

OW DSP&C

by Owen Wild

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Author: Owen Wild

Acknowledgement

MATLAB and excel where used to simulate, collected and show the dater.

Grammarly was used to proofread this assignment.

Contents

Acknowledgement	2
Table of Figures.....	2
Abstract.....	3
Introduction	3
Background	3
Simulation models	4
ASK	6
PSK	6
QPSK.....	7
QAM	9
Results.....	11
Discussion	11
Conclusion.....	12
Recommendation.....	12
References	12
Appendix	13

Table of Figures

Figure 1 - filter design	5
Figure 2 - ASK modulation.....	6
Figure 3 - PSK modulation	6
Figure 4 - QPSK modulation	7
Figure 5 - QPSK modulation (2).....	8
Figure 6 - QAM modulation	9
Figure 7 - QAM modulation	10
Figure 8 - Modulation graph	11
Figure 9 - Data collected	13
Figure 10 - Data collected (2).....	13

Abstract

This report shows how ASK, PSK, QPSK and QAM are effective by adding noise when transmitting and how the systems handle this by showing in the BER.

For this experiment controlled, independent and dependent variables apply to this and as outlined as follows. The controlled variables are filter design, carrier signal, the number of samples taken(25), the step size of the SNR increments at -5db and the time stop/sample rate of 100. The dependent variables are the BER, the average of the BER and the standard deviation of the BER. Finally, the independent variables are the Bernoulli binary and the AWGN.

All the modulation techniques were done in MATLAB using Simlink to be able to calculate the BER of the system. Excel was used to collect the sample data, the average of BER and the standard deviation of each modulation technique. A graph was also done in Excel from the collection of the data.

The finding is that QAM handles the best and PSK and QPSK are fairly similar in the handling of excess noise. This leaves ASK which performs the worst at handling added noise in the system.

Introduction

This Report outlines how simple and advanced modulation techniques are effective at dealing with added noise when transmitting. ASK, PSK, QPSK and QAM are all the modulation techniques that were looked at and simulated. The report goes through the general background of ASK, PSK, QPSK and QAM. For the simulation section, a detailed outline of the block diagram for all modulation techniques is provided and shown in MATLAB.

The controlled variables are filter design, carrier signal, the number of samples taken(25), the step size of the SNR increments at -5db and the time stop/sample rate of 100. The dependent variables are the BER, the average of the BER and the standard deviation of the BER. Finally, the independent variables are the Bernoulli binary and the AWGN.

The data collected was added to a graph in Excel where all four modulation techniques were added to easily compare them all together. The data collected including the samples data the average and the standard deviation can all be found in the appendixes.

To wrap this report up a discussion and conclusion were drawn up from the data being collected from all modulation techniques.

Background

The background research was done on the four modulation techniques required for this assignment. This includes ASK, PSK, QPSK, and QAM.

ASK (Amplitude Shift Keying) is the first modulation technique examined. ASK is a modulation to be able to transmit a binary sequence of data when a binary 1 wants to be transmitted a high analogue amplitude replaces the binary 1 and a low analogue amplitude replaces a binary 0.[1]

PSK (Phase-shift keying) was examined for the second simple modulation technique. How this modulation works is that the binary sequences of 1 and 0 have been allocated different phases to be

transmitted. When a change in the binary sequences ⁹ wants to do an M or upside-down M is outputted to indicate a change in 1 or 0. [2]

QPSK (Quadrature Phase Shift Keying) is similar to PSK as it utilises phase shifting to denote a change in a binary 1 or 0. QPSK uses four phase shifts that are all 90° from each other thus allowing us to send two bits of ¹⁰ dater.

QAM (Quadrature Amplitude Modulation) is the last advanced modulation technique that was examined. This modulation technique uses both amplitude and phase-shifting to transmit a binary sequence. ¹¹ QAM was looked at as it's the first widely used QAM and also enables us to transmit 4 bits at once. [4]

Simulation models

ASK ¹², PSK, and QAM are all simulated in MATLAB with the same filter design, carrier signal and time ¹³ sample rate of 100. These are all the control variables for all ¹³ mo in MATLAB. For the collection of data, the number of samples taken is 25 and the step size of SNR is at 5db. These are the controlled variables for all modulations on the collection of the dater. The independent variables are the Bernoulli binary and the AWGN. Finally, the dependent variables are the BER, the average of the BER and the standard deviation of the BER.

When simulating the ASK modulation first, ^{Use of 1st Person Voice} I noticed that I was at -220db before a 50% fail three times in a row and still going. This led me to lower the threshold to 45% to save on time and the amount of data being collected. The threshold of BER failures is set to 45% as this is the amount of errors that can occur to still be able to retrieve the data. For retrieving the correct amount of data error correction methods are used to determine what the data was originally.

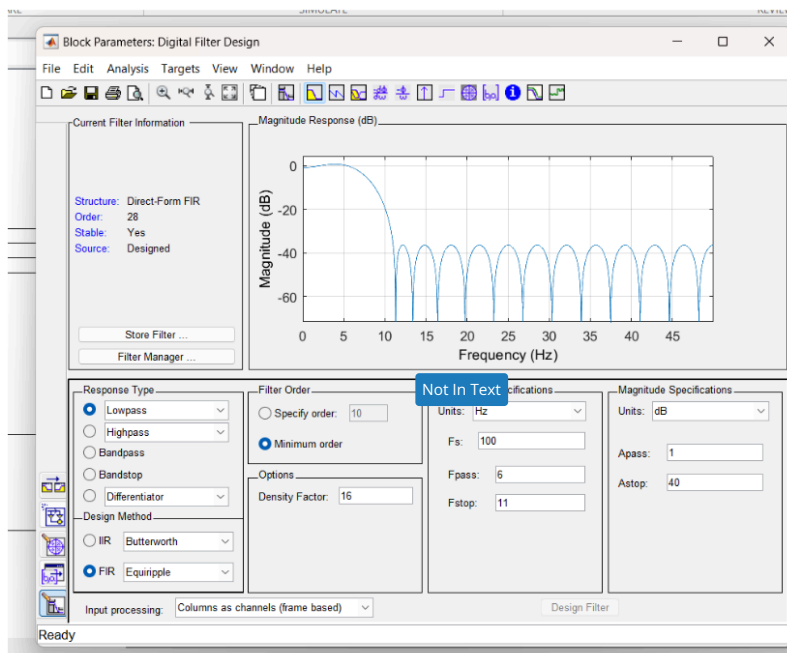


Figure 1 - filter design

ASK

The ASK modulation block diagram shows the constructions of an ASK modulation in MATLAB. It uses one carrier wave multiplied together and transmitted. The carrier wave is joined to the binary sequence to be able to propagate and be added. AWGN block is added to simulate the SNR that can be added in a real-world application. Then passed through a low-pass filter to remove most of the unwanted noise. A switch is added with a threshold of 0.5 so the analogue data can be turned into binary 1 or 0. The BER is calculated by taking the input data to the output data using the error rate calculator block.

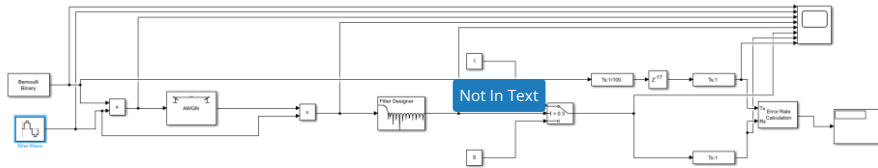


Figure 2 - ASK modulation

PSK

PSK modulation is shown below. The block diagram is laid out with the binary data inputted into a switch threshold with two carrier waves added at 2π and π phase apart. This is then fed through the AWGN and to two multiplied blocks with the same waves as the input ones. This is to take away the carrier waves as you can't divide them. Once multiplied both I and Q get added together and then passed through a low-pass filter. Finally passed through the switch with a constant of 1 and 0 the threshold being the filtered signal.

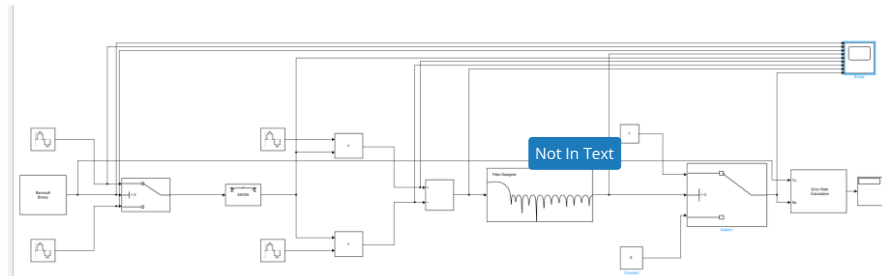


Figure 3 - PSK modulation

QPSK

QPSK uses a lot more blocks than PSK as 4 phase shifts needed to be modulated with 2 bits being sent at once instead of one phase shift and one bit being sent. The binary sequences are fed into a serial to parallel block which is set to 4. This means it will shift the sequences by one bit up to four bits. This then fed to a Demux which added two of the 4 sequences together. Two carrier waves are added at the same frequencies and $\pi/2$ apart. How this next section is laid out is that a -1 constant is being multiplied by both the carrier waves and then fed to one section of a switch. The other side of both switches is connected to the carrier wave and the threshold is the Demux signal. All of this section helps to get it to all four phase shifts with 2 bits in each one. Both the output of the switches are added together and then fed through the AWGN block.

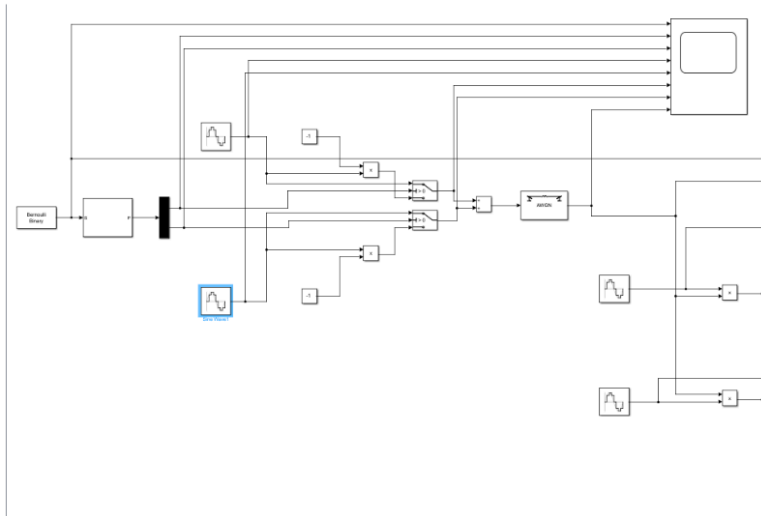


Figure 4 - QPSK modulation

The demodulation of QPSK is a bit simpler as the signal is branched off into two and multiplied with the same carrier signal. This takes away the carrier's signal so just get the four-phase shift sequences with added AWGN. Both are fed through a lowpass filter and to the threshold of two switches with a constant of 1 and 0. This will switch if the threshold is greater or less than one to produce binary sequences. Before these binary sequences can be read it needs to go through a mux and then a parallel to serialised which can now be read.

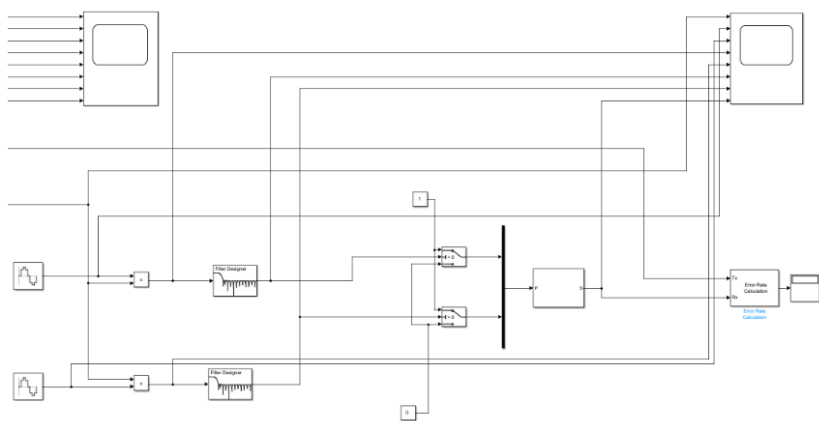


Figure 5 - QPSK modulation (2)

QAM

The QAM block diagram is as follows the binary data is split into 4 sequences and fed through the Demux. Thus, it creates the I phase and amplitude and the Q phase and amplitude. These are then fed through four switches with either a constant of 3, 1 or -1. These are then fed through two multipliers with the same carrier wave $2\pi \cdot 5$ and at $\pi/2$ apart. Both signals are added together and then fed through the AWGN. This simulates the transmission of the signal.

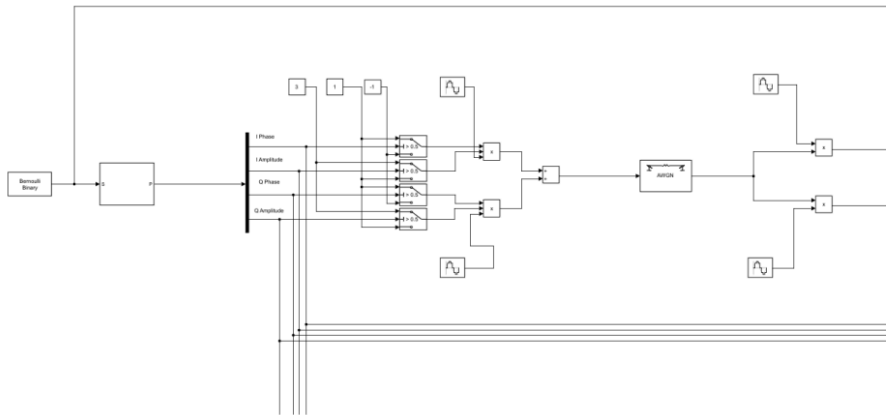


Figure 23: QAM modulation

To Demod the QAM, we need to multiply the same carrier out and then feed through a lowpass filter. Then fed to four switches with two lines fed through an abs block which gives the absolutes values of the signal. After going through the four switches all lines are sampled at 4 as we split the data 4 times. Finally fed through a mux and parallel to the serializer which then can do the BER calculation as this is the fully demodulated signal.



Page 10 of 14

Results

The graph below shows all modulation techniques from ASK, PSK, QPSK and QAM and how they can handle excess noise. The graph takes the average of the BER which has been sampled 25 times and displayed on the y-axis. Error are added which are at on standard deviation of the sampled data and added on both the positive and negative ends. All four modulation techniques follow the same trends. A fail threshold was added that when the data reaches an average BER of 45% three times in a row this would constitute the modulation has failed, thus means anything more and the original signal can't be retrieved.

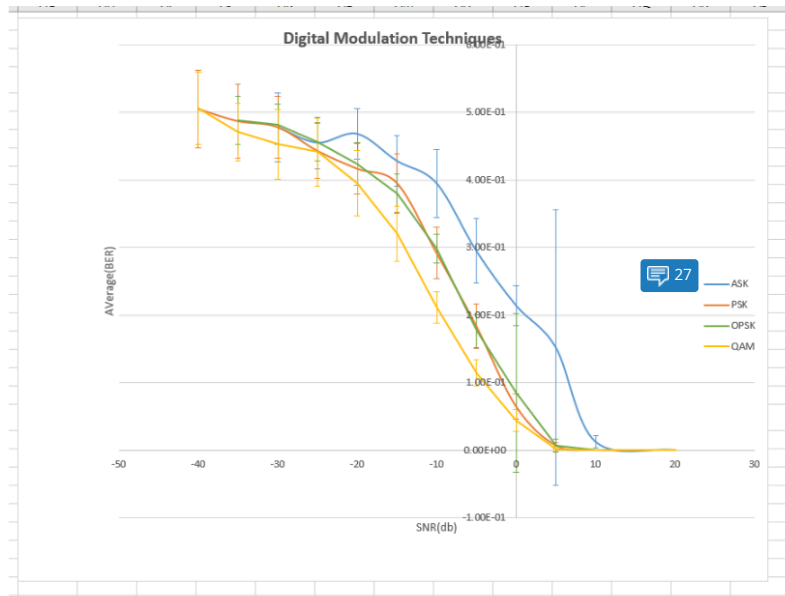


Figure 8 - Modulation graph

Discussion

The results show that all modulation techniques follow the same pattern with ASK starting more steps and QAM with a gentler include. ASK has a large Error bar as some values were 0 and some were 1 which gave a larger error calculation. QAM is the best modulation technique as it has a least step curve than QPSK, PSK and ASK. This means that QAM can handle noise better as it receives fewer errors from the transition with a higher SNR. PSK and QPSK have very similar lines thus handling added noises relatively the same. ASK is the outlier as it handles excess noises not very well.

Conclusion

To conclude this experiment of simple and advanced modulation techniques of ASK, PSK, QPSK and QAM highlights how each one is effective by noise added noise. ASK is effective more than PSK as it's a simpler modulation technique. PSK and QPSK have been found to act pretty much the same with QPSK performing slightly better as has a less-step cure. The finding of this report is that QAM performs the best at handling AWGN and ASK performs the worst at handling it. All modulation techniques fail around -30db to -40db SNR.

Recommendation

To make this work more accurate more sample can be taken with a smaller increment of SNR. Also, to increase the time step so more points can be simulated. More modulation techniques can be looked at like 16-bit and 32-bit QAM to give a bigger picture of the performance of different modulation techniques.

References

- [1] Tutorialspoint, "Amplitude Shift Keying," Tutorialspoint, [Online]. Available: https://www.tutorialspoint.com/digital_communication/digital_communication_amplitude_shift_keying.htm. [Accessed 05 12 2024].
- [2] "Phase Shift Keying Modulation," Libre texts engineering, [Online]. Available: [https://eng.libretexts.org/Bookshelves/Electrical_Engineering/Electronics/Microwave_and_RF_Design_I_-_Radio_Systems_\(Steer\)/02%3A_Modulation/2.13%3A_Phase_Shift_Keying_Modulation](https://eng.libretexts.org/Bookshelves/Electrical_Engineering/Electronics/Microwave_and_RF_Design_I_-_Radio_Systems_(Steer)/02%3A_Modulation/2.13%3A_Phase_Shift_Keying_Modulation). [Accessed 05 12 2024].
- [3] GaussianWaves, "QPSK – Quadrature Phase Shift Keying," GaussianWaves, 19 10 2010. [Online]. Available: <https://www.gaussianwaves.com/2010/10/qpsk-modulation-and-demodulation-2/>. [Accessed 05 12 2024].
- [4] Electrical4u, "Quadrature Amplitude Modulation (QAM): What is it?," Electrical4u, 24 05 2024. [Online]. Available: <https://www.electrical4u.com/quadrature-amplitude-modulation-qam/>. [Accessed 05 12 2024].

Appendix

[illegible]

Figure 9 - Data collected

[illegible]

Figure 10 - Data collected (2)

54

/100

PAGE 1

PAGE 2

PAGE 3

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

Generally, this wouldn't go in the abstract, it would be in the design of experiments section.



Comment 2

dB not db



Comment 3

The Bernoulli binary generator is not an independent variable. It is just a data source. The only independent variables in this study are the signal to noise ratio set in the AWGN block, and the type of modulation.



Comment 4

data



Comment 5

data



Comment 6

You should quantify your results in the abstract. How much better/worse were they?



Comment 7

This should not be a repeat of your abstract.

QM

Colloquialism

You should not use colloquialisms in formal writing.



Comment 8

More detail is required here. You have not described this clearly.

PAGE 4



Comment 9

I'm not sure the binary sequence "wants to do" anything - it is inanimate.

"When a change in the binary sequence is present, the phase of the modulated output signal changes from 0 to 180 degrees, or visa versa.



Comment 10

data



Comment 11

This version of QAM is not 16-bit, it is 4 bit resulting in 16 symbols.

16 bit QAM would have 65536 symbols - this would be very difficult to build.



Comment 12

step



Comment 13

modulation schemes



Use of 1st Person Voice

When writing technical reports, do not use first person voice. Instead, use the third person passive voice.

You should not use words like "I", "you", "we" etc..

PAGE 5



Not In Text

You have included a figure without mentioning it in the text. You should refer to the figure in the text, otherwise it is not worth including as the reader will not know what it relates to.

PAGE 6



Comment 14

...shown in figure 2...

Refer to your diagrams by their captions. Tell the reader what they need to be looking at when they read your work.



Comment 15

Missing units

You could have just put 5 Hz. As I explained in class, MATLAB uses radians per second for frequency.



Comment 16

This does not describe in enough detail how the signal is modulated



Comment 17

The filter is not there to remove the noise. It is there to remove the carrier wave and leave the data



Not In Text

You have included a figure without mentioning it in the text. You should refer to the figure in the text, otherwise it is not worth including as the reader will not know what it relates to.



Comment 18

...in figure 3..



Comment 19

See comment in ASK paragraph on the same point.



Not In Text

You have included a figure without mentioning it in the text. You should refer to the figure in the text, otherwise it is not worth including as the reader will not know what it relates to.

PAGE 7

PAGE 8

PAGE 9



Comment 20

I'm not sure what you mean.



Comment 21

data



Comment 22

This is not a 16 bit system. It is a 4 bit system which has 16 symbols. Please use the correct terminology to describe things.



Comment 23

demodulate



Comment 24

What about splitting into I and Q channels again?



Comment 25

multiplexer

PAGE 10



Comment 26

The start of the demodulator is missing. There should be a single connection coming into the demodulator, then into two multipliers.

PAGE 11



Comment 27

Nice graph

PAGE 12



Comment 28

But for a given noise level, ASK has a higher error rate than QAM. So in relation to resilience from noise, QAM is better.



Comment 29

Why is this the case? What is the cause of it?

You need to link to the constellation diagrams and the distance between the points. More distance between points means there is more space available for the points to move due to the noise, but still remain close enough to the original position to be received correctly.



Comment 30

You could have done this to make this report. Why didn't you?



Comment 31

You already looked at BPSK in this report.



Comment 32

32-QAM is NOT 32-bit QAM. 32-QAM uses only 5 bits of data.



Comment 33

performance



Ref Qual

You should try to use more high quality reference sources, such as textbooks from reputable academic publishers and articles from peer reviewed journals.



Ref Qual

You should try to use more high quality reference sources, such as textbooks from reputable academic publishers and articles from peer reviewed journals.



Ref Qual

You should try to use more high quality reference sources, such as textbooks from reputable academic publishers and articles from peer reviewed journals.

QM

Ref Qty

I was hoping for more references

PAGE 13

PAGE 14

GRADING FORM: SMU GENERIC_SMOSEY

OWEN WILD

54.10

ENGAGEMENT WITH LITERATURE

including reading, referencing, academic conventions and academic honesty



"References to a limited range of mostly relevant sources. Some omissions and minor errors. Referencing conventions evident though not always applied consistently.

4.5

Using more sources and higher quality sources, like textbooks or peer-reviewed journal papers would have increased your mark here.

KNOWLEDGE & UNDERSTANDING

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



Evidence of basic knowledge and understanding of the relevant concepts and underlying principles.

9

Some gaps in knowledge evident.

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 some attempts to synthesise, albeit with some weaknesses.

Some evidence to support findings/ views, but evidence not consistently interpreted.

Some relevant conclusions and recommendations, where relevant

Your analysis does not extend far beyond observation of the results. You need to ask why, and explain the results better. Make the links between cause and effect.

14.7

PRACTICAL APPLICATION SKILLS

Different approaches to solving problems in particular contexts.



A very good application of a range of methods, materials, tools and/or techniques.

Very good consideration of the context of the application, with use of examples, where relevant.

20.4

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 effectively in a suitable format, but may have minor errors.

Mostly coherent work and is in a suitable structure.

Quite a few word choice errors. Try to get your work proofread before submission - by someone else if possible.

When you insert an image, refer to it in the text by its caption, tell the reader what to look at, otherwise why bother putting it in?

5.5