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Department of Electronics and Communications Engineering

**COMPARATIVE ANALYSIS OF VARIOUS WIRELESS
DIGITAL MODULATION TECHNIQUES WITH
DIFFERENT CHANNEL CODING SCHEMES UNDER
AWGN CHANNEL**

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Letter of Transmittal

To
Md. Asif Hossain
Senior Lecturer
Department of Electronics and Communication Engineering
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Subject: Submission of Project Report as (ETE-498)

Dear Sir,

We are pleased to let you know that we have completed our project on "**Comparative Analysis of various Wireless Digital Modulation Techniques with different channel coding schemes under AWGN channel**". The attachment contain of the project that has been prepared for your evaluation and consideration. Working on this project has given us some new concepts. By applying those concepts we have tried to make something innovative by using our theoretical knowledge which we have acquired since last four years from you and the other honorable faculty members of EWU. This project would be a great help for us in future.

We are very grateful to you for your guidance, which helped us a lot to complete my project and acquire practical knowledge.

Thanking You.

Yours Sincerely

Md. Razaul Hoq Proloy
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Declaration

This is certified that the project is done by us under the course “Project (ETE-498)”. The project of **Comparative Analysis of various Wireless Digital Modulation Techniques with different channel coding schemes under AWGN channel** has not been submitted elsewhere for the requirement of any degree or any other purpose except for publication.

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Acceptance

This Project paper is submitted to the **Department of Electronics and Communication Engineering, East West University** is submitted in partial fulfillment of the requirements for the degree of **Bachelor of Science in Electronics & Telecommunications Engineering (ETE)** under complete supervision of the undersigned.

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Senior Lecturer
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Abstract

Wireless communication is the heart of all the modern communications techniques. The future communication is mostly all about related to wireless communications. In wireless communication, different modulation methods are playing the vital roles. To combat the error in transmission channel coding techniques are very much necessary. In this paper, theoretical BER (bit error rate) analysis with E_b/N_0 (Energy per Bit to Noise Power) has been done for various digital modulations techniques such as 8-PSK, 16-QAM and 64-QAM. The paper has also included various channel coding schemes such as block code and convolutional code in the analysis. For all the analysis, AWGN (Additive White Gaussian Noise) channel has been considered.

CHAPTER 1: INTRODUCTION

In telecommunications, modulation is the method of varying one or more properties of a waveform which is called ‘carrier signal’ along with a modulating signal which contains information to transmit. A carrier signal is a periodic signal with constant height (amplitude) and frequency (Hz), where information can be added to the carrier by varying its amplitude, frequency or phase. There are mainly two types of modulation techniques: **analog modulation** and **digital modulation**. If the modulating signal is analog then we use analog modulation and when the modulating signal is digital then we use digital modulation. In digital modulation, PSK, QAM, ASK, FSK modulation are popularly used [1].

While transmitting the signal through the wireless channel there might be some bit errors. To combat this bit error, various channel coding methods have been used such as convolutional coding, block coding, cyclic coding and so on [2]. In digital transmission, the number of bit errors is the number of received bits of a data stream over a communication channel that has been altered due to noise, interference, distortion or bit synchronization errors. It is the number of bit errors per unit time. It is a unit less performance measure, often expressed as a percentage. It is a great tool to analyze the performance of the various modulation techniques [3].

E_b/N_o (the energy per bit to noise power spectral density ratio) is a very important parameter in digital communication. It is a normalized signal-to- noise ratio (SNR) measure, also known as SNR per bit. It is especially useful when comparing the bit error rate (BER) performance of different digital modulation schemes without taking bandwidth into account [4].

AWGN (Additive White Gaussian Noise) Channel is a basic channel model used in analysis. It is the commonly used to transmit signal while signals travel from the channel and simulate background noise of the channel. Mathematical expression in received signal passed through the AWGN channel is: $r(t) = s(t) + n(t)$ where $s(t)$ is transmitted signal and $n(t)$ is background noise [5]. It is flat and not “frequency-selective” as in the case of other fading channel.

There are several researches have been done on the performance comparisons of the various modulation techniques and channel coding schemes with the lie of E_b /N_o vs. BER.

In [6], the authors have investigated the effect of multipath channels on bandpass modulation by simulating a selective frequency fading channel with 6 rays in MATLAB Environment. The authors in [7] have analyzed BPSK and QPSK Modulation with Convolution Coding under AWGN and Rician channel. Similar works have been found in [8-12].

The project has been organized as: chapter1 will introduce the project; chapter 2 will describe the modulation schemes while chapter 3 will describe the channel coding. The results have analyzed in chapter 4 and chapter 5 conclude the project.

CHAPTER 2: MODULATION

Electronic devices produce messages like analog baseband signals in the form of audio, video or even messages can be in the form of digital bits from computer. To send these messages we must have some communication channel like wires, co-axial cable, even wireless radio waves, microwaves or infrared. We can easily transmit messages through wires or cables. Voice, Video, bit streams from computer are having lower frequency band and can travel few distance with wires but cannot be sent through wireless media. Voice signal has lower Bandwidth therefore it will not propagate through space and will be attenuated.

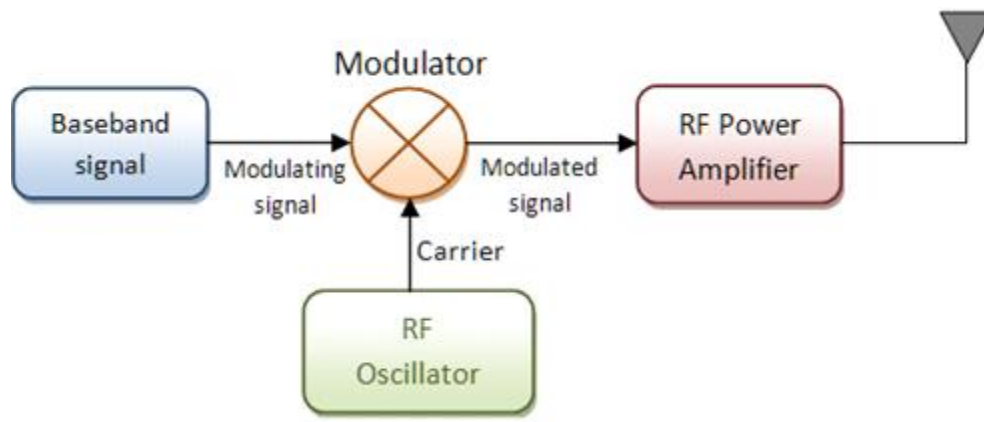


Fig. 1 Basic Modulation Block Diagram

To transmit voice signal a large size antenna is required as antenna length is proportional to half of wavelength. The size of the antenna will be more than the distance between transmitter and receiver. Again when more than one transmitter is involved all station will overlap in one frequency band. For those above reasons we choose a carrier, which is a high frequency radio wave, can travel long distance without attenuation and as the frequency is high smaller antenna is required. Selecting different carrier frequency for different transmitting stations can eliminate overlapping of frequency band.

Types of Modulation

There are two types such as,

- Analog Modulation
- Digital Modulation

Analog Modulation

The aim of analog modulation is to transfer an analog baseband (or lowpass) signal, for example an audio signal or TV signal, over an analog bandpass channel at a different frequency, for example over a limited radio frequency band or a cable TV network channel. Analog modulation facilitate frequency division multiplexing (FDM), where several low pass information signals are transferred simultaneously over the same shared physical medium, using separate passband channels (several different carrier frequencies).

This can be three types,

- Amplitude Modulation (AM)
- Frequency Modulation (FM)
- Phase Modulation (PM)

Digital modulation

The aim of digital modulation is to transfer a digital bit stream over an analog band pass channel, for example over the public switched telephone network (where a band pass filter limits the frequency range to 300–3400 Hz) or over a limited radio frequency band. Digital modulation facilitate frequency division multiplexing (FDM), where several low pass information signals are transferred simultaneously over the same shared physical medium, using separate pass band channels (several different carrier frequencies).

The aim of digital baseband modulation methods, also known as line coding, is to transfer a digital bit stream over a baseband channel, typically a non-filtered copper wire such as a serial bus or a wired local area network.

These can three types,

1. Amplitude shift keying (ASK)
2. Frequency shift keying (FSK)
3. Phase shift keying (PSK)

Amplitude shift keying (ASK)

Amplitude-shift keying (ASK) is a form of amplitude modulation that represents digital data as variations in the amplitude of a carrier wave. In an ASK system, the binary symbol 1 is represented by transmitting a fixed-amplitude carrier wave and fixed frequency for a bit duration of T seconds.

When the carrier amplitude is varied in proportion to message signal $m(t)$. We have the modulated carrier $m(t)\cos\omega_c t$ where $\cos\omega_c t$ is the carrier signal. As the information is an on-off signal the output is also an on-off signal where the carrier is present when information is 1 and carrier is absent when information is 0. Thus this modulation scheme is known as on-off keying (OOK) or amplitude shift key.

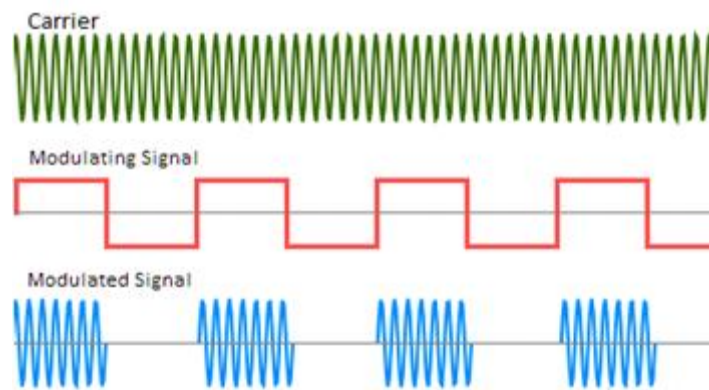


Fig. 2 ASK Modulation signal diagram

Application

- Used in our infrared remote controls
- Used in fiber optical transmitter and receiver.

- **Frequency shift keying (FSK)**

Frequency-shift keying (FSK) is a frequency modulation scheme in which digital information is transmitted through discrete frequency changes of a carrier signal. The technology is used for communication systems such as amateur radio, caller ID and emergency broadcasts. The simplest FSK is binary FSK (BFSK).

When Data are transmitted by varying frequency of the carrier, we have the case of frequency shift key. In this modulation carrier has two predefined frequency w_{c1} and w_{c2} . When information bit is 1 carrier with w_{c1} is transmitted i.e. $\cos w_{c1}$ and When information bit is 0 carrier with w_{c0} is transmitted i.e. $\cos w_{c0}$

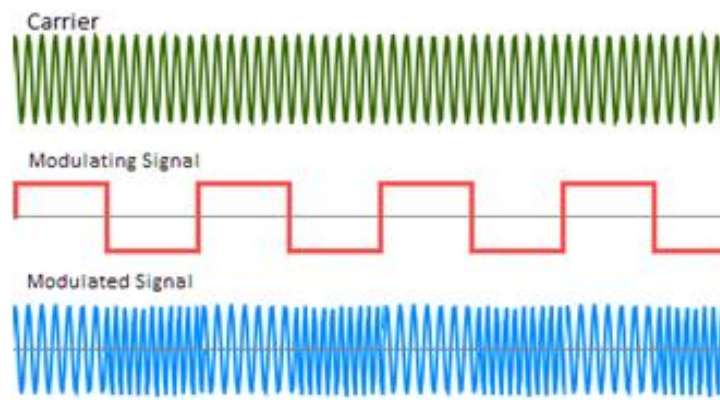


Fig. 3 FSK Modulation signal diagram

Application

- Many modems used FSK in telemetry systems

Phase shift keying (PSK)

Phase-shift keying (PSK) is a digital modulation scheme that conveys data by changing (modulating) the phase of a reference signal (the carrier wave). The modulation is impressed by varying the sine and cosine inputs at a precise time. It is widely used for wireless LANs, RFID and Bluetooth communication.

The phase of the carrier is shifted for this modulation. If the base band signal $m(t) = 1$ carrier in phase is transmitted. If $m(t) = 0$ carrier with out of phase is transmitted i.e. $\cos(\omega_c t + \Pi)$. If phase shift is done in 4 different quadrants then 2-bit of information can be sent at a time. This scheme is a special case of PSK modulation known as QPSK or Quadrature Phase Shift Key.

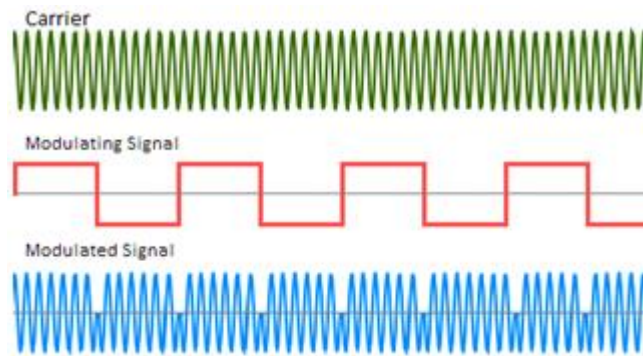


Fig. 4 PSK Modulation signal diagram

Application

- Used in our ADSL broadband modem
- Used in satellite communication
- Used in our mobile phones

8-PSK

8-PSK modulation basics or multilevel PSK modulation which is a type of digital modulation based on carrier phase change. In Phase Shift keying modulation or PSK modulation phase of carrier is changed according to the digital data. It is digital modulation technique. It is used in broadcast video systems, aircraft and satellite systems. We can achieve bandwidth efficiency when we represent each signal element to map more than one bit. In BPSK modulation digital data of 1 and 0 is represented by 180 degree phase change. In QPSK by phase shift of 90 degree, here 2 bits are mapped on each signal. In Multilevel PSK more than 2 bits are mapped using different phase

angles. In 8-PSK eight different phase angles are used to represent bits, here 3 bits. Figure below shows constellation of 8-PSK signal.

QAM (Quadrature Amplitude Modulation)

QAM is a method of combining two amplitude-modulated (AM) signals into a single channel, thereby doubling the effective bandwidth. QAM is used with pulse amplitude modulation (PAM) in digital systems, especially in wireless applications.

Types of QAM

1. 8-QAM
2. 16-QAM
3. 32-QAM
4. 64-QAM
5. 128-QAM
6. 256-QAM

Comparison of 8-QAM, 16-QAM, 32-QAM, 64-QAM 128-QAM, 256-QAM

QAM is widely used in many digital data radio communications and data communications applications. A variety of forms of QAM are available and some of the more common forms include 16 QAM, 32 QAM, 64 QAM, 128 QAM, and 256 QAM. Here the figures refer to the number of points on the constellation, i.e. the number of distinct states that can exist.

The various flavors of QAM may be used when data-rates beyond those offered by 8-PSK are required by a radio communications system. This is because QAM achieves a greater distance between adjacent points in the I-Q plane by distributing the points more evenly. And in this way the points on the constellation are more distinct and data errors are reduced. While it is possible to transmit more bits per symbol, if the energy of the constellation is to remain the same, the points on the constellation must be closer together and the transmission becomes more susceptible to noise. This results in a higher bit error rate than for the lower order QAM variants. In this way there is a balance between obtaining the higher data rates and maintaining an acceptable bit error rate for any radio communications system.

QAM applications

QAM is in many radio communications and data delivery applications. However some specific variants of QAM are used in some specific applications and standards. For domestic broadcast applications for example, 64 QAM and 256 QAM are often used in digital cable television and cable modem applications. In the UK, 16 QAM and 64 QAM are currently used for digital terrestrial television using DVB - Digital Video Broadcasting. In the US, 64 QAM and 256 QAM are the mandated modulation schemes for digital cable as standardized by the SCTE in the standard ANSI/SCTE 07 2000. In addition to this, variants of QAM are also used for many wireless and cellular technology applications.

Constellation diagrams for 8PSK, QAM

The constellation diagrams show the different positions for the states within different forms of QAM, quadrature amplitude modulation. As the order of the modulation increases, so does the number of points on the QAM constellation diagram.

The diagrams below show constellation diagrams for a variety of formats of modulation:

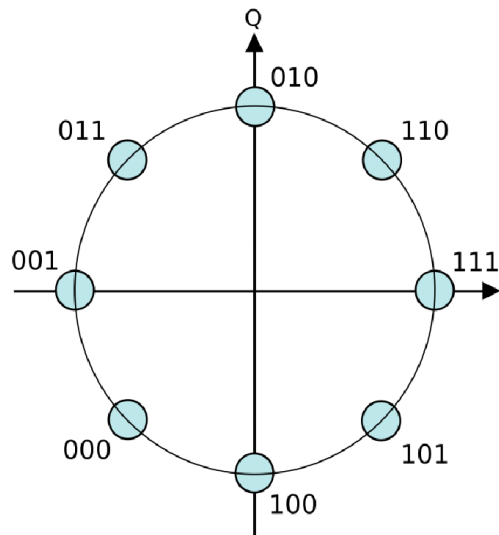


Fig. 5 Constellation Diagram of 8-PSK

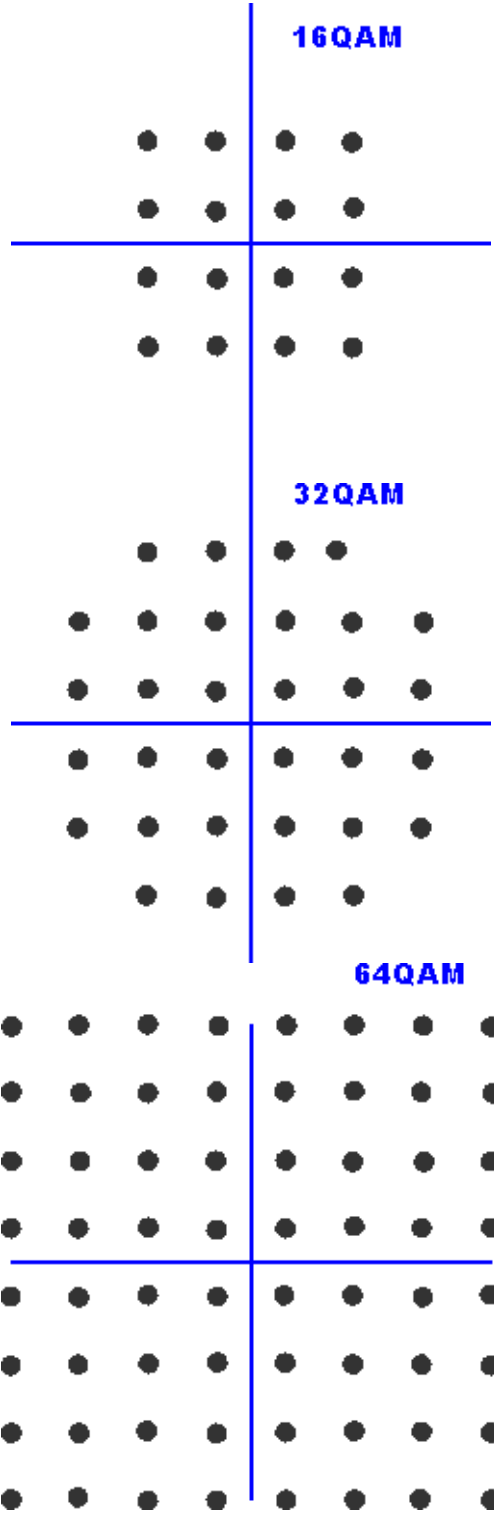


Fig. 6 Constellation Diagrams of various QAM

QAM bits per symbol

The advantage of using QAM is that it is a higher order form of modulation and as a result it is able to carry more bits of information per symbol. By selecting a higher order format of QAM, the data rate of a link can be increased.

The table below gives a summary of the bit rates of different forms of QAM and PSK.

Table 1: Bit rates of different forms of QAM and PSK.

Modulation	Bit per symbol (BPS)	Symbol rate
BPSK	1	1/1 bit rate
QPSK	2	1/2 bit rate
8-PSK	3	1/3 bit rate
16-QAM	4	1/4 bit rate
32-QAM	5	1/5 bit rate
64-QAM	6	1/6 bit rate
128-QAM	7	1/7 bit rate
256-QAM	8	1/8 bit rate

CHAPTER 3: CHANNEL CODING

The purpose of channel coding theory is to find codes which transmit quickly, contain many valid code words and can correct or at least detect many errors. While not mutually exclusive, performance in these areas is a trade off. So, different codes are optimal for different applications. The needed properties of this code mainly depend on the probability of errors happening during transmission. In a typical CD, the impairment is mainly dust or scratches. Thus codes are used in an interleaved manner. The data is spread out over the disk.

Although not a very good code, a simple repeat code can serve as an understandable example. Suppose we take a block of data bits (representing sound) and send it three times. At the receiver we will examine the three repetitions bit by bit and take a majority vote. The twist on this is that we don't merely send the bits in order. We interleave them. The block of data bits is first divided into 4 smaller blocks. Then we cycle through the block and send one bit from the first, then the second, etc. This is done three times to spread the data out over the surface of the disk. In the context of the simple repeat code, this may not appear effective. However, there are more powerful codes known which are very effective at correcting the "burst" error of a scratch or a dust spot when this interleaving technique is used.

Algebraic coding theory is basically divided into two major types of codes.

- Linear block codes
- Convolution codes

It analyzes the following three properties of a code – mainly:

- code word length
- total number of valid code words
- the minimum distance between two valid code words, using mainly the Hamming distance, sometimes also other distances like the Lee distance

Linear Block Code

In coding theory, a linear block code (LBC) is an error-correcting code for which any linear combination of code words is also a codeword. Linear codes are traditionally partitioned into block codes and convolution codes, although turbo codes can be seen as a hybrid of these two types.

(7, 4) Linear Code

[7, 4] LBC is a linear binary code which represents 4-bit messages using 7-bit code words. Two distinct code words differ in at least three bits. Linear codes are used in forward error correction and are applied in methods for transmitting symbols (e.g., bits) on a communications channel so that, if errors occur in the communication, some errors can be corrected or detected by the recipient of a message block. The codewords in a linear block code are blocks of symbols which are encoded using more symbols than the original value to be sent. A linear code of length n transmits blocks containing k symbols. For example, the [7, 4, 3] LBC is a linear binary code which represents 4-bit messages using 7-bit codewords. Two distinct codewords differ in at least three bits. As a consequence, up to two errors per codeword can be detected while a single error can be corrected. This code contains $2^4=16$ codewords.

Convolution Code

In telecommunication, a convolution code is a type of error-correcting code that generates parity symbols via the sliding application of a Boolean polynomial function to a data stream. Convolution codes are a bit like the block codes discussed in the previous lecture in that they involve the transmission of parity bits that are computed from message bits. Unlike block codes in systematic form, however, the sender does not send the message bits followed by (or interspersed with) the parity bits; in a convolution code, the sender sends only the parity bits. In practice, we would like to pick r and the constraint length to be as small as possible.

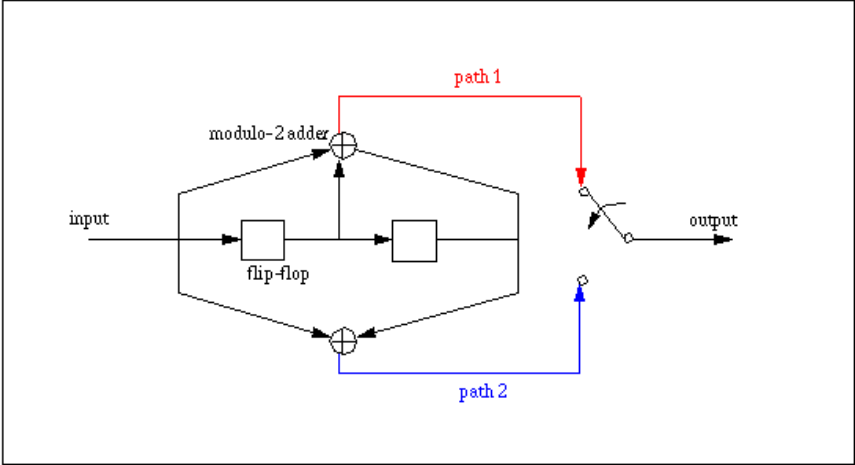


Fig. 7 An example of Convolutional encoder

CHAPTER 4: SNR, BER, E_b/N_0 & AWGN

SNR (Signal-to-noise ratio)

Signal-to-noise ratio (abbreviated SNR or S/N) is a measure used in science and engineering that compares the level of a desired signal to the level of background noise. It is defined as the ratio of signal power to the noise power, often expressed in decibels.

BER (bit error rate)

The bit error rate (BER) is the number of *bit* errors per unit time. The bit error ratio (also BER) is the number of bit errors divided by the total number of transferred bits during a studied time interval. BER is a unit less performance measure, often expressed as a percentage.

Difference between SNR & BER

SNR is signal to noise ratio. Generally, it is the ratio of signal magnitude to thermal noise for the signal bandwidth which you are examining. Bit error rate is a measure of the errors one gets over time for a given digital signal. The two are strongly coupled. They are not 1:1 coupled in that interference other than thermally generated noise can increase bit error rate.

Normally, one can measure what is known as a waterfall diagram for a given channel. The channel characteristics such as bandwidth, frequency, modulation, etc can give one a “best case” waterfall diagrams. This is usually based on thermal noise alone. The following graphic was taken from Wikipedia and illustrates a waterfall diagram for several PSK modulation schemes.

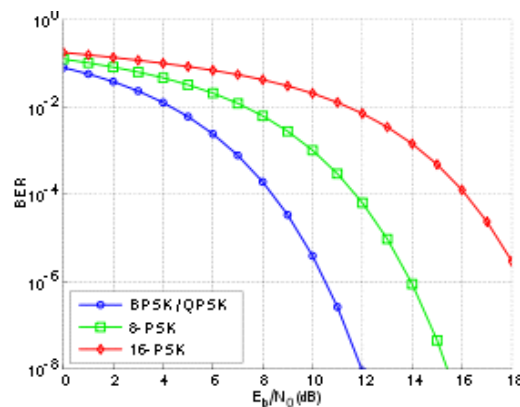


Fig. 8 waterfall diagram of BER vs. SNR

As one can see from the waterfall diagram, BPSK/QPSK modulation is more "robust" than 16PSK modulation in that at 10dB bit to thermal noise (a measure of signal to noise), a QPSK signal experiences slightly more than 1 error per million bits while 16PSK experiences 1 error per 50 bits. If you were sending a ZIP file, the QPSK channel has a decent chance of getting through while the 16 PSK channel would fail badly.

E_b/N_0

E_b/N_0 (the energy per bit to noise power spectral density ratio) is an important parameter in digital communication or data transmission. It is a normalized signal-to-noise ratio (SNR) measure, also known as the "SNR per bit". It is especially useful when comparing the bit error rate (BER) performance of different digital modulation schemes without taking bandwidth into account.

As the description implies, E_b is the signal energy associated with each user data bit; it is equal to the signal power divided by the user bit rate (not the channel symbol rate). If signal power is in watts and bit rate is in bits per second, E_b is in units of joules (watt-seconds). N_0 is the noise spectral density, the noise power in a 1 Hz bandwidth, measured in watts per hertz or joules. These are the same units as E_b so the ratio E_b/N_0 is dimensionless; it is frequently expressed in decibels. E_b/N_0 directly indicates the power efficiency of the system without regard to modulation type, error correction coding or signal bandwidth (including any use of spread spectrum). This also avoids any confusion as to which of several definitions of "bandwidth" to apply to the signal.

Channel

In telecommunications and computer networking, a communication channel or channel, refers either to a physical medium such as a wire, or to a logical connection over a multiplexed medium such as a radio channel. A channel is used to convey an information signal, for example a digital bit stream, from one or several senders (or transmitters) to one or several receivers. A channel has a certain capacity for transmitting information, often measured by its bandwidth in Hz or its data rate in bits per second.

Noise

Noise is any type of disruption that interferes with the transmission or interpretation of information from the sender to the receiver.

Gaussian noise

Gaussian noise is statistical noise having a probability density function (PDF) equal to that of the normal distribution, which is also known as the Gaussian distribution. In other words, the values that the noise can take on are Gaussian-distributed.

AWGN (Additive white Gaussian noise)

Additive white Gaussian noise (AWGN) is a basic noise model used in Information theory to mimic the effect of many random processes that occur in nature. The modifiers denote specific characteristics: Additive because it is added to any noise that might be intrinsic to the information system.

Bit rate

The number of bits per second that can be transmitted along a digital network. In telecommunications and computing, bit rate (sometimes written bit rate or as a variable R) is the number of bits that are conveyed or processed per unit of time.

Sample rate

Sample rate is the number of samples of audio carried per second, measured in Hz or kHz (one kHz being 1 000 Hz). For example, 44 100 samples per second can be expressed as either 44 100 Hz, or 44.1 kHz. Bandwidth is the difference between the highest and lowest frequencies carried in an audio stream.

Baud rate

In telecommunication and electronics, baud is the unit for symbol rate or modulation rate in symbols per second or pulses per second. It is the number of distinct symbol changes (signaling events) made to the transmission medium per second in a digitally modulated signal or a line code.

CHAPTER 5: SIMULATION MODEL

In this project, we have used Matlab 2016 Simulink to generate the results. We have also used 'bertool' to generate the graphs discussed in chapter 5. In this project we have analyzed in theoretical mode of simulation. In Matlab command unit, we have to type 'BER-Tool' to open the BER analysis tool.

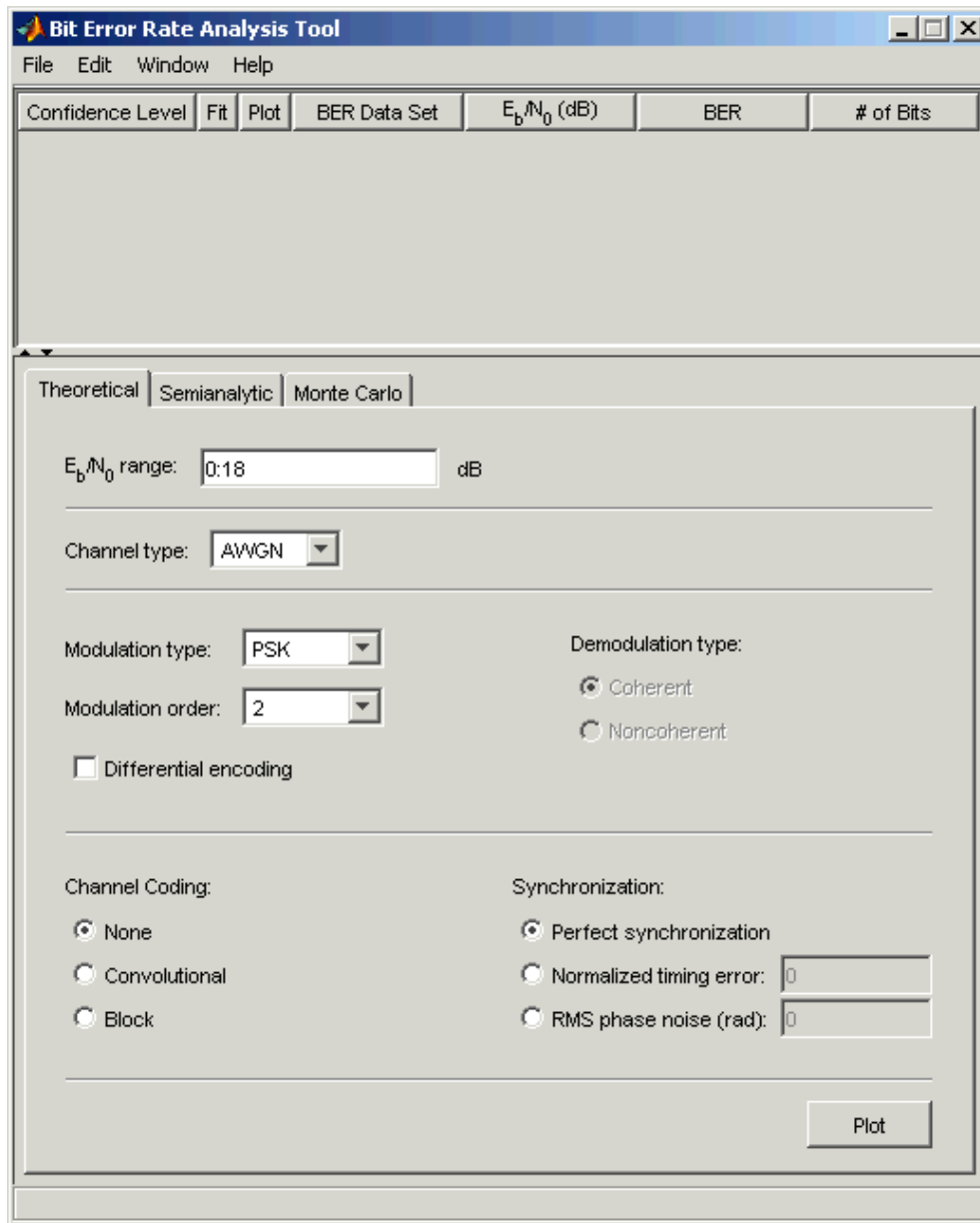


Fig. 9 BER Analysis Tool

A set of tabs on the bottom. Labeled Theoretical, Semi analytic, and Monte Carlo, the tabs correspond to the different methods by which BER-Tool can generate BER data.

- We have opened BER-Tool, and went to the Theoretical tab.
- We have set the parameters to reflect the system whose performance we wanted to analyze. Some parameters are visible and active only when other parameters have specific values.
- We have clicked Plot.

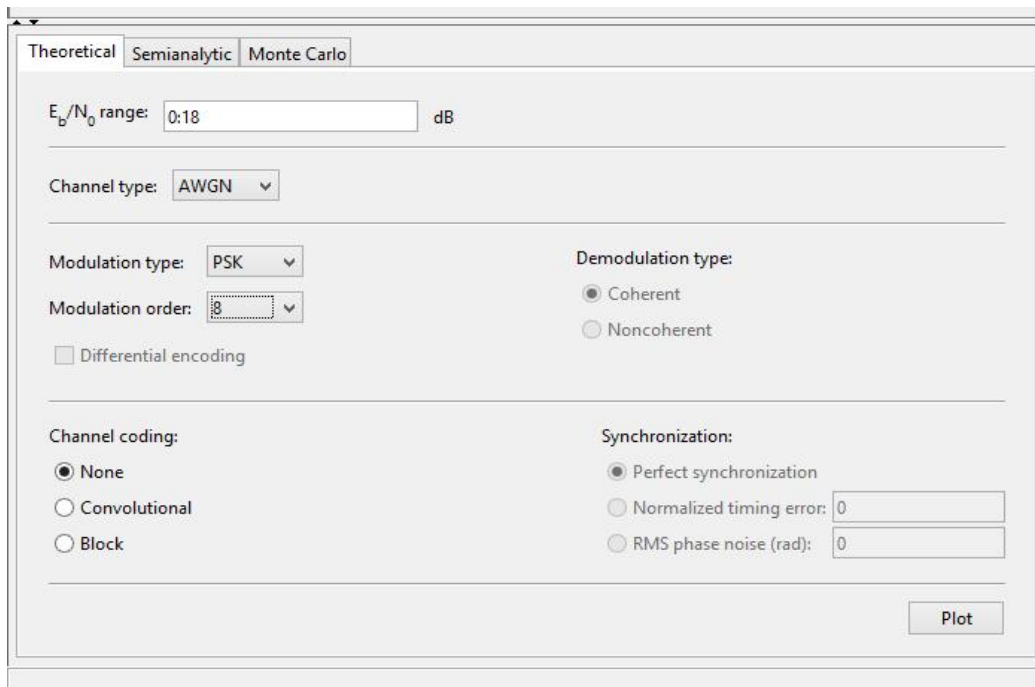


Fig. 10 To Analyze 8-PSK

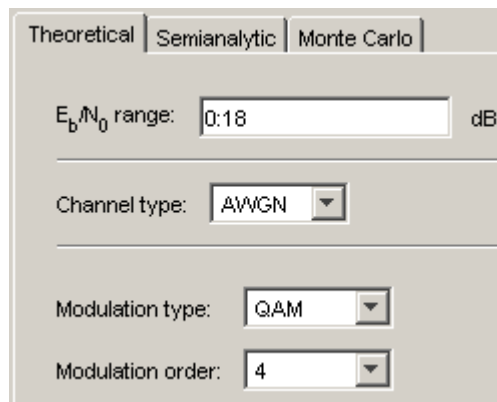


Fig. 11 To Analyze QAM

We have changed the Modulation order parameter to 16, and clicked Plot.BERTool creates another entry in the data viewer and plots the new data in the same BER Figure window.

Then we have changed the Modulation order parameter to 64, and clicked Plot.BERTool creates another entry in the data viewer and plots the new data in the same BER Figure window, as shown in the following figures.

Confidence Level	Fit	Plot	BER Data Set	E_b/N_0 (dB)	BER	# of Bits
		<input checked="" type="checkbox"/>	theoretical-exact0	[0 1 2 3 4 5 6...	[0.0786 0.0...	N/A
		<input checked="" type="checkbox"/>	theoretical-exact1	[0 1 2 3 4 5 6...	[0.1409 0.1...	N/A
		<input checked="" type="checkbox"/>	theoretical-exact2	[0 1 2 3 4 5 6...	[0.1998 0.1...	N/A

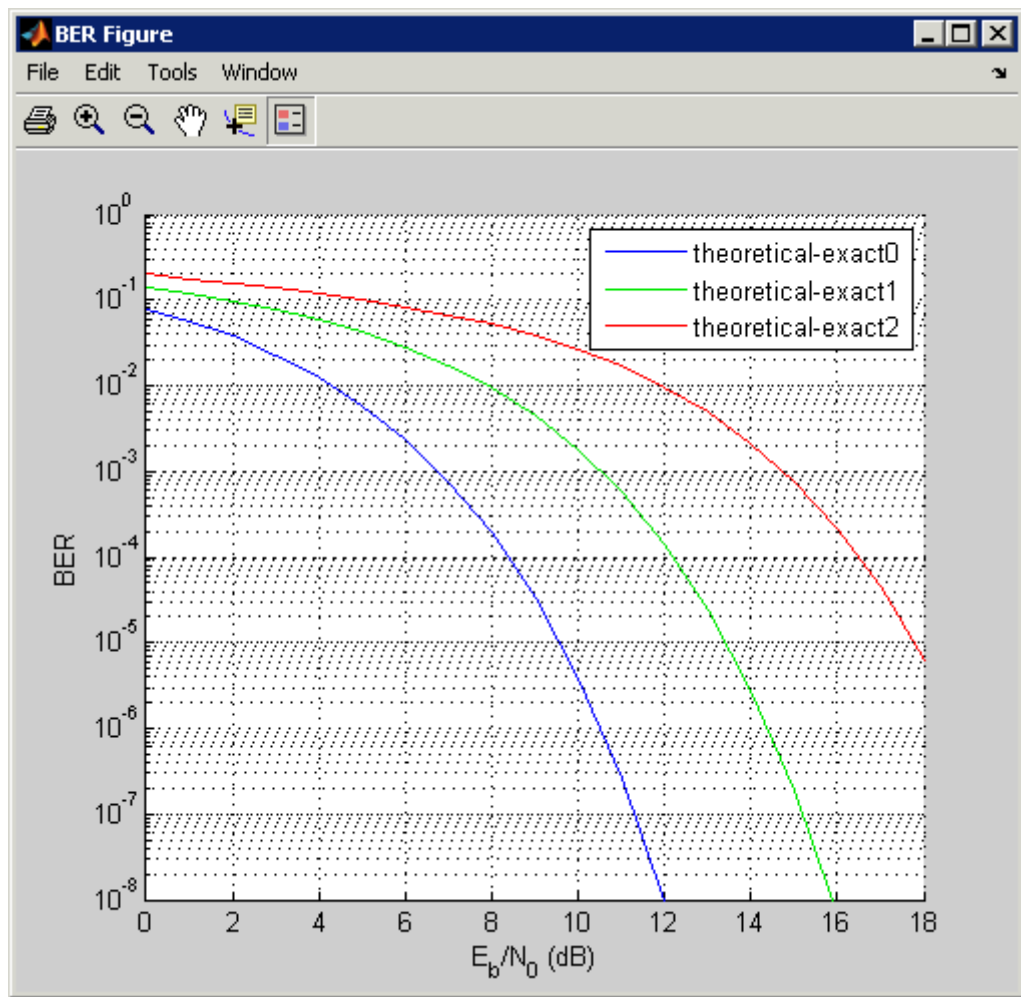
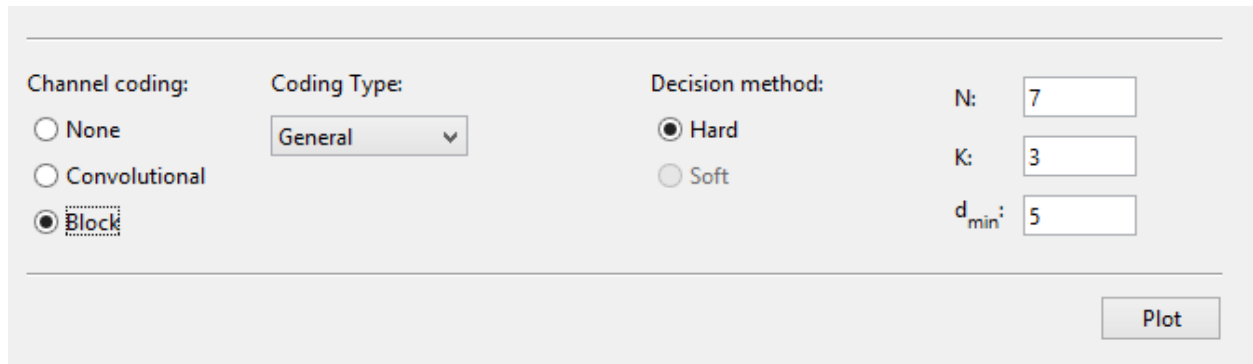


Fig. 12 The result after clicking the plot

To recall which value of Modulation order corresponds to a given curve, we have clicked the curve. BER-Tool responds by adjusting the parameters in the Theoretical tab to reflect the values that correspond to that curve.

Similarly, we can include channel coding scheme for the simulation from the BER-Tool.



The screenshot shows the 'Channel coding' section of the BER-Tool interface. It includes the following controls:

- Channel coding:** Three radio buttons: 'None', 'Convolutional', and 'Block'. The 'Block' option is selected.
- Coding Type:** A dropdown menu currently set to 'General'.
- Decision method:** Two radio buttons: 'Hard' (selected) and 'Soft'.
- Parameters:** Three input fields: 'N' with the value 7, 'K' with the value 3, and 'd_{min}' with the value 5.
- Plot:** A button located at the bottom right of the control area.

Fig. 13 Selecting the Channel Code

In these processes, we have got the corresponding results for the 8PSK, 16QAM, 64 QAM with or without channel coding like block code, convolutional code. The results have been analyzed in the following chapter.

CHAPTER 6: RESULTS AND ANALYSIS

This section will discuss and analysis the results obtained from MATLAB 2016a. In various figures we have presented the performances of various modulation techniques with and without channel coding.

In Fig. 14, it has been found that the performance of 8-PSK increases tremendously when convolutional coding has been incorporated. Though for low E_b/N_o case, block performs better. Say for 4 dB E_b/N_o , block code's BER is less than without channel coding case and much better than convolutional coding case. But increasing the value of E_b/N_o , convolutional coding improves much better. Say in 10 dB E_b/N_o , with convolutional coding, BER is around 10^{-6} , while for block code it is around 10^{-4} and without coding it is around 10^{-3} .

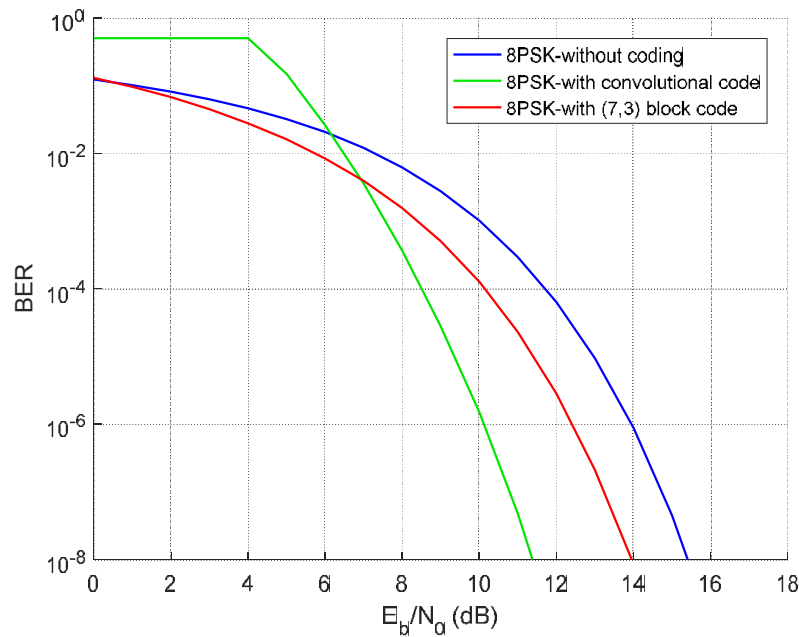


Fig. 14 BER analysis of 8PSK with or without channel coding

In Fig. 15, it has been found that the performance of 16-QAM increases greatly when convolutional coding has been integrated. Though for low E_b/N_o case, block performs better. Say

for 4 dB E_b/N_o , block code's BER is less than without channel coding case and much better than convolutional coding case. But increasing the value of E_b/N_o , convolutional coding improves much better. Say in 10 dB E_b/N_o , with convolutional coding, BER is around 10^{-5} , while for block code it is less than 10^{-3} and without coding it is near 10^{-2} .

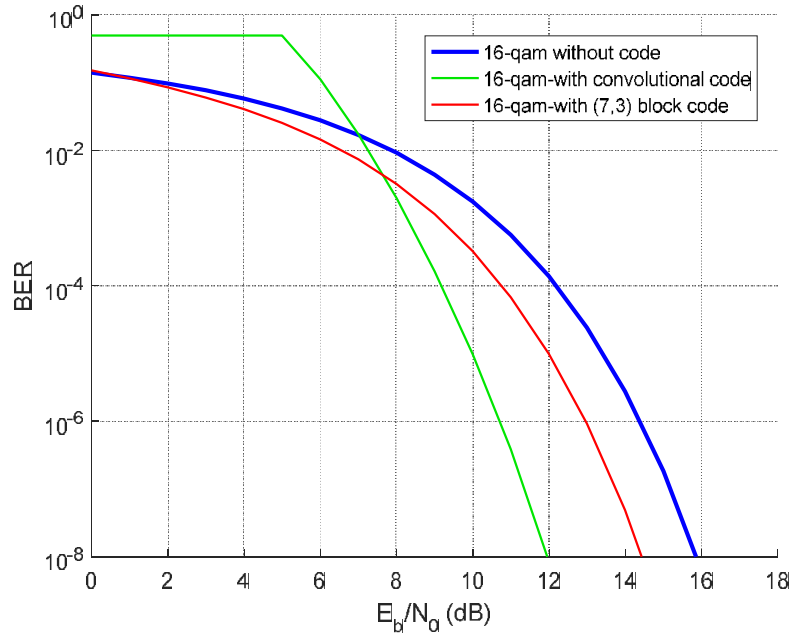


Fig. 15 BER analysis of 16-QAM with or without channel coding

In Fig. 16, it has been found that the performance of 64-QAM increases greatly when convolutional coding has been integrated. Though for low E_b/N_o case, block performs better. Say for 5 dB E_b/N_o , block code's BER is less than without channel coding case and much better than convolutional coding case. But increasing the value of E_b/N_o , convolutional coding improves much better. Say in 15 dB E_b/N_o , with convolutional coding, BER is less than 10^{-6} , while for block code it is around 10^{-4} and without coding it is near 10^{-3} .

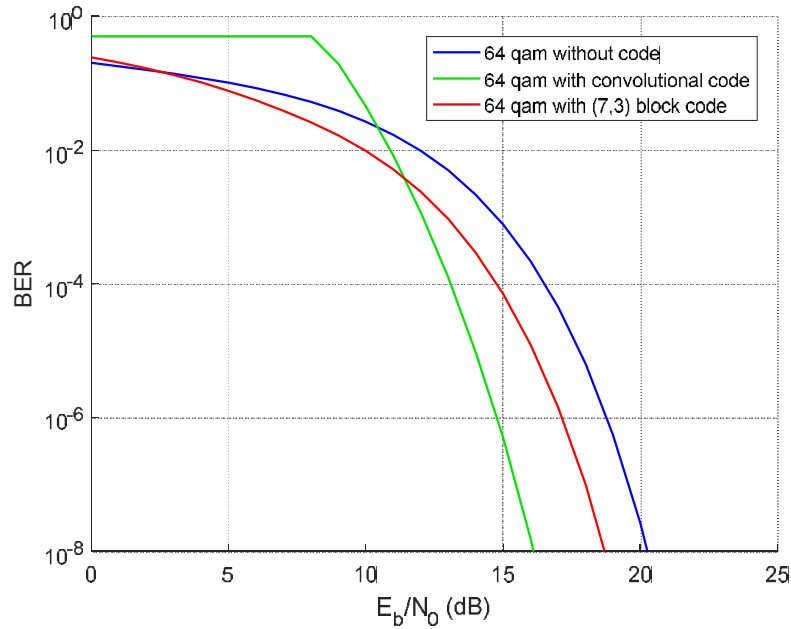


Fig. 16 BER analysis of 64-QAM with or without channel coding

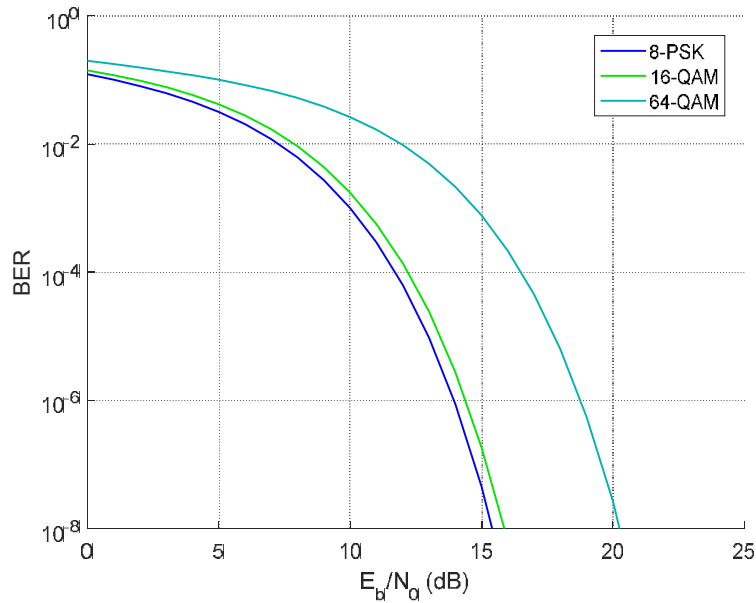


Fig. 17 BER analysis of different modulation techniques without any channel coding

In Fig. 17, the analysis has been done for the performances of 8-PSK, 16-QAM and 64-QAM without considering any channel coding. To achieve BER of 10^{-8} , 8-PSK needs 15.5 dB, 16-QAM needs 16 dB and 64-QAM needs 20.5 dB value of E_b/N_0 .

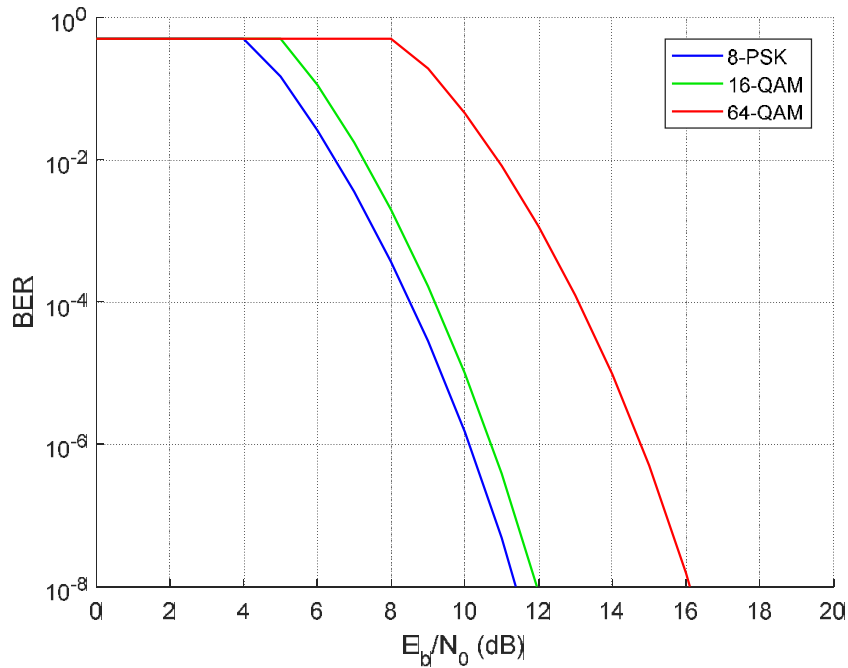


Fig. 18 BER analysis of different modulation techniques with convolutional coding

Similar analysis been done in Fig. 18 for convolutional case. Here to achieve BER of 10^{-8} , 8-PSK needs 11.5 dB, 16-QAM needs 12 dB and 64-QAM needs 16 dB value of E_b/N_0 . 8-PSK performs better here also.

In Fig. 19, the analysis has been done for the performances of 8-PSK, 16-QAM and 64-QAM with considering block coding. To achieve BER of 10^{-8} , 8-PSK needs 14 dB, 16-QAM needs 14.25 dB and 64-QAM needs 18.5 dB value of E_b/N_0 . Here, 8-PSK and 16-QAM acts quite similar while 64-QAM performs poor.

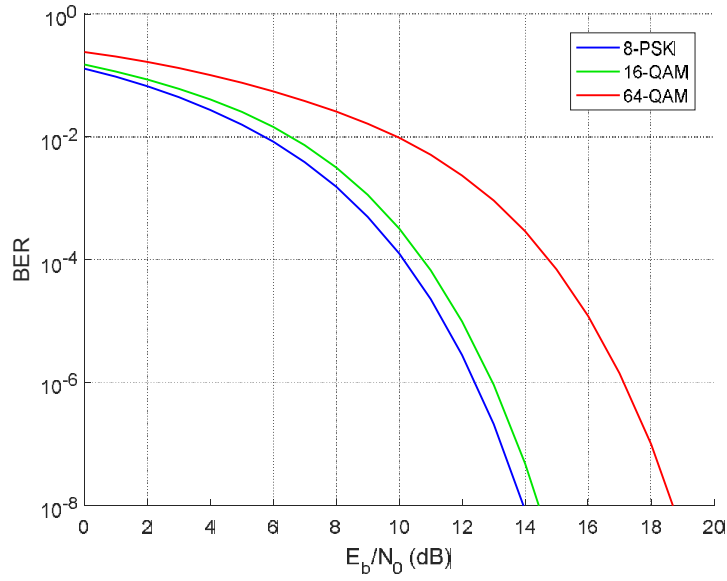


Fig. 19 BER analysis of different modulation techniques with block coding

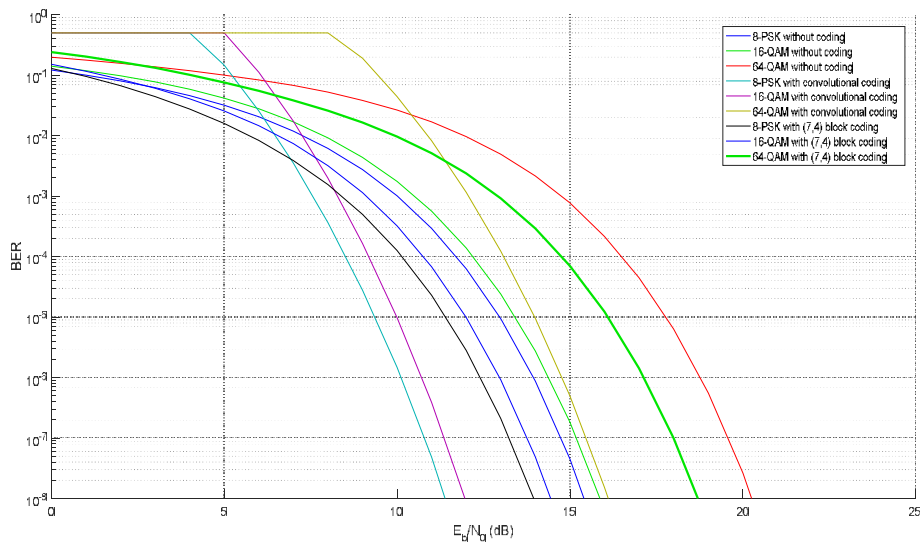


Fig. 20 BER analysis of different modulation techniques with and without channel coding

In Fig. 20, all the above performances analysis have been shown in a figure. From the Fig. 20 it is clear that the performance of 8-PSK with convolutional coding is the best while 64-QAM without any channel coding is the worst. From coding perspective, convolutional coding's overall performance is the best and from the modulation perspective 8-PSK is the best. To achieve the similar BER, 64-QAM needs much more value of E_b/N_0 than 8-PSK.

Conclusion

In this paper, the bit error rate has been theoretically analyzed for various different wireless modulation techniques. In the analysis, it has been found that the performance of 8-PSK with convolutional coding is the best and the 64-QAM without any channel coding is the worst. Though the throughput of the 64-QAM is much better than 8-PSK but BER is high. It is due to sending more bit causes more bit error. To reduce the BER of 64-QAM, several filtering techniques can be used. In future, similar analysis will be done for practical cases with considering some parameters like filters, channel equalizers, other channels and so on.

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