# Study and Performance of Digital Modulation Techniques

Asad Ali
Hamdard University, Karachi, Pakistan

asadali.rahi@gmail.com

Rabia Ansari
MS Mega Tech, Karachi, Pakistan

rabia4338@gmail.com

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***Abstract***: The Fastest growing world has required fastest communication. The advancement in the technology brings the revolution in the world by introducing 1G to 6G in wireless technology. The research highlights the review of comparative analysis of BPSK, QPSK, QAM, 16 QAM, and 64 QAM in LTE 4G Systems, and uses of QAM and QPSK for implementation of 5G. Further the study of wirelessly transfer of RFID Code using Amplitude Shift Keying Modulation. Finally, performances of Amplitude shift keying and frequency shift keying is given.

**Index Terms:** Performance analysis of digital modulation techniques, ASK, FSK, Digital modulation techniques.

## 1. INTRODUCTION

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. Information source, modulator, demodulator, communication channel and digital pulse generator are used in digital communication system[1]. In the modulation process, a parameter of the carrier wave (like amplitude, frequency or phase) is changed accordance with the modulating signal (Message). This variation acts as a code for data transmission. This modulated signal is then transmitted by the transmitter. The receiver demodulates the received modulated signal and gets the original information signal back.

There are two types of modulation Analog and Digital. Sine wave (Continuous signal) is used as a carrier wave which modulates the message signal, In analog Modulation. Whereas Digital modulation is similar to analog except base band signal is of discrete (0 or 1) amplitude level. Digital modulation has three types ASK, FSK and PSK. ASK modulation process used when the carrier amplitude is differentiate in part to message signal. The modulating signal has 3 properties of carrier signal, Amplitude with Phase is QAM (Quadrature Amplitude Modulation), FSK (Frequency Shift Keying), or PSK (Phase Shift Keying)[2]. FSK modulation method varying the frequency of the carrier and transmits the receiving data. PSK modulation basically shifts the transmit data. A CNN-based robust automatic modulation recognition (RAMR) method can be used to recognize three types of modulation signals ( FSK, PSK and QAM)[3]. Paper[4] proposed a ASK communication protocol for image transmission was made using the GNU-Radio software environment.

In this paper, the performance analysis of digital modulation techniques and their usage in 5G and 4G

communication systems are presented. There are various issues in telecommunications and these all modulation methods helps to solve out these issues. The problem is, various kind of data like video, bit stream and voice from the system with the lower frequency band wireless, so data cannot travel properly because they cannot spread through the space, and the solution of the problem is using the modulation method and carry the signals, modulation helps to carry the signals with carrier wave, this process signals travels more fast through the space. Other problem is, without modulation the antenna distance would be unworkable for video, bit stream and voice, and the solution is antenna size is decrease through the high frequency carrier waves. Further the problem is, overlapping of channels due to similar frequency range of transmission of data without modulation, and solution is, carrier radio waves provide the extensive range of frequencies and provide the non-overlapping channels.

## 2. USES OF QAM AND QPSK FOR IMPLEMENTATION OF 5G

The Advancement of technology has increased the thrust of fastest communication. Researchers are busy in finding the fastest ways of communication. For fastest communication in LTE and beyond LTE many types of digital modulation are used and QPSK and QAM are commonly used. The study comparatively analyzes the two types of digital modulation in 4G and beyond 4G Communication architecture over Simulation. The Bit Error Rate with respect to Signal to Noise Ratio is compared for good output.

QAM has high data rate and bit error rate. But QPSK has bit error rate is very low. So, the combination of these two modulation scheme can be used where QAM can be used in the area close to the tower and QPSK can be used in the border of the cells where low data rate can be accepted and also the data will be better because the BER of QPSK is low[5]. Higher data rate is required with very low bit error rate for 5G. So, the combination of QAM and QPSK can be used for implementation of 5G.

## 3. Comparative Analysis of BPSK , QPSK, QAM, 16 QAM, and 64 QAM in LTE 4G Systems

The performance measurement of modulation is done by finding its probability of error produced by noise and interference induced in the channel. The transmission of modulation with more bits per symbol is more vulnerable to error due to noise. However, the basic criteria for performance measurement are depends on bit error rate, signal to noise ratio, bandwidth availability, power efficiency, quality of service, and low cost.

Many things effect the digital modulation techniques. A good modulation technique must give low bit error rates, good performance in multipath and fading conditions, consume least bandwidth and low cost[6]. The modulation used for OFDM-LTE (4G) systems are M-PSK and QAM. So, in this paper the Bit error rate (BER) of M-PSK and QAM digital modulation schemes are compared under AWGN, and Rayleigh fading channels to identify a suitable digital modulation scheme for OFDM application. The research has been performed by using MATLAB for simulation and evaluation of Bit Error Rate (BER) and Signal-to-Noise Ratio (SNR) for OFDM system models.

According to Ndujiuba et.al, by studying of BPSK, QPSK, QAM, 16 QAM, and 64 QAM, the research has found that, higher order QAM can transfer more data but have a high error rate compare to lower order QAM[7]. The error can by reduced by Convolution Coding and Turbo coding techniques of error correction. Millimeter wave and sub THz communication systems offer high band width that enables multi Gbit/sec transmission, most of the reported systems are using BPSK, QPSK and 16 QAM[8]. The research shows that lower end phase shift keying schemes involves low error performance, minimum power and low bandwidth efficiency. And the higher schemes require higher bandwidth efficiency but are low power efficient.

## 4. Wirelessly transfer of RFID Code using Amplitude Shift Keying Modulation

Research has improved the wireless communication technology in the modern world. Some technology of wireless communication is ZigBee communication, and combination of GPS and GSM. IOT was introduced in the world by Kevin Ashton in 1999, at that time he was doing work in the auto ID lab at MIT and presented, the technologies that makes IOT, RFID and wireless sensor network[9]. Hussain and Maen purposed a wireless transceiver signaling system for the sending of RFID code signals using ASK (Amplitude Shift Keying) digital modulation, and results show that the proposed model is good for transferring RFID tag codes wirelessly[10].

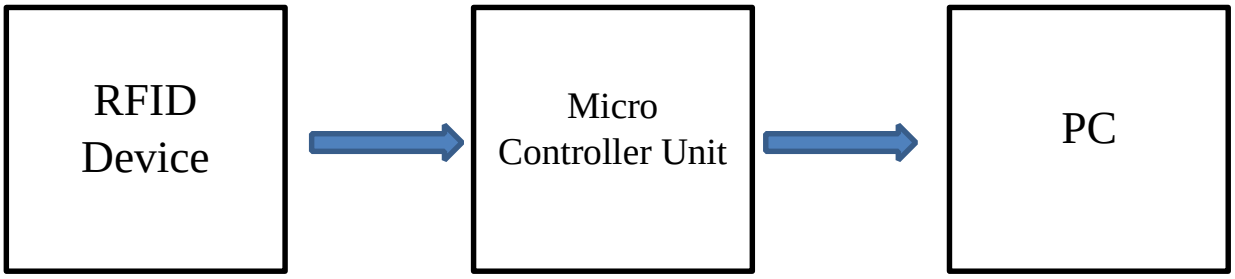



Figure 1: Diagram of Wired RFID code transceiver system

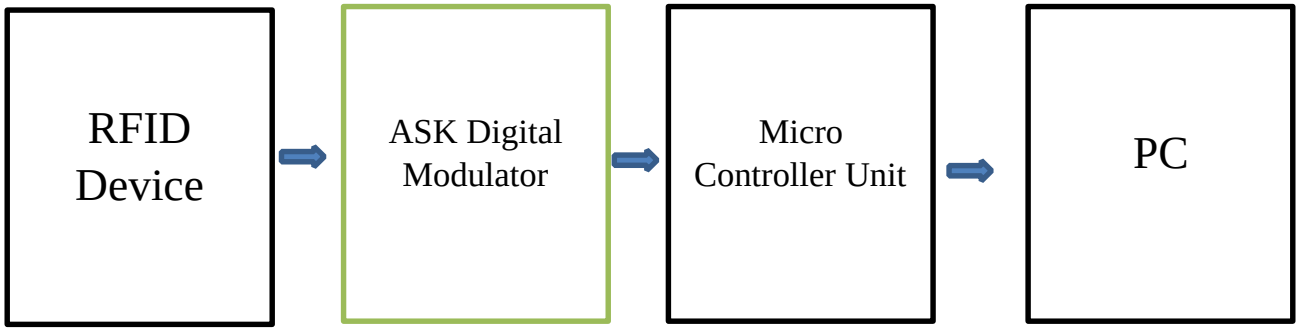



Figure 2: Diagram of Wireless RFID code transceiver system

The research proposed the wireless RFID code signaling system by using Amplitude Shift keying modulation. It will used in replacement of wired RFID code signaling system for applications where the RFID reader is not physically attached to the computer. The researched focused on wireless signaling digital block which can be used with conventional RFID code system to offer flexibility and reliability in different domestic and industry use.

## 5. ASK MODULATION & DEMODULATION PERFORMANCE ON MATLAB

ASK is Amplitude Shift Modulation, which assigns bit value to digital (discrete) amplitude levels. The carrier signal is modulated between the discrete values for transmitting the information. It is used for transmitting digital data over fiber optics. ASK Applications are used in mobile communications.

M-Ary ASK modulation method can be used to increase bit per symbol and also increase the performance with compare to low symbol rate of resonance coupling communication system[11]. The word keying means to transmit the digital

signals between the channel through the ASK techniques. The problem of missing tags in RFID module can be solved by the transmitter based on spatial ASK modulation[12].

The whole setup rest of signal generators that can be provide the high-frequency waves, between the digital signals and the band pass filter. When the value is 1 so the switching is close and the voltage is high. This all process allows the carrier singles to ready to transmit. Switching is open when the voltage is low thus controlling the carrier signals. For these reasons the output signals represents only the higher voltage. For reshaping the pulse the band controlling filer is used with the filter characteristics. GORDAY et.al presented the comparison of several neural network topologies for non-coherent classification of complex-valued data; the topologies are suitable for non-coherent demodulation of power-efficient modulations such as FSK, GFSK, MSK, ASK, and M-orth[13].

The benefits of ASK modulation are; ASK provides the high bandwidth, minimalistic receiver design, transmit the digital data between the channel over the optical fiber, ASK modulation and demodulation procedure are relatively inexpensive, it is used to controlling the more codes using the radio frequencies. LIWEN et.al proposed the new architecture of the Space Time MS to get an Amplitude Modulation scheme for reaching the need of wireless communication system and it is successful fabricated and a Quasi Optical scheme is designed to obtain the desired form of Amplitude Modulation[14]. The disadvantages of ASK modulations are; ASK provide the low power good organization, its is suitable for the noise interference. This all done due to the noise affects. The one more technique is used BPSK this technique provide less error instead of ASK[11].

## 6. Methodology of ASK

The performance of ASK modulation and Demodulation is done on MATLAB Simulink software. The required element in the software are Sine wave carrier with fc=1000 radian/second. The Discrete pulse generator is used as digital data signal. Product block as modulator in ASK modulation. And the scope is used for observing output. Other virtual components for demodulation is used are Uniform noise block, Butter worth low pass filter, and Sample and hold block.

### A. MATLAB DIAGRAM OF ASK

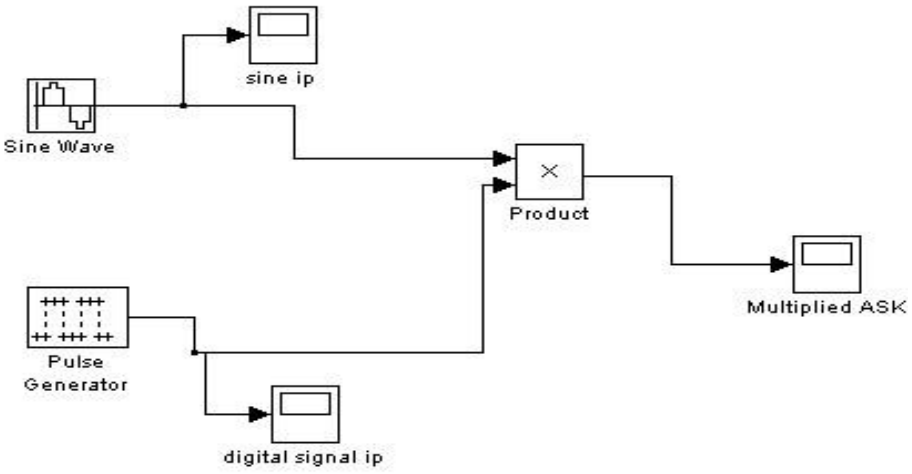
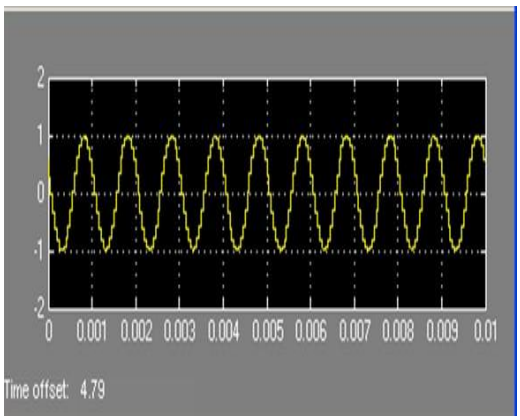
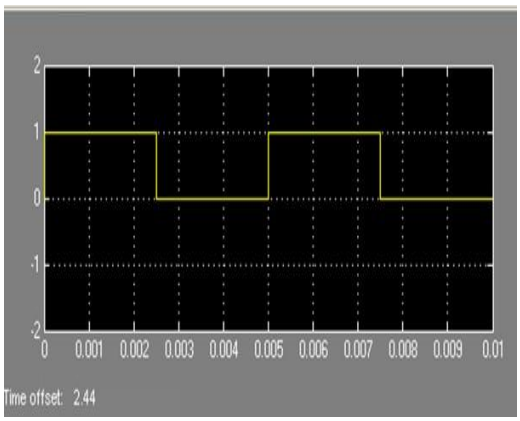



Figure 3: MATLAB diagram of ASK Modulation

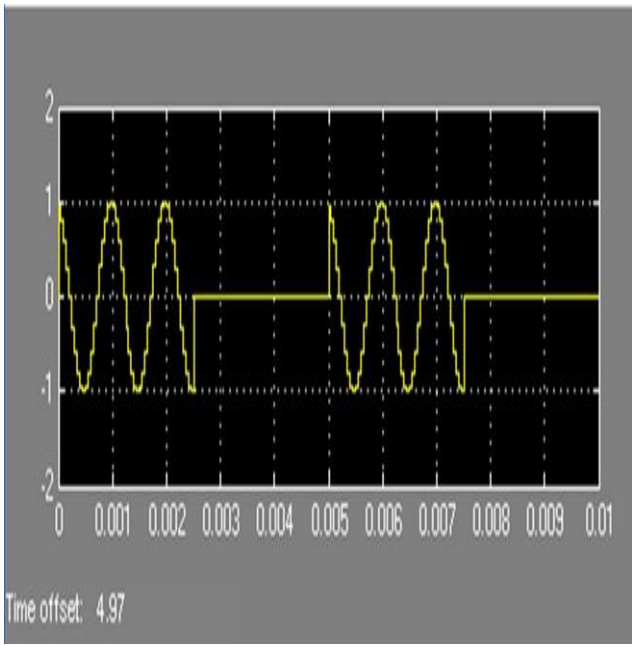
**B. The output Scope module**




(a) The output of Sine wave




b) The output of Digital Pulse Generator




(c) The output of Product

Figure 4: The output of result of ASK

## 7. ASK DEMODULATION

Modulation

ASK has two demodulation techniques “Synchronous” and “Asynchronous”. When the transmitter clock frequency match with the receiver frequency is called synchronous technique, when gives the synchronized is called the asynchronous. Asynchronous ASK allocate of the half-wave rectifier, comparator and the low pass filter. This half-ware rectifier provides the positive half-output. And the low pass filter provides the higher frequency and gets back the covering detected output.

Synchronous ASK allocate of a Square law identifier, comparator, low-pass filter and the voltage limiter. The Square law identifier output voltage is relatively to the amplitude of square input voltage. Low pass filter reduce the highfrequency. The voltage limiter and comparator assist to find a clean digital output.

### I. ASK DEMODULATION MATLAB Diagram

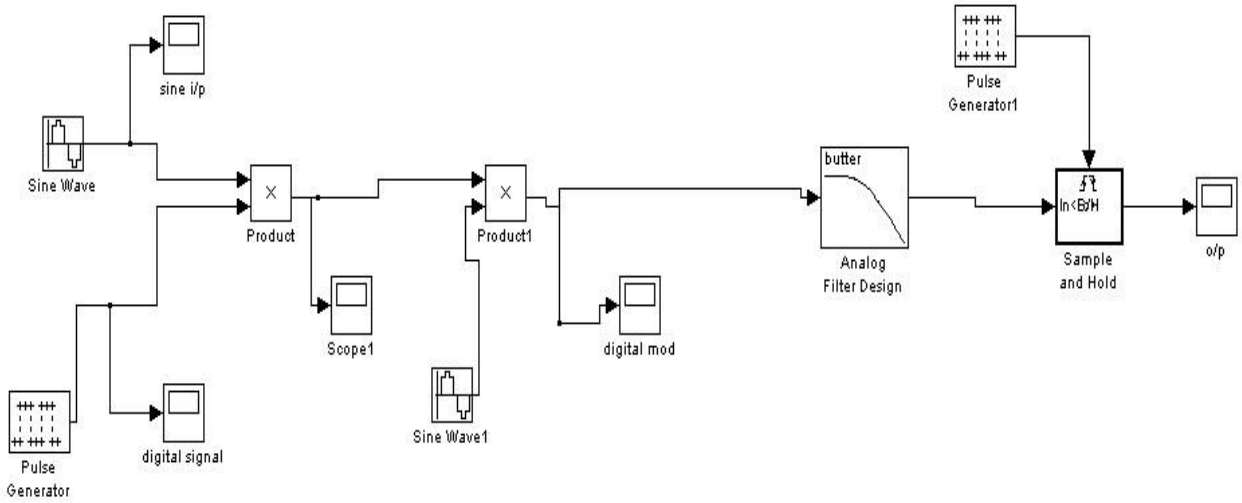
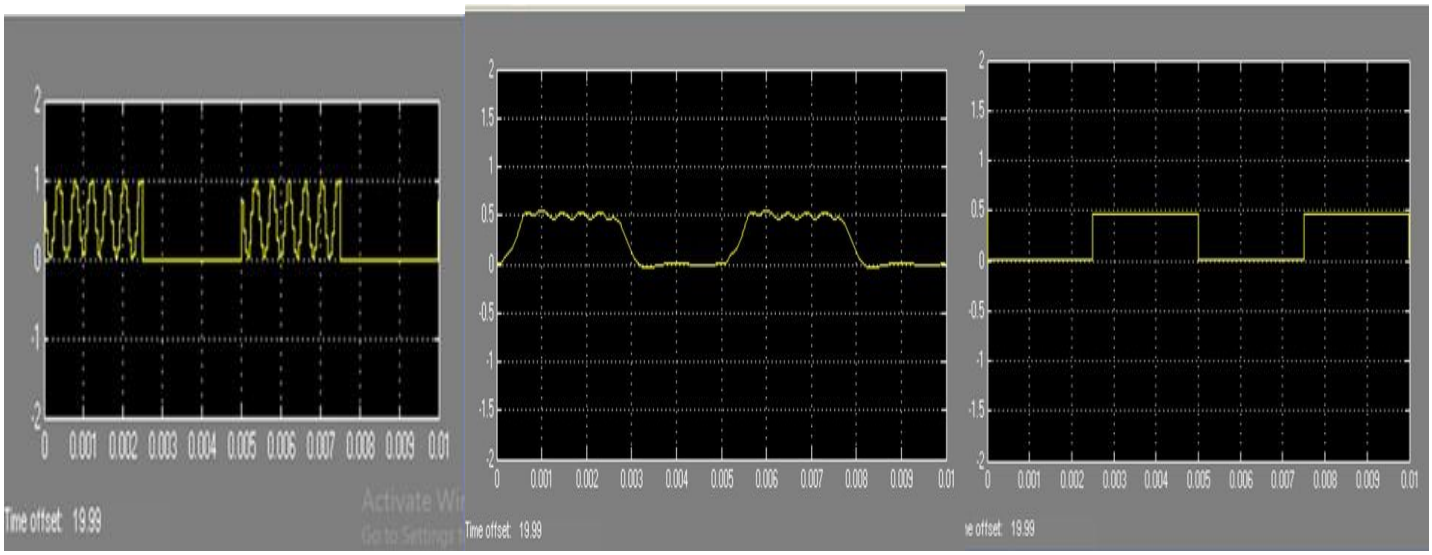



Figure 5: MATLAB diagram of ASK Demodulation

### II. Result of ASK Demodulation



(a) ASK Demodulation (b) The output of low pass filter (c) The output of getting original digital signal by ASK Demodulation

Figure 6: The output of result of ASK Demodulation

## 8. Performance of Frequency Shift Keying (FSK) Modulation and Demodulation

FSK is a frequency modulation that allocates bit values to discrete frequency. FSK is separated into coherent and noncoherent forms. In non-coherent forms of FSK, the instantaneous frequency shifts between two discrete values termed the "mark" and "space" frequencies. And there is no phase discontinuity in the output signal in coherent forms of FSK. In frequency shift keying carrier frequency is changed with respect to message signal (baseband digital input

signal)[6]. Frequency shift keying modulation formats create modulated wave forms, which are strictly real values, and thus tend not to share common features with quadrature modulation schemes.

Digital modulation methods that allocate the data transmission and this methods change the carrier frequency waves parallel to the digital modulation signals this all process call the FSK. FSK methods are the efficient and simple digital signal transmission system. M-ary FSK is used for low data rate and low power IOT applications[15]. FSK is a end-toend communication, such as over voice lines, radio transmission, telephone modern and high-frequency. BFSK shifting is the simplest form that changed the carrier signals into the discrete binary values. According to the binary values the carrier frequency shows the different variations.

Benefits of FSK modulations are; FSK provide the 0% amplitude variations, less errors, easy process to build the circuit, support high SNR and high data rate, it is very useful in radio transmissions and noise immunity, FSK provide the low digital applications and high frequency communications.

The detriments of FSK are; FSK need the additional bandwidth than the PSK and the ASK, bit error rate is low then the PSK, due to the large bandwidth requirements, so the FSK provide the less-speed modems bit rate is 1200bits/sec. thus, the FSK is a digital modulation methods in this method we grow the frequency of the binary input signals. With the few digital applications we can get the error free communication. FSK has the more bandwidth and finite data rate these two things we can overcome with the quadrature amplitude modulation. It is the arrangement of phase and amplitude modulation.

## 9. Methodology of FSK

The performance of FSK modulation and Demodulation is done on MATLAB Simulink software. The required element in the software are Sine wave carrier with f1 = 2000 and f2 = 1200 radian/second. The Discrete pulse generator is used as digital data signal. Product block as modulator in FSK modulation. Uniform Noise Block, summer, and the scope are also used. Other virtual components used for demodulation are Summer, Uniform noise block, Butter worth low pass filter, and Sample and hold block.

A. **MATLAB block diagram of FSK Modulation**

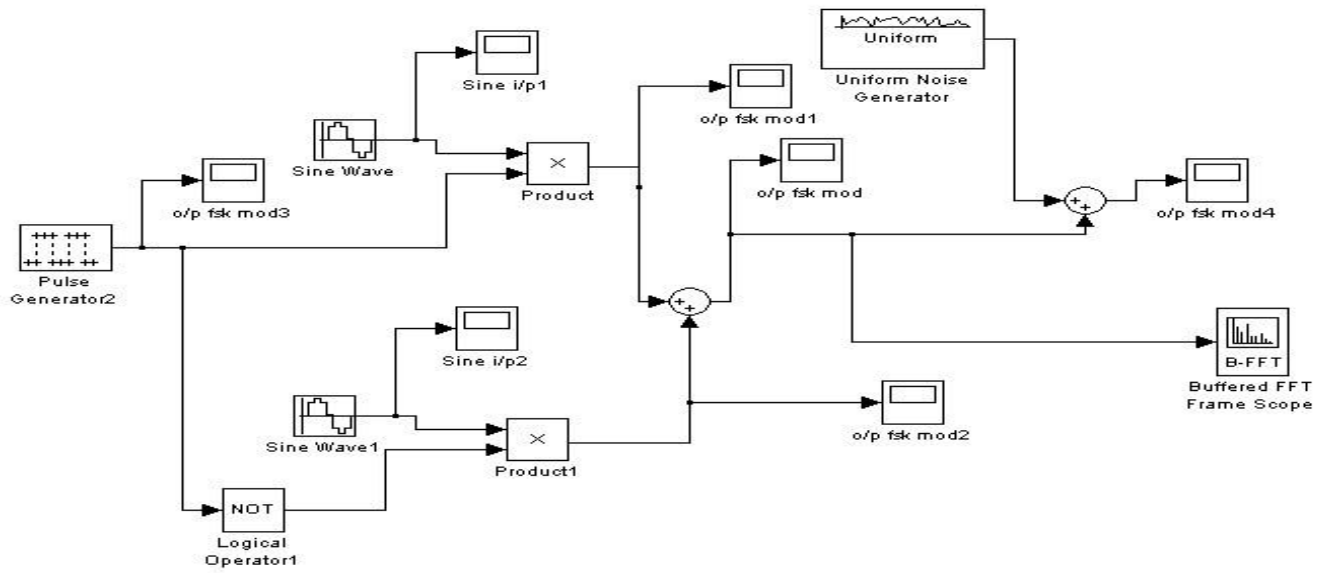
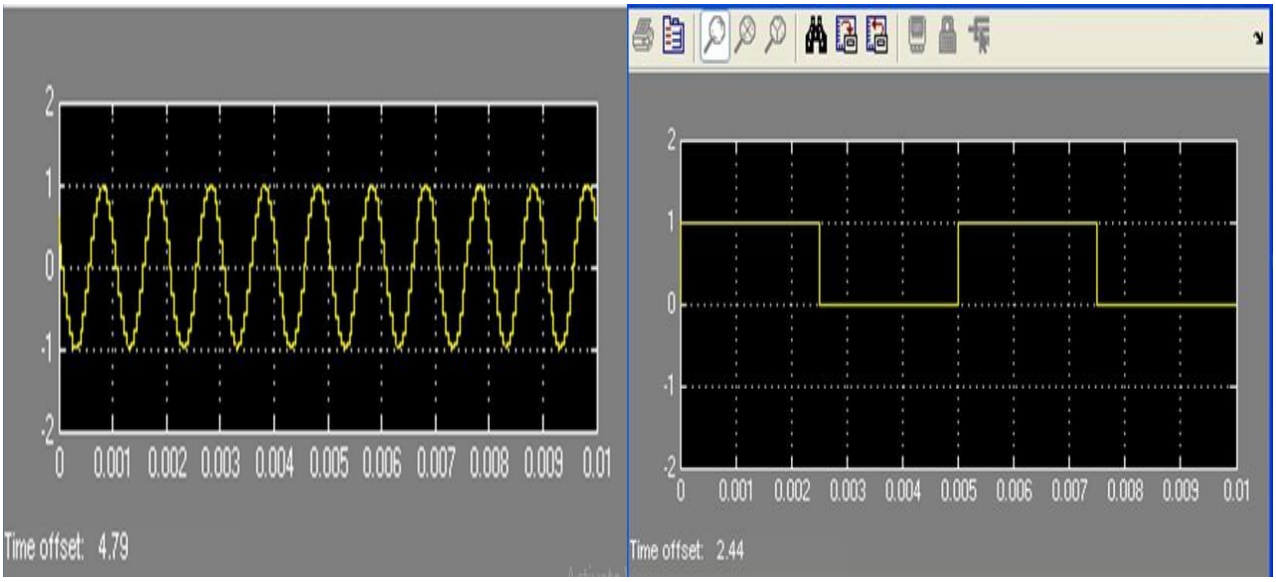



Figure 7: MATLAB diagram of FSK Modulation




(a) The output of carrier signal

(b) The output of message signal

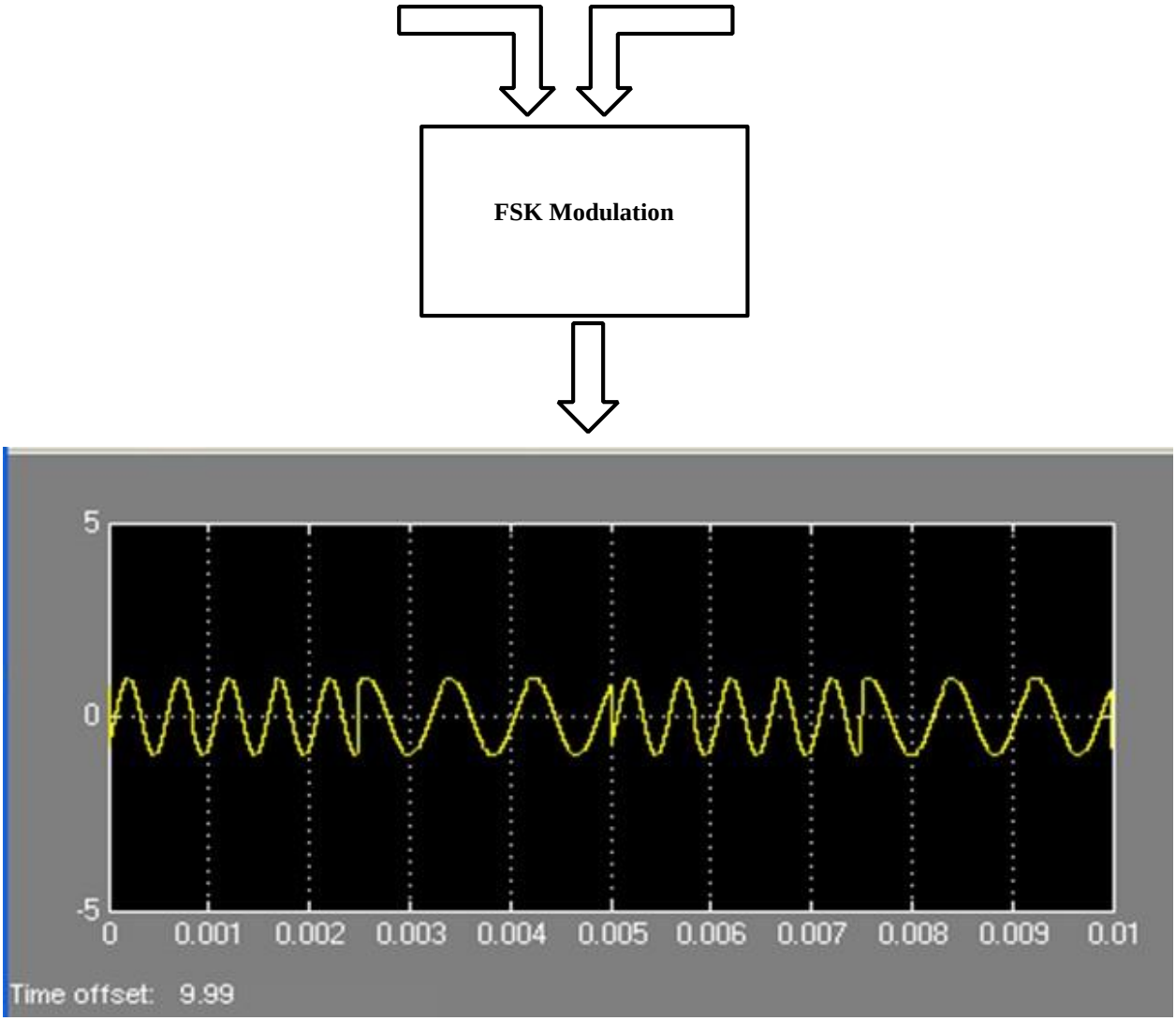



Figure 8: The output of result of FSK Modulation

## 10. FSK Demodulation

There are two techniques of FSK demodulator, “synchronous” and “asynchronous”. The synchronous method is coherent and the asynchronous method is non-coherent. In the synchronous FSK we have two band pass filter one is envelope detector and the second is decision circuit. The FSK signals accepted these two bands pass filters BPFs, adjust to “mark” and “space” frequencies. Enveloped detector signal is modulated in asynchronously. The circuit selects the output which is more suitable and selects this output from the envelope detectors. And it is also redesign the waveform in to a rectangular form.

FSK synchronous detector has two methods with oscillator circuits, first is decision circuit and second is band pass filters, this mixture precede as demodulation. The circuit selects that output which is more suitable. These two signals

provide the lowest frequency division. Both demodulator bandwidths build up on their bit rate. Synchronous demodulation is more difficult than the asynchronous ASK demodulator.

**A. FSK Demodulation on MATLAB**

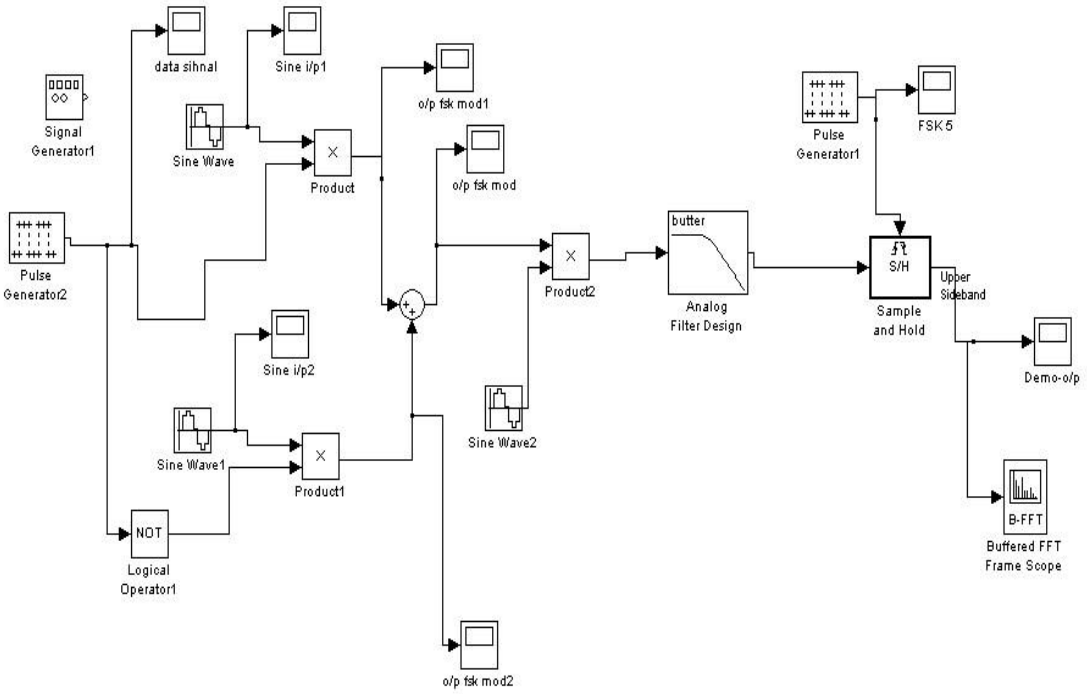



Figure 9: MATLAB diagram of FSK Demodulation **B.**

**Result of FSK Demodulation**

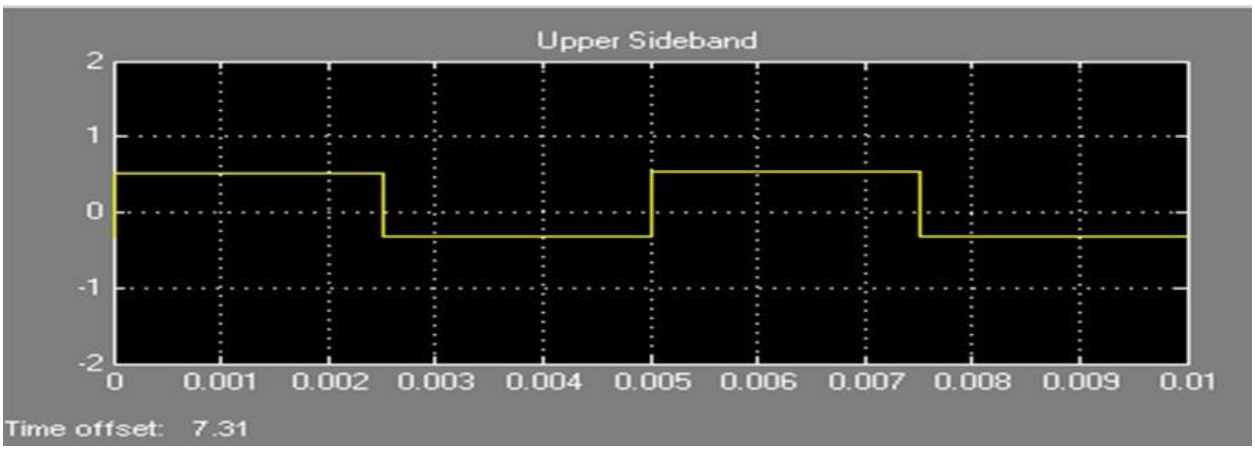



Figure 10: The output of FSK Demodulation

## 11. Conclusion

The study and performance of digital modulation techniques is presented in the paper. The review of comparative analysis of different modulation techniques is done in LTE 4G Systems. The higher order QAM can transfer more data but have a high error rate compare to lower order QAM. The paper further discussed the uses of QAM and QPSK for implementation of 5G. In which QAM has high data rate and bit error rate. But QPSK has bit error rate is very low. The study of wirelessly transfer of RFID Code using Amplitude Shift Keying Modulation is also shown. At the end the performance of ASK and FSK is done with the MATLAB. The performed modulated techniques can be used in IOT and wireless communication. Further there are many usages of ASK and FSK with modern software tools and algorithms.

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**Authors' Profiles**

**Asad Ali** received the bachelor of engineering degree in Computer Systems Engineering from Hamdard University, Karachi, Pakistan. His research interests include E-learning and Big Data Analytics.

**Rabia Ansari** received the bachelor of science degree in Computer Science from Sindh Madressatul Islam University, Karachi, Pakistan. Her research interests include Information Technology and Artificial Intelligence.