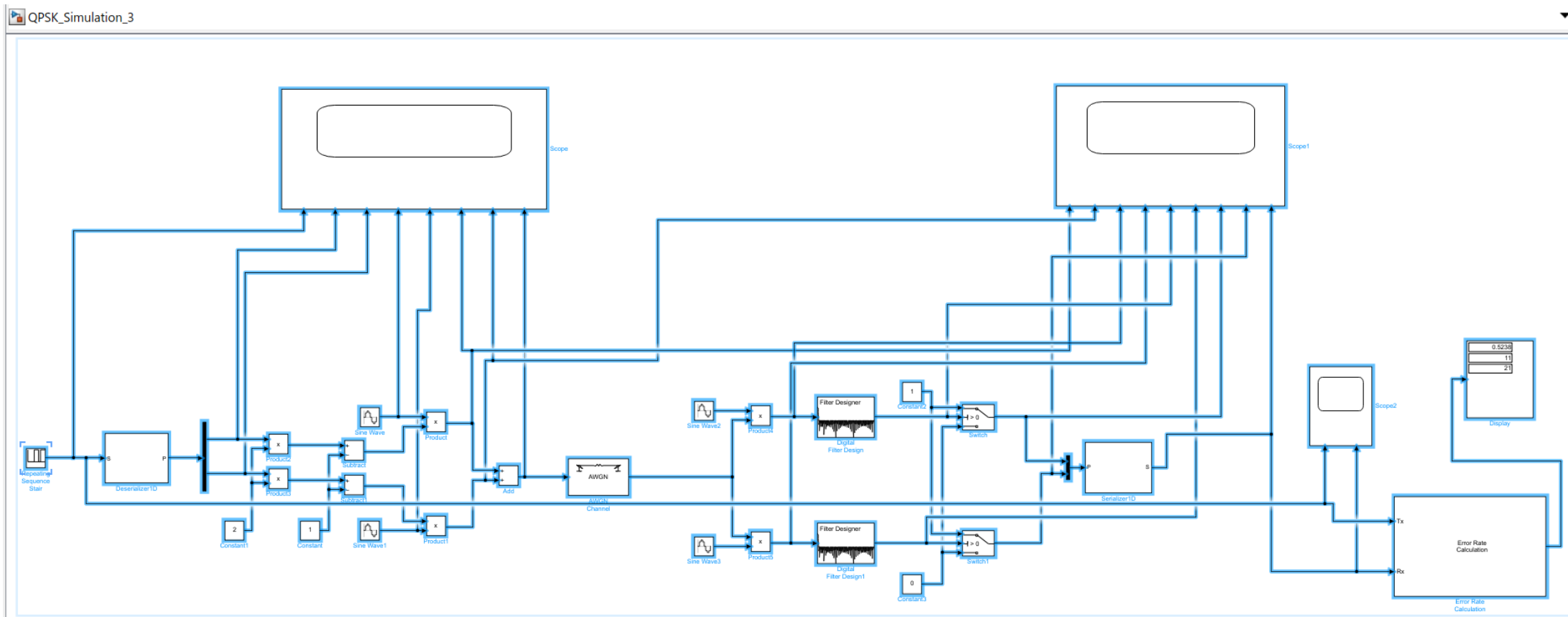
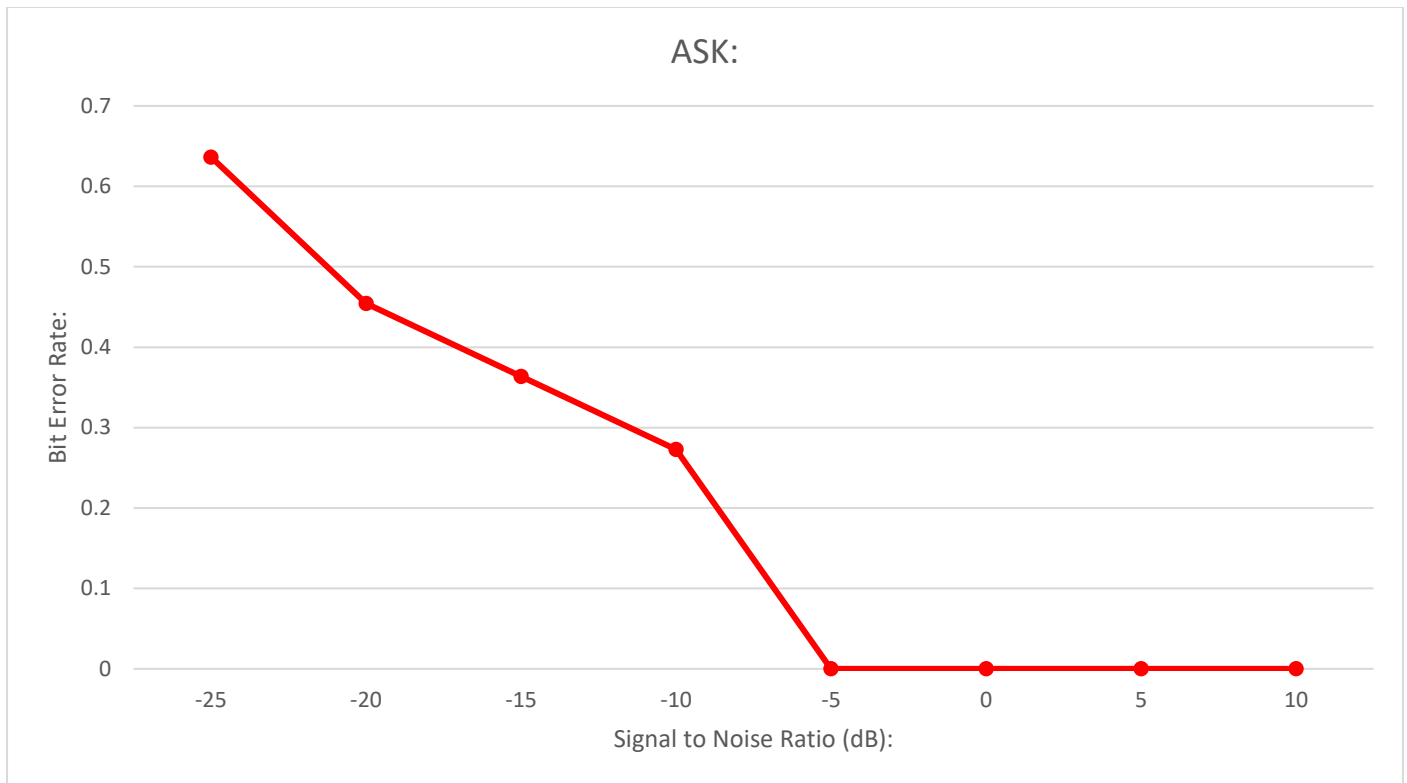


Figure 5: QPSK Simulation set up on Simulink – MATLAB (By author)

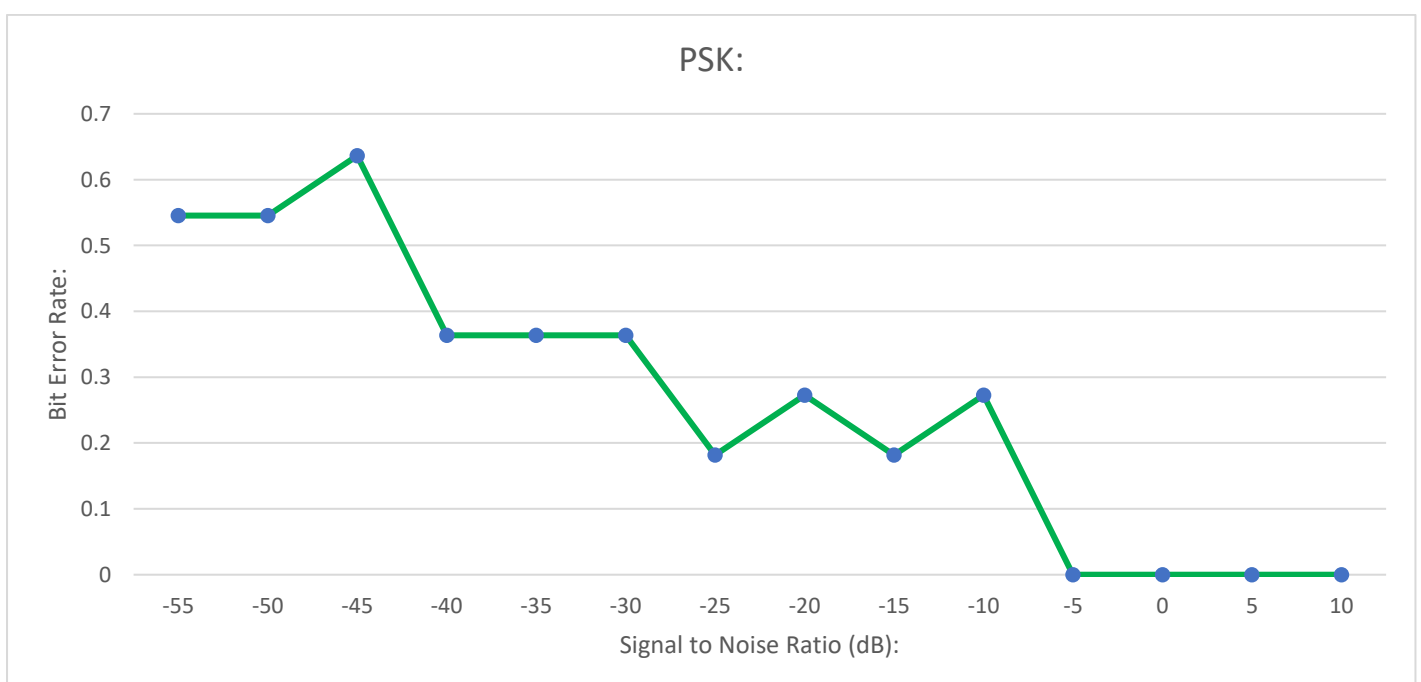
4. Results

4.1. ASK Plot:

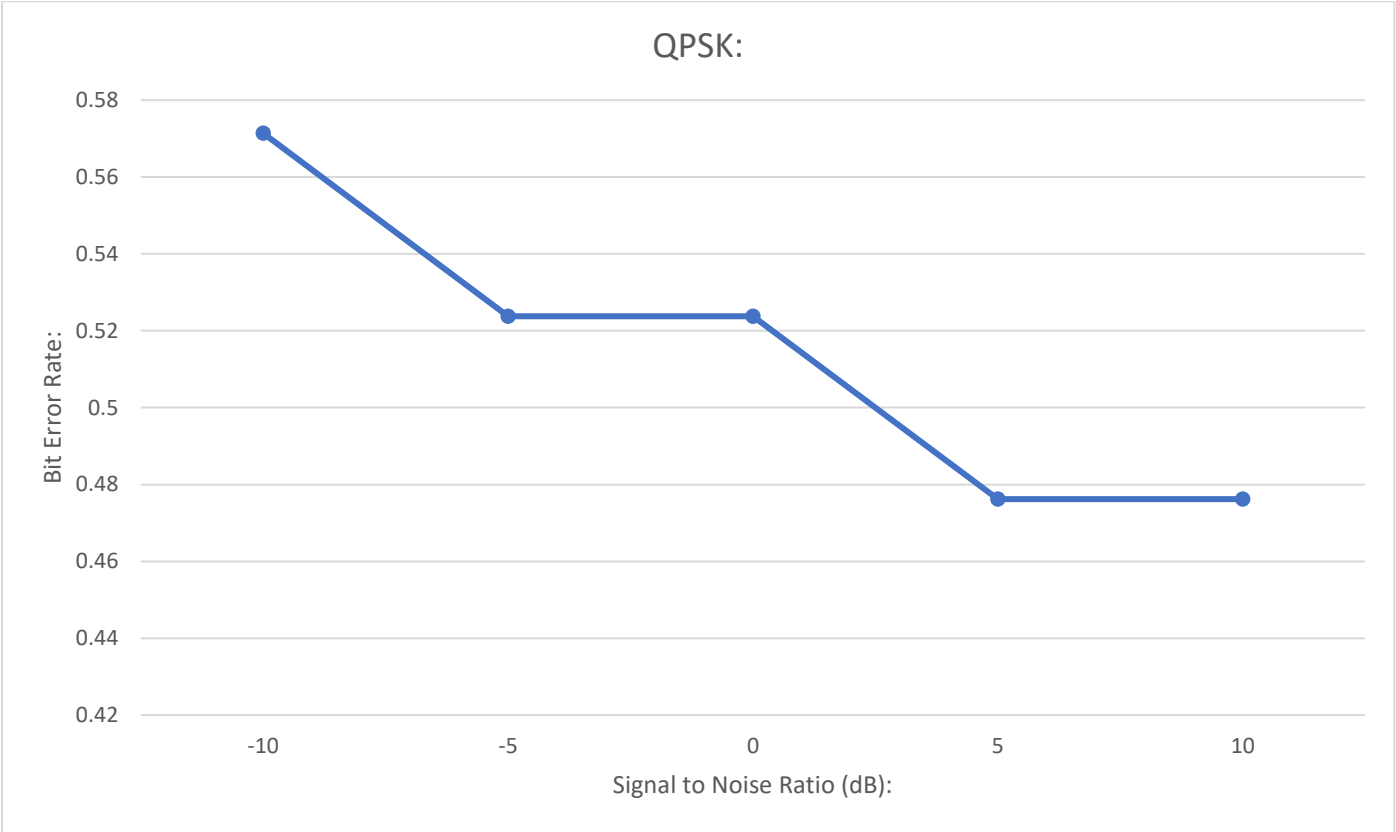
The results of the simulations have been plotted as graphs of Bit Error Rate (BER) against Signal to Noise Ratio (SNR) and can be seen below:



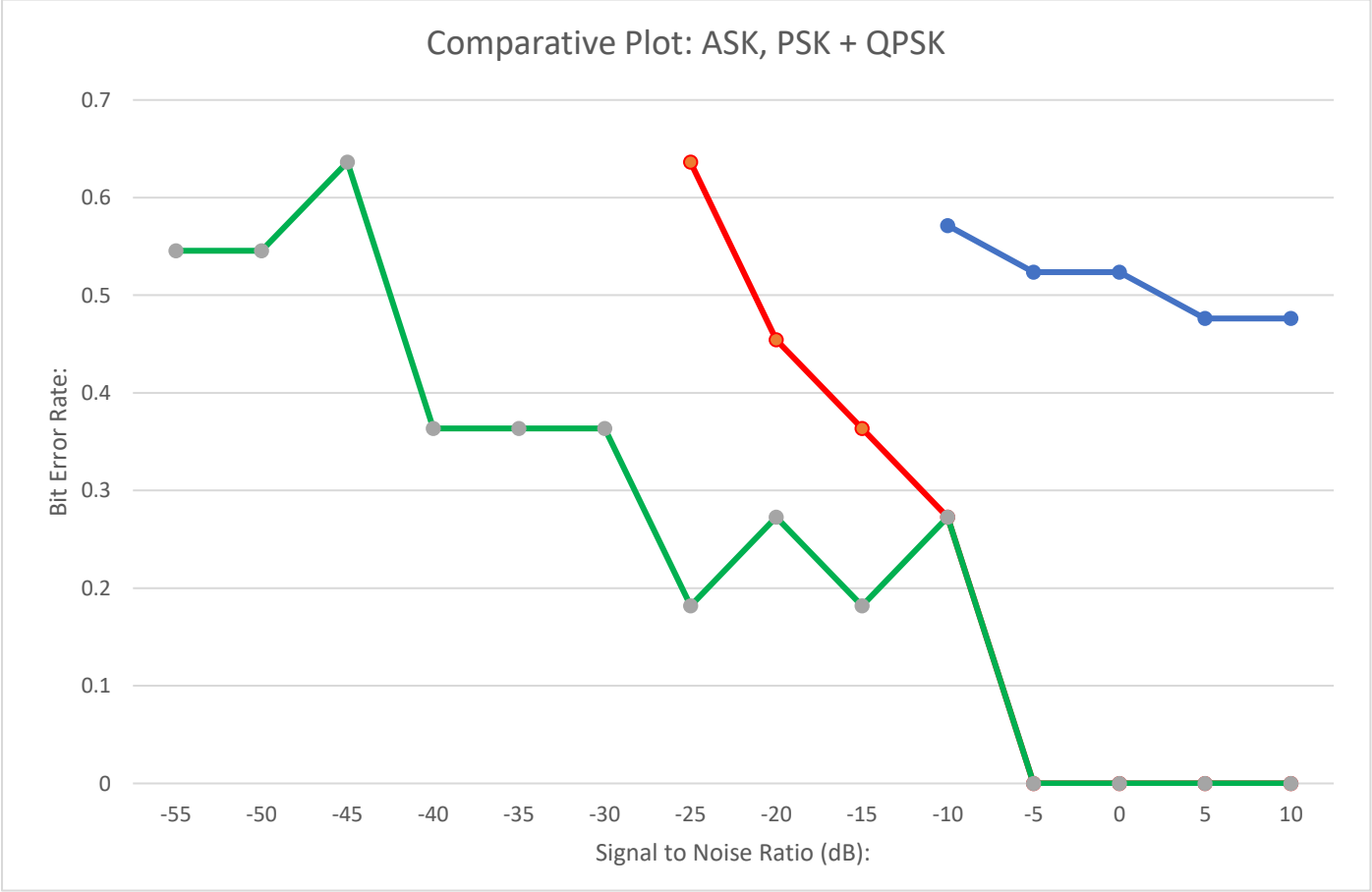
4.2. PSK Plot:



4.3. QPSK Plot:



4.4. Comparative Plot:



5. Discussion

The results as displayed in the Results sections 4.1, 4.2, 4.3 and 4.4, show the results for the ASK, PSK, QPSK and the comparative plot of all three modulation systems, when subjected to increasing amounts of AWGN (shown by the decreasing signal to noise ratio (SNR)). As stated in the introduction the BER of 0.5 or 50% was considered the point of failure of the particular modulation system. The following describes the results of each modulation system in turn and the comparison of all three:

Amplitude-Shift Keying (ASK):

The results for the ASK simulations start with a positive SNR of 10, meaning that the signal data is 10 times higher than that of the AWGN, at this SNR the BER is 0. The BER remains the same for the SNR of 5, 0 and -5. The BER then increases to just under 0.3 or 30% at a SNR of -10, there is then a proportionate increase in BER as the SNR decreases or the amount of AWGN increases, giving BER of just under 40% and 50% respectfully for SNR of -15 and -20. As the SNR increases to -25 the BER is then over the failure point of 50% at 63.64%, showing the ASK modulation system clearly failed between a SNR of -20 and -25.

Phase-Shift Keying (PSK):

The results for the ASK simulations start identically to the ASK results, in that from a SNR of 10 to -10 gives exactly the same BER of 0,0,0,0 and just below 30% respectively. The BER then oscillates between just below 30% to just below 20% from a SNR of -10,-15, -20 to -25, then at a SNR of -30, -35 and -40 the BER goes up to just under 40%. At some above a SNR of -40 the BER rate goes over 50%, but does oscillate a bit.

Quadrature Phase-Shift Keying (QPSK):

The results for the QPSK simulations start on a high BER even at a SNR of 10 and 5 the BER is already just below 50%. Then at a SNR of 5 to 0 the BER goes over the 50% failure point of the modulation system.

The comparison between ASK, PSK and QPSK modulation simulations:

The comparative graph shows that the QPSK modulation systems simulations show system failure very early on in the SNR of between 0 and 5. The ASK and PSK modulation simulations show that they fair better than the QPSK, not even giving a BER higher than 0% for SNR from 10 to -5. The ASK modulation simulation then show that the failure point of 50% BER occurs between SNR of -20 and -25. The PSK modulation system can be seen to not hit the 50% BER system failure rate between a SNR of -40 and -45.

The significance of these results will be addressed in the conclusions section.

6. Conclusion

The conclusions that can be drawn from the results in section 4 and as discussed in section 5 are that the modulation system most effective for noisier signals (up to just over -40 dB) is the Phase-Shift Keying modulation simulation. The Amplitude-Shift Keying modulation system also works effectively for SNR of up to just over -20 dB, so works effectively for quite a noisy channel. It is only really the Quadrature Phase-Shift Keying (QPSK) modulation simulation which does not perform well at all with very high (~47% BER) even at high signal over AWGN (i.e. SNR 10) and the signal quickly deteriorates to failure at a SNR of between 0 to 5. The conclusion that the PSK modulation system has a greater allowance for a noisier signal than both ASK and QPSK is supportive of the predictions and evidence presented in the introduction in figures 1 and 2. [7] [8]

It should be noted that the graphs in figures 1 and 2 express BER in a logarithmic scale which often allows data with large distances to look smoother and can sometimes make it look as though there is a good correlation between data. This is not always the case and as the data produced through carryout this investigation was not plotted on a logarithmic scale is not directly comparable with those graphs, but each modulation scheme is comparable with one another. Further investigation could be carried out into say FSK or BPSK also to compare those schemes. Use of smaller incremental increases in AWGN will also allow more accurate determination of when the scheme actually fails.

7. References

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