

coms and protocols assignment

by Nicholas Regan

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Title:

**Comparative Performance of Advanced Modulation
Schemes**

Module: Communications and Protocols

ACDA5000

HND Electronic Engineering

University of Wales Trinity St David

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Date: 20.1.20

Declaration

The work of this assignment which has been completed under the supervision of:

Dr. Steve. Mosey

I declare that this assignment is the product of my own work and has not been submitted for any other degree etc.

Signed: NSB

Date: 20.1.20

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Abstract

This report covers a critical comparison of the performance of amplitude shift keying, (ASK) and phase shift keying, (PSK), in the presence of additive white Gaussian noise.

Background research was carried out on ASK, PSK, QPSK and QAM

Simulated models were created using using Mat Lab Simulink software, and their performances compared with no noise, followed by increasing amounts of noise.

Graphs were plotted of the bit error rate against signal to noise ratio.

The conclusion was that there were less errors in ASK and .that both ASK and PSK had clear results when there was no noise. When there was noise, the results were unexpected. Also there was a delay in demodulation data. Further research is necessary to ascertain the reason for both of these.

Introduction

The main subject of this report is based on amplitude shift keying and phase shift keying. These are both types of 'digital modulation'. There are two types of modulation, Continuous wave modulation and digital modulation. The research for this report will concentrate on digital modulation.

Vashishtha in his online tutorial explains that "Modulation is a process in which a part of the carrier wave is varied, depending on the value of the signal." (1) A carrier wave is a radio frequency wave that is analogue. There are three parts of a carrier wave which are: amplitude, frequency and phase. Each of these three parts can be modulated (varied) in different ways. by sending a digital input signal. As mentioned there are three parts of a carrier wave to vary so there will be three different types of digital modulation. They are known as: amplitude shift keying, frequency shift keying and phase shift keying

Sklar when explaining modulation describes digital modulation as "the process by which the digital symbols are transformed into wave forms that are compatible with the channel." (2 p118)

Amplitude Shift Keying (ASK)

In ASK the amplitude of the carrier wave is changed depending on the input signal, which is the modulating signal. Vashishtha explains, that  the carrier wave is not transmitted when the digital input signal (of binary data) is '0' and is transmitted, as it is, when the digital input signal is '1'. (1). ASK is also known as 'on-off keying, (OOK) for this reason. OOK is used for Morse code.

For advantages and disadvantages of ASK see Appendix 1.

Frequency Shift Keying (FSK)

This is another type of digital modulation which changes the frequency part of the carrier wave, but will not be looked at as it is not part of the exercise.

Phase Shift Keying (PSK)

In PSK it is the phase part of the carrier wave is changed. Vashishtha explains, "according to the instantaneous value of the input signal the information of this digital signal is present in the phase shift variations of the carrier wave." (1). In BPSK, (which is a two level version of PSK) when the digital input bit changes (from binary input 0 to 1 or 1 to 0), a phase shift of 180° takes place in the carrier wave. No phase change takes place when there is no change in the digital bit. (0 to 0 or 1 to 1).

For advantages and disadvantages of PSK see Appendix 1.

Quadrature Phase Shift Keying (QPSK)

QPSK is a four level form of PSK. In ASK the carrier wave has two states or symbols i.e. no transmission for '0' and transmission 'as it is' for '1'. In BPSK also, there are two symbols except when binary '0' is transmitted there is a phase shift of 0° and when binary '1' is transmitted there is a phase shift of 180° . In these cases one bit per symbol is transmitted. However, in QPSK, two bits per symbol are transmitted. Because there are two bits in each of the two symbols there are now four possible combinations or phases, of '0' and '1' as below:



'00' '10' '01' '11'

Vashishtha explains that as there are four phases that the 360° can be divided into four sections each of 90° . Because in BPSK 0° and 180° are used, it would be difficult if they were used again in QPSK. Therefore in QPSK the following phases are used instead: (4)

45° ; 135° ($45^\circ + 90^\circ$); 225° ($135^\circ + 90^\circ$); 315° ($225^\circ + 90^\circ$)

QPSK therefore has more data capacity than BPSK. As it transmits two bits in one signal, the signal rate is reduced. Vashishtha adds that also it reduces the frequency of the carrier wave so results in reduced bandwidth. (4).

Quadrature Amplitude Modulation (QAM)

In an educational article on www.rfwireless.com website it explains that "QAM is a combination of both amplitude and phase modulation techniques." (5). It continues by explaining that there are two signal frequencies, each shifted 90° from one another, which can be transmitted on the same carrier wave. (5).

Vashishtha explains in more detail; the process in QAM is that there are two signals, (two analogue signals or two digital bit streams). Two carrier waves are used, one for each of the two signals. So there are two product modulators. The second carrier wave has a phase shift of 90° . The signals change the amplitude of two carrier waves, instead of one, (ASK if the signal was digital). But because the two carrier waves are out of phase with each other by 90° then it can be said that both amplitude modulation has been used and phase modulation. This is called quadrature. The transmitted signal is created by adding the two carrier waves together. (6).

Thermal Noise

Thermal noise is present in all communication systems. It is caused by the thermal motion of electrons in all conductors" (2 p 202).

The characteristics of thermal noise, (additive, white, and Gaussian) are most often used to model the noise in communication systems." (2 p30).

Noise will affect the results as it causes symbol errors first which will then produce bit errors. The number of bit errors should be measured and compared to the original number of bits received. This will show how well bits are being transferred which is an important part of the process.

Equipment

To create models of amplitude shift keying, (ASK), phase shift keying, (PSK), quadrature phase shift keying, (QPSK) and quadrature amplitude modulation, (QAM), MATLAB Simulink is used. Simulink is a simulator used with MATLAB for this purpose.

The components used for creating a ASK model are a Bernoulli binary generator, a sine wave, a product, an additive white Gaussian noise (AWGN) channel, a transport delay, a signal specification, a scope, a digital filter design, a constant, a switch, an error rate calculation, and a display.

The components used for creating a PSK model are basically the same as ASK, however instead of a digital filter design, a low pass filter is used and a sum component is used for PSK, but not for ASK.

Method

When creating a model for an ASK the right components need to be chosen and the right values need to be given to these components to make sure they work properly. The first component is the Bernoulli binary generator which generates random binary data, the values given to this were 0.5 for the probability of zero meaning it can be either 1 or 0 and 1 for the sample time. The second component is a sine wave and these two components were connected to a product which multiplies the two to become a carrier wave.

Next is the AWGN channel. This was used to add some noise to the data to see the effect it had. The initial speed used for this was 67 and the signal to noise ratio will change depending on how much noise is wanted. This will range from anything between -50 – 50. Another sine wave was added and these components were connected to another product and multiplied by two.

A digital filter design used as a low pass filter with a pass band of 5Hz and a stop band of 75Hz was added and was connected to a switch. The switch was used to switch inputs at the point of threshold which was 0.25, so when input 2 is higher than 0.25 the output will come from input 1 and when input 2 is lower than 0.25 the output will come from input 3.

A scope was added to different parts of the model to show different results.

A transport delay was connected to the output of the binary generator. This was used to put a time delay in between the input and output. The time used for this was 0.039. This was connected to a signal specification with a sample time of 1 which had to match the binary sample time. A scope was connected to the both of these.

An error rate calculation was connected to the signal specification and switch to collect data, and a display was connected to this to show the data. The data

shown is the error rate, followed by the number of errors and the total number of symbols compared.

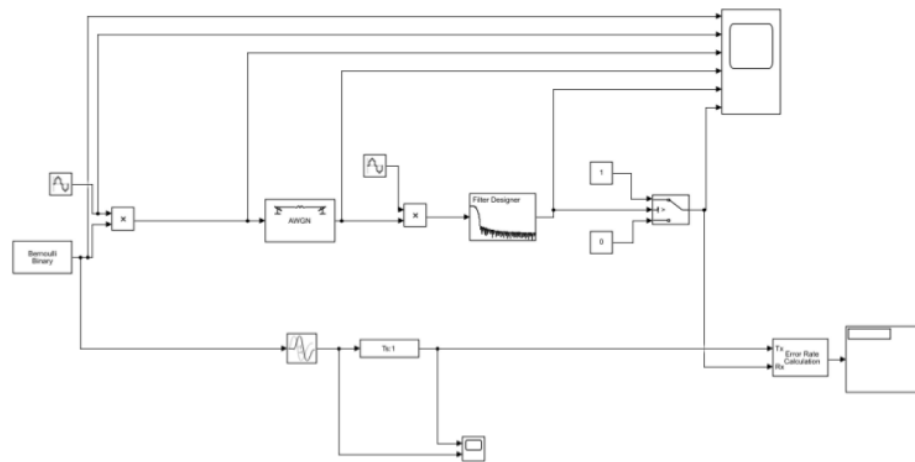


Figure 1: Model for ASK using Simulink

So when creating the model for PSK, just like ASK the first component used was a binary generator with a sample time of 1, a sine wave is multiplied by -1 to show the 180° carrier wave using an oscilloscope. These components were also connected to a switch that has a threshold of 0.5 which was also connected to the scope.

Some noise was added using an AWGN channel component with an initial speed of 67 and again different signal to noise ratios will be used. This was multiplied with a sine wave and connected to a low pass filter that has a stop band of 6Hz, a pass band of 2Hz, a pass band ripple of 0.1dB and a stop band attenuation of 80dB. This was added to 0.5 and connected to a switch with a threshold of 0.5. A scope was used to show data from different parts of this model.

A delay of 45 with a sample time of 0.01 was connected to the binary generator and subtracted from the demodulated data then connected to the scope to show the difference between the original data and demodulated data.

A transport delay, signal specification, error rate calculation and display was all connected to show the error rate, the number of errors and the number of samples compared.

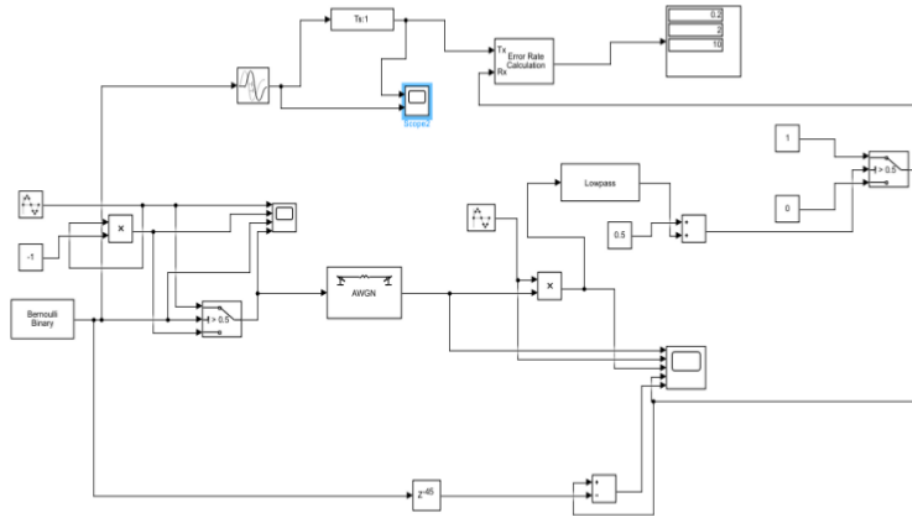


Figure 2: Model for PSK using Simulink

Result

Once the models had been created in Simulink, the oscilloscopes could be used to collect data. The data collected for ASK is shown below.

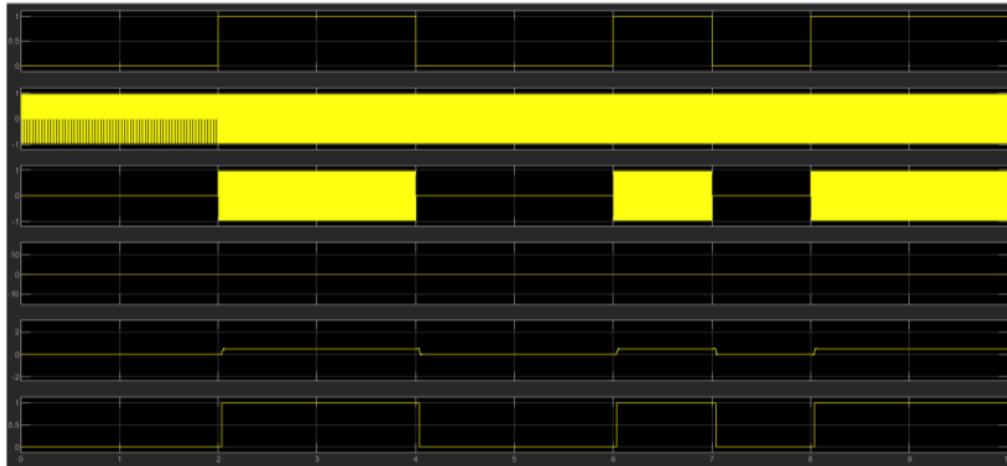


Figure 3: ASK with no noise, using Simulink

This is the data shown for ASK when there is no noise. The top is the original data, then it's the carrier wave, then it's the modulated data, then it's the AWGN data, then the filtered data and lastly, the demodulated data.

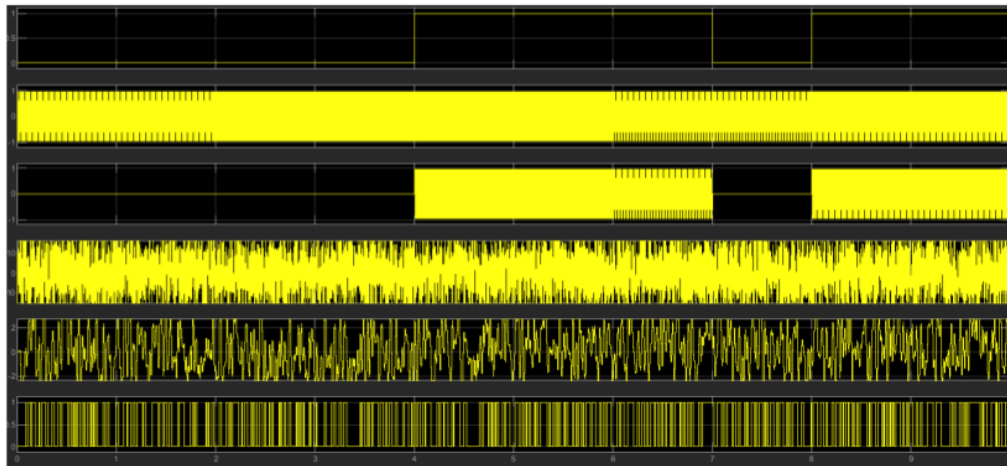


Figure 4: ASK with SNR is -20dB using Simulink

This is the data shown when the SNR is -20dB. As shown, the data for the AWGN is a lot more distorted, the filter hasn't made much of a difference and the demodulated data is completed incorrectly.

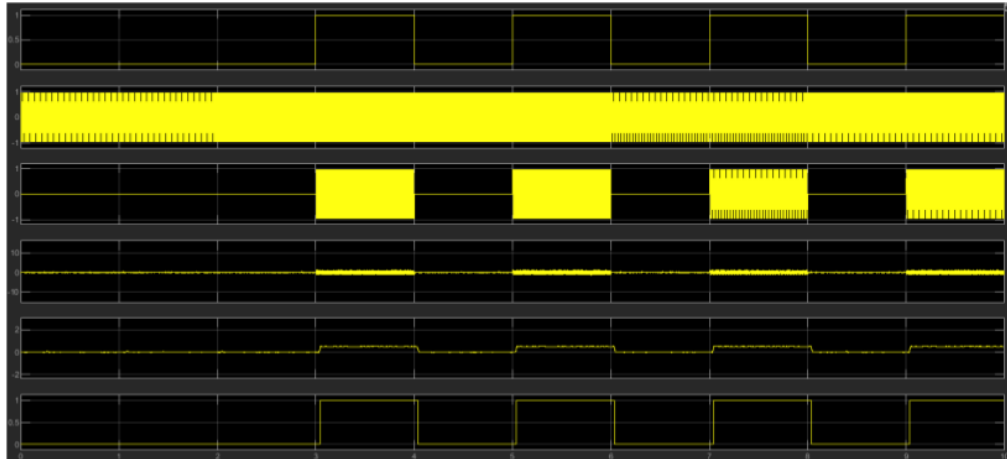


Figure 5: ASK with SNR of 20dB using Simulink

This is the data when the SNR is 20dB. The data shown for the AWGN is much cleaner, as is the filtered data and as shown the demodulated data matches the original data.

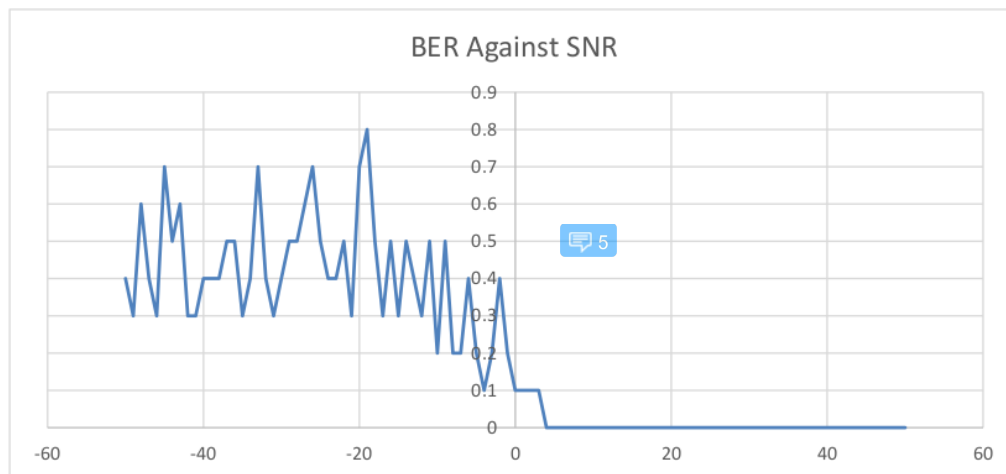


Figure 6: Graph for BER against SNR using Simulink

First use This is the graph for BER against SNR. This shows that when there is more noise to signal (SNR is negative) there are more errors and when there is more than 4dB of signal to noise ratio there are no errors. The most errors are at -19dB. For corresponding table see Appendix 2.

The data collected for PSK is shown below.

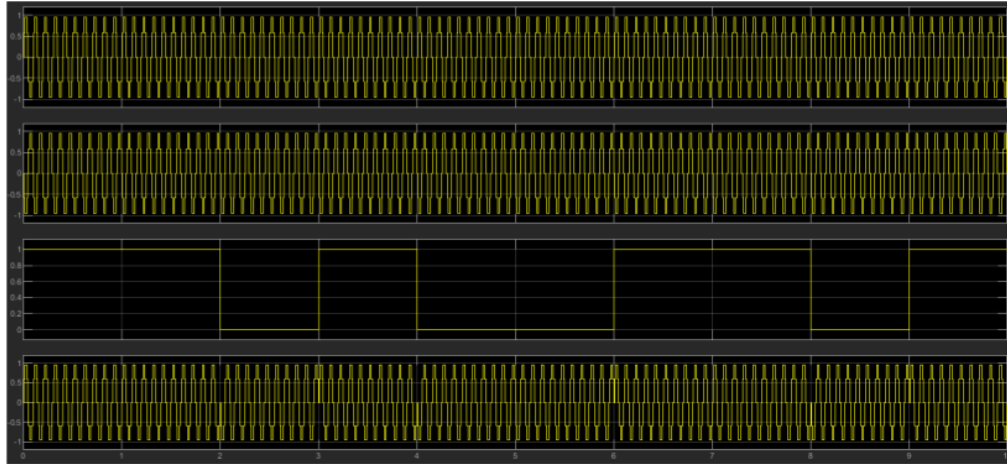


Figure 7: PSK using Simulink

This is the data from the 1st scope of PSK. From top to bottom is the 0° carrier wave, then the 180° carrier wave, then the original data and lastly it's the modulated data. This data will always be the same

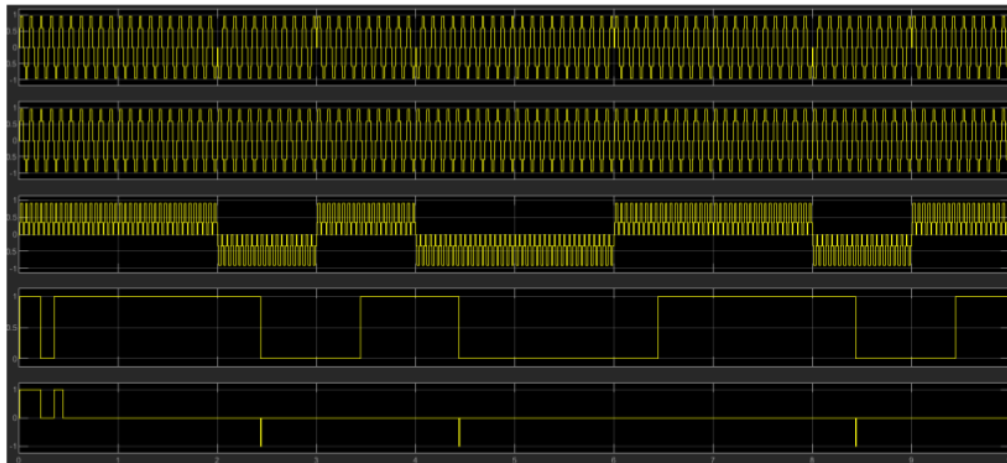


Figure 8: PSK with no noise using Simulink

This is the data shown for the 2nd scope when there is no noise. The data shown from top to bottom is the modulated data, then it's the carrier wave for demodulation, then it's the modulated data multiplied by the carrier wave, then it's the demodulated data and then it's the demodulated data subtracted from the original data.

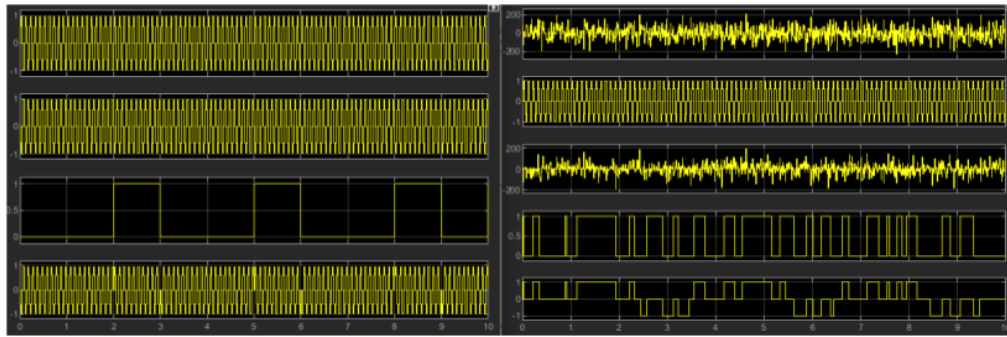


Figure 9: PSK with SNR of -20dB

This is the data from both scopes when the SNR is -20dB. On the 2nd scope the top row shows the modulated data with noise, then it's the carrier wave, then it's the two multiplied together again with noise, then it's the demodulated data after being filtered which is completely different to the original data and then it's the demodulated data subtracted from the original data which does not look correct.

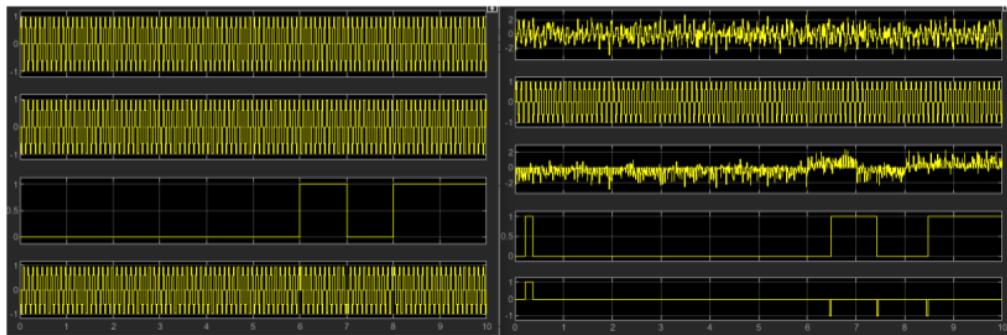


Figure 10: PSK with SNR 20dB

This is the data shown when the SNR is 20dB, as shown the demodulated data looks more like the original data and the demodulated data subtracted from the original data looks very close to how it should do.

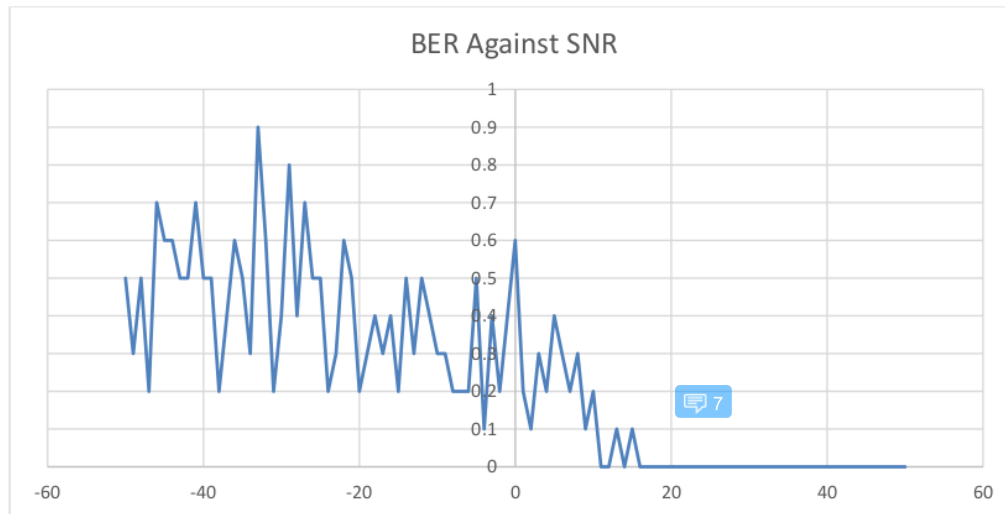


Figure 11: Graph for BER against SNR using Simulink

This is a graph to show BER against SNR. As shown in the graph when the SNR is negative there are a lot more errors, when the SNR is positive there still a few errors but not as many and once the SNR reaches 16dB there are no errors at all. For corresponding tables see Appendix 2.

Discussion

As shown in the results both for ASK and PSK the modulated data is correct because for ASK only the binary number 1 is represented by the transmitted data and for PSK when the binary number changes the carrier changes from 0 to 180°.

When there is no noise the demodulated data for both ASK and PSK matches the original data however for ASK there is a very slight delay and for PSK there is a much longer delay, so much so that other pulses are visible, this could be due to the type of filter or **wrong order filter** being used.  8

When the SNR was -20dB for ASK the BER was 0.7 which meant the demodulated data should have had 7 errors. The results are not very clear which could be due to the amount of noise or the delay of the transmitted data. For PSK the BER was 0.2, as shown in the results the demodulated data was very clear and there was more than 2 errors this could be due again to the amount of noise or maybe an error in the circuit.

When the SNR was 20dB for ASK the BER was 0 and as shown in the results this was correct, and also there was very little noise disruption which was blocked out by the filter. For PSK the BER was 0 and as shown in the results this was correct. However there was still some noise disruption which was not blocked out very well which could have been the cause of the delay.

The BER against SNR graphs show that PSK had the highest error of 0.9 whereas the ASK highest error was 0.8. PSK had a lot more errors than ASK and needed bigger **SNR's** than ASK to clear the errors.

Misplaced apos.

Conclusion

In conclusion the ASK model is defiantly easier to build with a lot less components needed. This could be the reason why there are not as many errors as PSK in the results. Both models are clear when there is no noise or have a bigger SNR compared to when there is noise.  9

The results when there was additional noise was not as expected and the reason for this unknown. Further research and time is needed to ascertain the reason.

The same will apply to finding the reason why there is a delay in the demodulation data, but overall the circuits were built okay and the information collected was very useful.

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Appendices

Appendix 1: Advantages and Disadvantages of ASK and PSK

Appendix 2: Tables showing BER Against SNR

Appendix 1

Advantages and Disadvantages of ASK and PSK

ASK:

An educational article on website www.rfwireless.com (7) discuss the disadvantages of ASK briefly listed below:

Advantages: High bandwidth efficiency; Simple receiver design; Can be used to transmit digital data over optical fibre; Inexpensive.

Disadvantages: Lower power efficiency; Very susceptible to noise interference (noise affects the amplitude);

In addition to this, Professor I. Wells, the author of a Communications and Protocols UWTSD module lecture, states that a disadvantage of ASK is that it is subject to gain changes. (8 slide 7)

Professor Wells also mentions that ASK can be used for LED transmissions and for Laser transmissions. In the case of LED transmission (one signal element is a light pulse; the other is an absence of light). In Laser transmitters by low amplitude light level representing one signal element and a higher amplitude level. (8 slide 7)

PSK:

In an educational article on rfwireless.com, (5), several advantages and disadvantages of PSK are discussed. They are briefly listed here:

Advantages: Carries data over RF signal more efficiently; more power efficient than ASK or FSK; less susceptible to errors than ASK; occupies same bandwidth as ASK; less susceptible to noise; Higher data rate of transmission can be achieved as higher levels modulations can be used such as and QPSK and QAM .(see below).

Disadvantages: It has lower bandwidth efficiency; QPSK is susceptible to phase variations and is less robust. (9).

Appendix 2

Tables BER Against SNR

ASK BER Against SNR Table:

SNR	error rate
-50	0.4
-49	0.3
-48	0.6
-47	0.4
-46	0.3
-45	0.7
-44	0.5
-43	0.6
-42	0.3
-41	0.3
-40	0.4
-39	0.4
-38	0.4
-37	0.5
-36	0.5
-35	0.3
-34	0.4
-33	0.7
-32	0.4
-31	0.3
-30	0.4
-29	0.5
-28	0.5
-27	0.6
-26	0.7
-25	0.5
-24	0.4
-23	0.4
-22	0.5
-21	0.3
-20	0.7
-19	0.8
-18	0.5
-17	0.3
-16	0.5
-15	0.3

-14	0.5
-13	0.4
-12	0.3
-11	0.5
-10	0.2
-9	0.5
-8	0.2
-7	0.2
-6	0.4
-5	0.2
-4	0.1
-3	0.2
-2	0.4
-1	0.2
0	0.1
1	0.1
2	0.1
3	0.1
4	0
5	0
6	0
7	0
8	0
9	0
10	0
11	0
12	0
13	0
14	0
15	0
16	0
17	0
18	0
19	0
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21	0
22	0
23	0
24	0
25	0
26	0
27	0
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31	0

32	0
33	0
34	0
35	0
36	0
37	0
38	0
39	0
40	0
41	0
42	0
43	0
44	0
45	0
46	0
47	0
48	0
49	0
50	0

PSK BER Against SNR Table:

-50	0.5
-49	0.3
-48	0.5
-47	0.2
-46	0.7
-45	0.6
-44	0.6
-43	0.5
-42	0.5
-41	0.7
-40	0.5
-39	0.5
-38	0.2
-37	0.4
-36	0.6
-35	0.5
-34	0.3
-33	0.9
-32	0.6
-31	0.2
-30	0.4
-29	0.8
-28	0.4
-27	0.7
-26	0.5
-25	0.5
-24	0.2
-23	0.3
-22	0.6
-21	0.5
-20	0.2
-19	0.3
-18	0.4
-17	0.3
-16	0.4
-15	0.2
-14	0.5
-13	0.3
-12	0.5
-11	0.4
-10	0.3
-9	0.3
-8	0.2
-7	0.2

-6	0.2
-5	0.5
-4	0.1
-3	0.4
-2	0.2
-1	0.4
0	0.6
1	0.2
2	0.1
3	0.3
4	0.2
5	0.4
6	0.3
7	0.2
8	0.3
9	0.1
10	0.2
11	0
12	0
13	0.1
14	0
15	0.1
16	0
17	0
18	0
19	0
20	0
21	0
22	0
23	0
24	0
25	0
26	0
27	0
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35	0
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49	0
50	0

coms and protocols assignment

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

Instructor

64/100

PAGE 1

PAGE 2

PAGE 3

PAGE 4

QM

First use

You should introduce acronyms and symbols the first time you use them so the reader understands what you are talking about.

QM

First use

You should introduce acronyms and symbols the first time you use them so the reader understands what you are talking about.



Comment 1

MATLAB is one word

PAGE 5



Comment 2

You should try to make headings stand out from the body text of your report more. Consider underlining or using a bold face font.



Comment 3

missing 't' - the

PAGE 6



Comment 4

Good

PAGE 7

PAGE 8

PAGE 9

PAGE 10

PAGE 11

PAGE 12

PAGE 13



Comment 5

Axis labels missing.

QM

First use

You should introduce acronyms and symbols the first time you use them so the reader understands what you are talking about.

Additional Comment

Bit Error Rate



Comment 6

do you mean the amplitude of the noise is greater than the amplitude of the signal?

PAGE 14

PAGE 15

PAGE 16



Comment 7

You should label your axis so the reader can determine which axis relates to which parameter.

PAGE 17



Comment 8

Not the wrong order. but resulting from the length of the filter used.

It's a result of the number of coefficients used in the filter and the convolution process.

QM

Misplaced apos.

Misplaced apostrophe:

An apostrophe can function to indicate a possessive when accompanied by an -s ("the book that belongs to Roy" = "Roy's book"). For words that already have an -s at the end, just adding the apostrophe will do ("the team belonging to the boys" = "the boys' team"). Certain exceptions to this rule apply, and possessive personal pronouns ("like ours," "yours," "hers," "his," "its") are possessive already and therefore do not take an apostrophe. It is always wrong to use a possessive apostrophe to simply make a word plural.

PAGE 18



Comment 9

It would have been nice to see both modulation techniques compared on the same graph - this would allow a more direct comparison to be made.

PAGE 19

QM

Refs missing info

Some of your references are missing information. To understand what information should be included, see the university IEEE referencing handbook on the library website.

https://uwtsd.ac.uk/media/uwtsd-website/content-assets/documents/library-and-learning-resources/infoskills/IEEE-eng_v.1.2.pdf

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ENGAGEMENT WITH LITERATURE

including reading, referencing, academic conventions and academic honesty



Inclusion of a wide range of research-informed literature, including sources retrieved independently. Selection of relevant and credible sources. Very good use of referencing conventions, consistently applied.

6.5**KNOWLEDGE & UNDERSTANDING**

Knowledge of the basic underlying concepts and principles of a subject.



Excellent knowledge and understanding of the main concepts and key theories. Clear awareness of challenges to established views and the limitations of the knowledge base.

14**COGNITIVE & INTELLECTUAL**

Evaluate underlying concepts and principles of a subject and interpret qualitative and quantitative data in order to develop lines of argument and make sound judgements.



Evidence of some logical, analytical thinking and synthesis. Can analyse new and/or abstract data and

17.4

situations without guidance. An emerging awareness of different stances and ability to use evidence to support the argument. Valid conclusions and recommendations, where relevant

PRACTICAL APPLICATION SKILLS

Different approaches to solving problems in particular contexts.



A very good application of a range of methods, tools and techniques. Very good consideration of the context of the application, with perceptive use of examples, where relevant. Evidence of some innovation and creativity.

19.5

TRANSFERABLE SKILLS

Communicate the results of their study/work accurately and reliably, and with structured and coherent arguments; the qualities needed for employment requiring the exercise of some personal responsibility within a structured and managed environment.



Can communicate professionally and, confidently in a suitable format. Work is coherent, very fluent and is presented professionally.

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