Application of Matlab Software for Implementing Shift Keying Techniques.

[1]Yusuf M. Limdiwala, [2]Karuna A.Mahajan
IDS, Nirma University, Ahmedabad, Gujrat.
[1]yusuf.limdiwala1991@gmail.com, [2]karuna_mahajan@nirmauni.ac.in

.

***Abstract*— We live in the digital world. Communication is intricate part of our daily life. Communicating effectively over a large distance has always been the quest of engineers and scientists. Several modulation techniques like the AM and FM, have been tried and tested in the past century to get the desired analog signal at the receiver. But with the introduction of digital systems we find ourselves in the time of ever increasing demand for high data rates and optimum bandwidth usage. This has forced us to look for better modulation techniques with higher immunity to environmental noise and channel distortion. Some of these techniques are ASK, FSK and PSK. This paper discusses the introduction of Matlab software in implementation of these techniques. The results which are found by using this software can easily correlate with the results that are found by doing the experiments with the help of hardware kits used in the communication laboratory. Implementing these techniques using software not only enhances the learning interest of students, but also improves their practical ability.**

Keywords- Amplitude Shift Keying(ASK), Frequency Shift Keying (FSK), Phase Shift Keying(PSK), Signal to Noise Ratio(SNR)

I. INTRODUCTION

The global communication systems have seen drastic changes and developments in the techniques and technological paradigms, in the past couple of decades. The transmission of digital signals is increasing at a rapid rate. Low frequency analogue signals are often converted to digital format before transmission. The source signals are generally referred to as baseband signals. Of course, one can send analogue and digital signals directly over a medium. From electro-magnetic theory, for efficient radiation of electrical energy from an antenna it must be at least in the order of magnitude of a wavelength in size; c = f l, where c is the velocity of light, f is the signal frequency and l is the wavelength. For a 1k Hz audio signal, the wavelength is 300 km. An antenna of this size is not practical for efficient transmission. The low-frequency signal is often frequency-translated to a higher frequency range for efficient transmission. The process is called modulation. The use of a higher frequency range reduces antenna size. In the modulation process, the baseband signals constitute the modulating signal and the high-frequency carrier signal is a sinusoidal waveform. There are three basic ways of modulating a sine wave carrier. For binary digital modulation, they are called binary amplitude-shift keying (BASK), binary frequency-shift keying (BFSK) and binary phase shift keying (BPSK). Modulation also leads to the possibility of frequency multiplexing. In a frequency-multiplexed system, individual signals are transmitted over adjacent, nonoverlapping frequency bands. They are therefore transmitted in parallel and simultaneously in time. If we operate at higher carrier frequencies, more bandwidth is available for frequency-multiplexing more signals.

There are three ways in which the bandwidth of the channel carrier may be altered simply. It is worth emphasizing that these methods are chosen because they are practically simple, not because they are theoretically desirable. These are the altering of the amplitude, frequency and phase of the carrier sine wave. These techniques give rise to amplitude-shift keying (ASK), frequency-shift-keying (FSK) and phase-shift-keying (PSK), respectively.

In this paper implementation of these digital modulation techniques using Matlab is done. Simulation of these modulation techniques using Matlab software is very easy and cheap method. It gives clarity of concept at each block level and creates interest in learning.

The rest of the paper is organized as follows. Section II gives the overview of Matlab software and simulink. In Section III different digital modulation techniques are discussed in detail. Comparison of these techniques is done in Section IV. Finally the conclusion is presented in Section V.

II. OVERVIEW OF MATLAB SOFTWARE AND SIMULINK

A. Matlab Software

Matlab (Matrix Laboratory) software is launched by MathWorks company of the United States in the mid-80s of20th century. It is an interactive, object-oriented echnology application. It is a specially designed advanced interactive package for scientific and engineering calculations, widely used in industry and academia. It is the most widely used mathematical software.

Matlab software is powerful, and rich, with more than 600 math functions that can be used in projects. It is very convenient for users to use its various computing functions, including the general numerical analysis, matrix computation, digital signal processing, modeling, system control and optimization, dynamic simulation, finite element analysis applications . MATLAB is a powerful mathematical software, which can easily handle a variety of mathematical calculations and draw visual graphics. MATLAB commands are very similar to the corresponding mathematical expression. They are known as mathematical calculations on paper, which is easy to get started. Before using this software, you need to give the use of guidance in the basic operations (including the basic matrix operations, visual graphics), and then used for related problems. Matlab language presentation and its mathematical expressions are the same, which does not need the traditional method of programming and is easy to use.

B. *Simulink*

Simulink® is an environment for multi domain simulation and Model-Based Design for dynamic and embedded systems. It provides an interactive graphical environment and a customizable set of block libraries that let you design, simulate, implement, and test a variety of time-varying systems, including communications, controls, signal processing, video processing, and image processing. With Simulink, you can easily build models from scratch, or modify existing models to meet your needs. Simulink supports linear and nonlinear systems, modeled in continuous time, sampled time, or a hybrid of the two. Systems can also be multirate having different parts that are sampled or updated at different rates.

C. *Key Features of Simulink*

- Extensive and expandable libraries of predefined blocks.
- Interactive graphical editor for assembling and managing intuitive block diagrams.
- Ability to manage complex designs by segmenting models into hierarchies of design components.
- Model Explorer to navigate, create, configure, and search all signals, parameters, properties, and generated code associated with your model.
- Application programming interfaces (APIs) that let you connect with other simulation programs and incorporate hand-written code.
- MATLAB Function blocks for bringing MATLAB algorithms into Simulink and embedded system implementations.
- Simulation modes (Normal, Accelerator, and Rapid Accelerator) for running simulations interpretively or at compiled C-code speeds using fixed- or variable-step solvers.
- Graphical debugger and profiler to examine simulation results and then diagnose performance and unexpected behavior in your design.
- Full access to MATLAB for analyzing and visualizing results, customizing the modeling environment, and defining signal, parameter, and test data.
- Model analysis and diagnostics tools to ensure model consistency and identify modeling errors

III. DIGITAL MODULATION TECHNIQUES

For simplicity, this paper is restricted to discussion of the coherent detection of the modulation schemes. In the coherent method the receiver exploits the knowledge of the carrier's phase to detect the original signal [4], which increases the complexity of the coherent system but the price paid is the decreased probability of error (P_{BER}). A low P_{BER} is always desired in satellite links, since the cost of retransmission is enormously high. Especially to achieve high data rates transmission, for high definition (HD) video, coherent detection is a critical parameter in terms of having the desired P_{BER} value.

A. *Amplitude Shift Keying(ASK)*

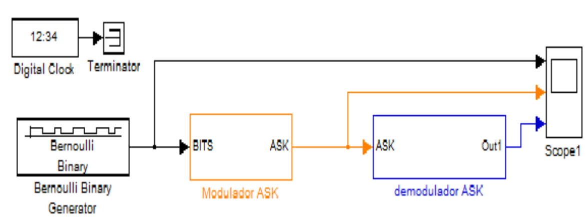

Fig.1 Simulation Diagram of ASK Modulator and Demodulator

ASK was one of the earliest forms of digital modulation used in radio telegraphy at the beginning of the nineteenth century[4]. It is the simplest form of modulation to implement, but is very susceptible to noise and distortion. The advantage of using ASK signals is that it does not require a large amount of bandwidth when transmitting the signal. On the other hand, the modulation depends on the strength of the amplitude, which consumes more power. The general form of ASK can be expressed as:

$$\mathrm{Si(t)} = \sqrt{\frac{2Ei(t)}{T}}\cos(wt + \varphi)$$

Where $\sqrt{\frac{2Ei(t)}{T}}$ represents the amplitude with discrete values.

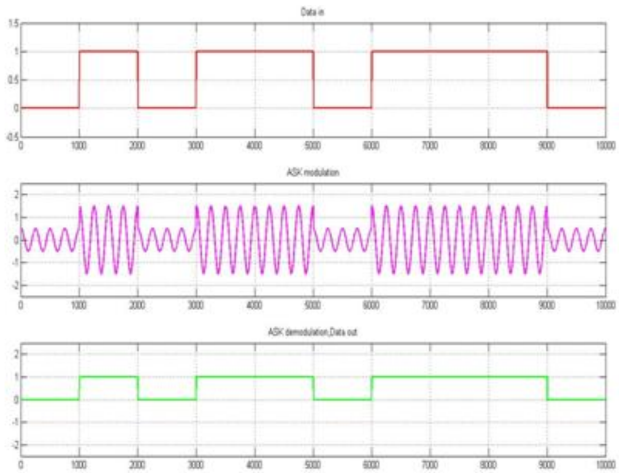

Fig.2 Waveforms of ASK Modulatior and demodulatior .

In amplitude shift keying the frequency (ω) and phase (ϕ) remains constant and varying variable is the amplitude. The function M is a result of powers of 2 such that

$$M = 2^K \quad \text{Where } K = 1, 2, \ldots.\infty$$

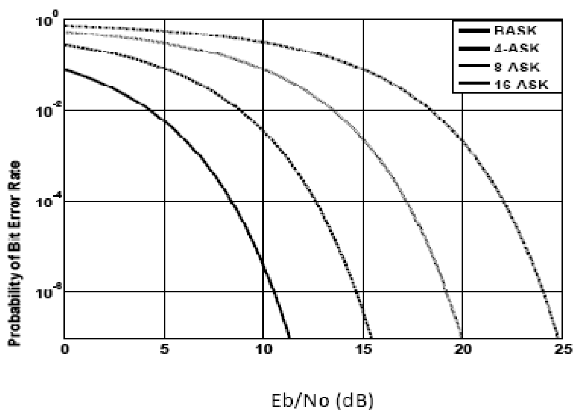

Fig.3: SNR versus the P_{BER} for different values of M in MASK [4]

In practice, the signal quality is judged by the required signal to noise ratio (SNR) *Eb/No* (dB), the ratio of bit energy to noise power spectral density[4] that accounts for the suboptimal channel conditions. Also, the required Eb/No can be considered to be a common platform that characterizes the performance of one system versus another [4]. In the case of MASK modulation scheme, as the M in the M-ary signaling increases, the tolerance of the system also increases. If M > 2, the bandwidth requirement increases proportionally and so does the value Eb/No. For MASK:

$$P_B = Q\left(\sqrt{\frac{E_B}{N_O}}\right)$$

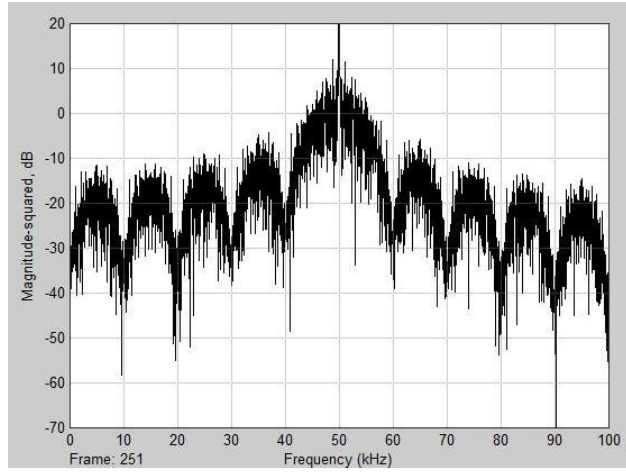

Fig. 4 Spectrum for the BASK modulation scheme

The Fig. 4 simulates the spectrum of the received BASK signal with first null at 20 KHz.

B. Frequency Shift Keying(FSK)

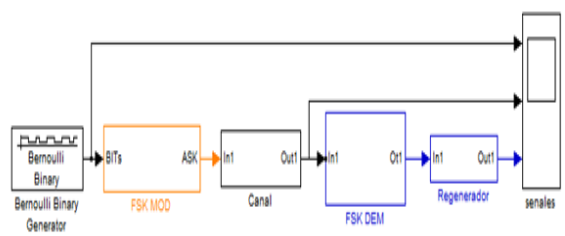

Fig. 5 Simulation Diagram of FSK Modulator and Demodulator

The general form of FSK modulation can be expressed as

$$s_i\,(t) = \sqrt{\frac{2E}{T}}\,\cos\,(w_i(t).t + \varphi)$$

Where $w_i(t)$ is the frequency component that varies in time with discrete values M.

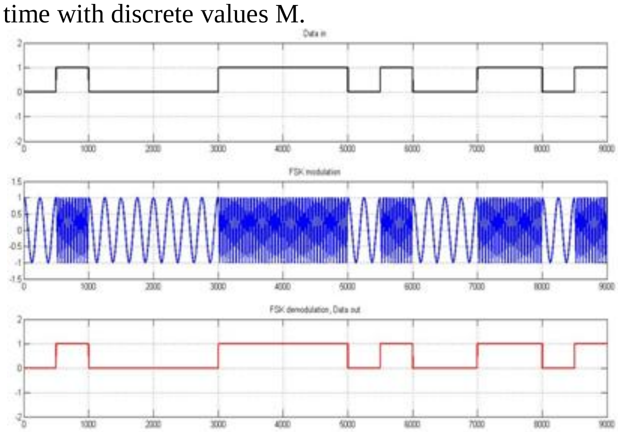

Fig.6 Waveforms of FSK Modulatior and demodulatior .

Since it is a frequency modulated signal, the amplitude and phase (φ) remains constant. The advantage of using FSK compared to ASK is that it does not require a large amount of power when transmitting the signal. On the other hand, the modulation suffers by requiring a large number of bandwidth in transmitting the signal.

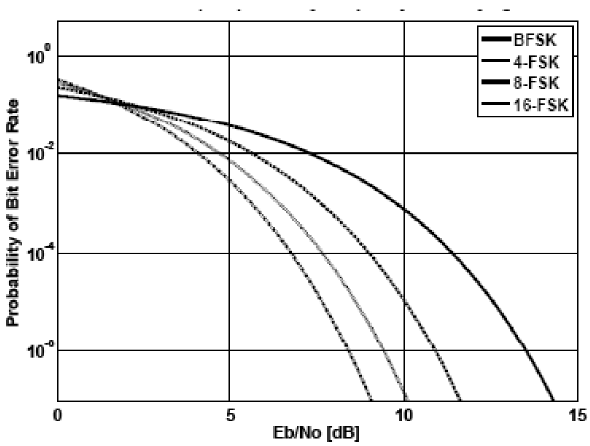

Fig. 7: SNR versus the P_{BER} for different values of M in MFSK [4]

The bit energy per noise power spectral density (*Eb/No*), is the key parameter to estimate the bit error probability (PB). Fig. **6** illustrates PB versus *Eb/No* for coherently detected FSK over a Gaussian channel. In the M-ary FSK system the length of the noise vector remains the same, irrespective of the number of signal vectors [4].Unlike the M-ary PSK system where, as M increases the communication link becomes more prone to error, on the other hand MFSK system shows increased M decreases P_B, thus increasing system performance.
For coherent MFSK:

$$P_B = Q\left(\sqrt{\frac{E_B}{N_O}}\right)$$

C. Phase Shift Keying(PSK)

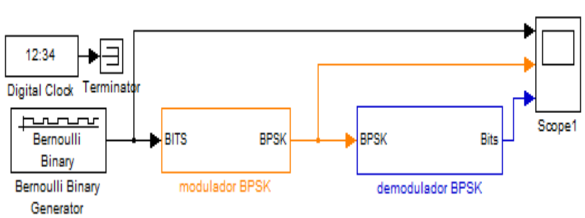

Fig. 8 Simulation Diagram of PSK Modulator and Demodulator

Phase shift Keying (PSK) was developed in the early days of deep space exploration program and is today widely used in commercial and military communication. In general the PSK modulated signals are more immune to noise than its counterparts the ASK and FSK.

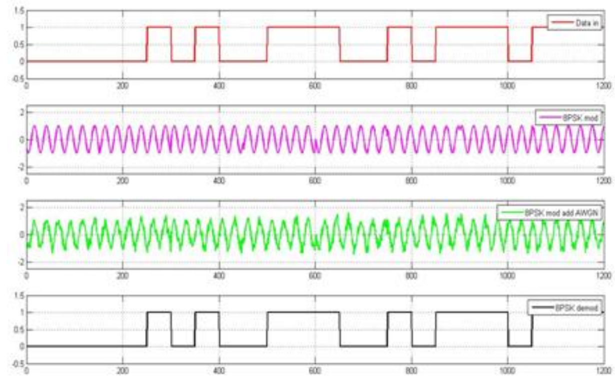

Fig. 9 Waveforms of PSK Modulator and demodulator .

Systems with M-ary phase encoding (e.g. QPSK) assumes that the receiver has the perfect knowledge of the carrier phase. This underlying principle requires the receiver to have a minimal phase estimation error, which is very hard to achieve, especially in a fast fading environment. Where channel phase changes rapidly owing to multipath interference. A general analytic expression for PSK can be written as,

$$s_i(t) = \sqrt{\frac{2E}{T}}\cos\left(w_0(t) + \varphi_i(t)\right)$$

Where the phase component of the signal varies in time.

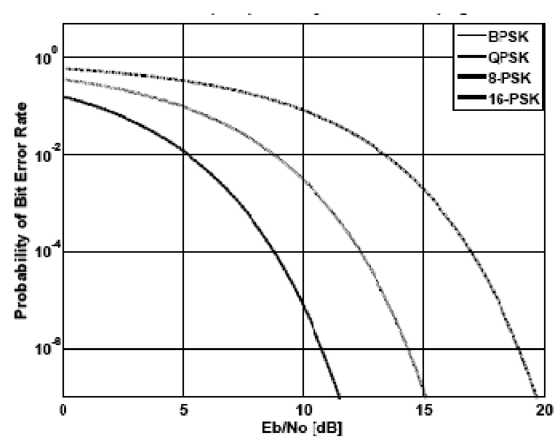

Fig. 10: SNR versus the P_{BER} for different values of M in MPSK [4]

In the figure 10 as k increases, $M = 2^k$, the signal vectors get closer to the adjacent signal vector, which in turn reduces the minimum energy of the noise vector increasing the probability of the detector to make a symbol error [4].

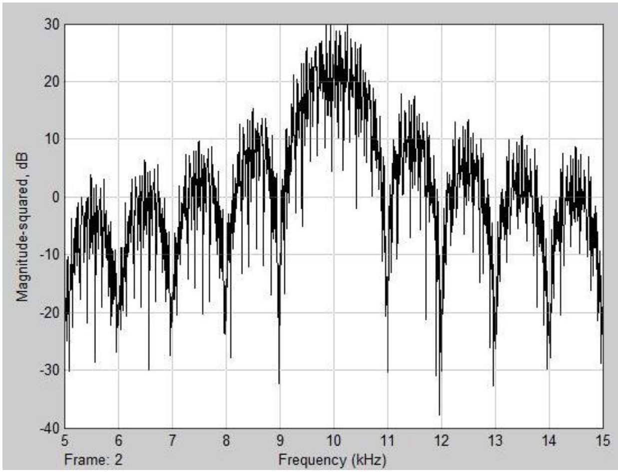

Fig 11: Spectrum for BPSK modulation scheme

As shown in Fig. 11 a spectrum for Binary PSK signal achieves its first null at 2 KHz, making the required BW as 2 KHz. Thus making the multiple phase signaling more efficient in conserving BW, as M increases the probability of bit error (P_B) also increases.

$$P_B = Q\left(\sqrt{\frac{2E_B}{N_O}}\right)$$

From the results obtained it can be said that in MPSK increasing M, depreciates the error performance, but improves bandwidth utilization. In the M-ary PSK system bandwidth performance can be achieved at the expense of PB. Thus for a satellite link with a limited bandwidth, the link performance can be improved by decreasing M.

TABLE 1 Comparison of digital modulation techniques

Sr. No.	Parameters	ASK	FSK	PSK
1	Change in Parameter	Amplitude	Frequency	Phase
2	Line Code used	ON-OFF	Combination of two ON-OFF Codes	Polar code
3	Immunity to noise	Good	Better	Best
4	Efficiency	Bandwidth Efficient	Power Efficient	Bandwidth Efficient
5	Bit Error Probability	$P_B = Q\left(\sqrt{\frac{E_B}{N_O}}\right)$	$P_B = Q\left(\sqrt{\frac{E_B}{N_O}}\right)$	$P_B = Q\left(\sqrt{\frac{2E_B}{N_O}}\right)$
6	Application	DC/DC converters	Satellite Communicati on	Mobile Communication

IV. CONCLUSION

The analog modulation is obsolete now a days. Wired analog communication links have transformed into modern day digital wireless systems, which make use of several different modulation schemes and various multiplexing techniques. Amplitude shift Keying (ASK), Frequency Shift Keying (FSK) and Phase Shift Keying (PSK) are some of those. This paper focuses on the basic concept and pros and cones of these techniques. A Comparative study of these techniques is done so that one can easily understand and analyze them. Also the implementation is done using Matlab. Use of Matlab in generating different shift keying methods is cheap and reliable compare to experimental kits used in communication laboratory. The simulink part of generation creats more awareness about how the modulation is actually carried out at different stages.

REFERENCES

[1] Chirag Warty, Richard Wai Yu, "Resource Allocation using ASK, FSK and PSK Modulation Techniques with varying M" *IEEE*, 2011

[2] A. H. Aghawami, "Digital Modulation Techniques for mobile and personal communication systems" *ELECTRONICS & COMMUNICATION JOURNAL*, June 1993

[3] John Proakis and Masoud Salehi, *"Digital Communications"*, 5th Ed. New York: McGraw-Hill, 2008

[4] Bernard Sklar, "Digital Communications – Fundamentals *and Applications",*2nd Ed, New Jersey: Prentice Hall, 2001.

[5] Andrea Goldsmith, "*Wireless Communications*," Cambridge University Press, Singapore, 2005

[6] JIN Lihong, BI Chongrong , ZHAO Yi'nan, "Application of MATLAB software for Linear Algebra" *IEEE*, 2011

[7] T.K.Cheung, K.W.E.Cheng, D.Sutanto Y.S.Lee and Y.L.Ho'"Application of ASK Modulation for DC/DC Converters Control in DC Distribution Power System"