BER Analysis of Modulation Techniques Based OFDM System

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Abstract- **Efficient utilization of the spectrum is the key challenges is multiplexing technology, and have OFDM is a transmission technique which ensures efficient utilization of the spectrum by allowing overlap of the spectrum by allowing overlap of carriers. It has various advantages like high spectral density, its robustness to channel fading, its ability to overcome several radio impairment factor such as the effect of AWGN impulse noise, multi-path fading etc. Most of the wireless LAN standards like IEEE 802.11a or IEEE 802.11 use OFDM as the main multiplexing scheme for better use of spectrum.**

Keywords- Digital multi-carrier modulation, OFDM (Orthogonal frequency division multiplexing), Bit Error Rate (BER), AWGN, Simulation.

I. INTRODUCTION

Wireless communication is a budding field, which has seen massive growth in the last several years. The huge uptake of mobile technology, WLAN (wireless local area network), and the internet have resulted in an increased demand in wireless network, They not only need mobile phones to connect to the network but also require some multimedia services (like video, audio, graphics etc..) to connect with the single network. OFDM is the most suitable techniques for high data rate applications.

OFDM becomes a worldwide used modulation technique and giving directions to the engineers to enter into a new generation of digital transmission [1].OFDM is the solution for providing telephony services as well as multimedia services and have a single network connection. The OFDM technique is a data transmission specific case where sub-carriers are used for sending data simultaneously and the higher data rate is split into lower data rate. One of the types of multi-carrier modulation technique is OFDM which transmits signals through multiple carriers. These sub-carriers are orthogonal to each other and have different frequencies. It is used in various wired Asymmetric digital subscriber line (ADSL) and wireless networks, Local Area Network (LAN).Asymmetric digital subscriber line is a sort of digital subscriber line (DSL) technology, in which a copper telephone lines are used for faster data transmission than a conventional voiceband modem. Local Area Network [2] is a wireless network that links two or more devices in a relatively small area (like home, office etc.). It allows interconnection and sharing of data between independent devices within a limited geographic area. The most extensively used standard for LAN is IEEE 802.11[3].

II. SYSTEM MODEL

OFDM is a kind of frequency division multiplexing (FDM) in which a single sub-carrier utilizes multiple channels on adjacent frequencies. As the channels in OFDM are overlapping, therefore it enhances the spectral efficiency. The presence of orthogonal channels makes OFDM system less interfere [4].

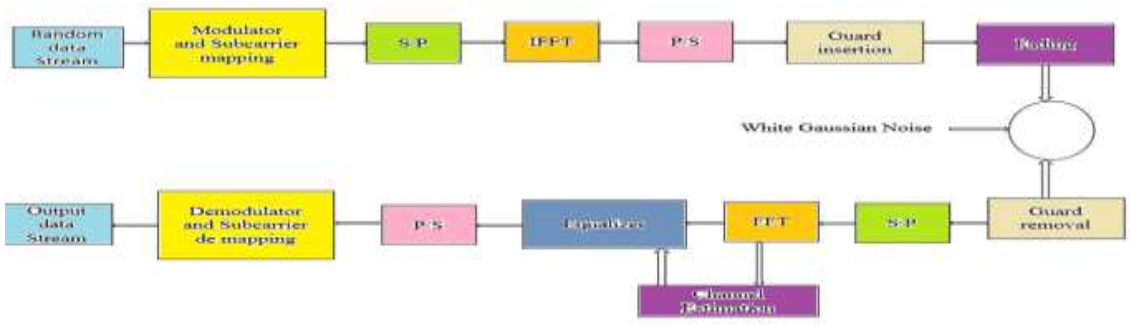


Figure1. Block Diagram of OFDM Model

The block diagram of OFDM model is shown in figure 1 the random data from the stream is mapped and then it is converted into parallel form. After mapping is done, the IFFT (Inverse Fast Fourier Transform) operation is executed which convert frequency domain signal into time domain signal. After that attenuation of the signal is varied with various variables using fading. At the receiver end, the FFT (Fast Fourier Transform) operation is performed to again convert the time domain signal into the frequency domain and then the signal is further passed through the channel. After passing it to parallel to serial converter, the recovered signal is obtained after the demodulation of the signal is done [5].

In digital transmission, the number of bit errors is the number of received bits that are changed or altered due to noise, distortion or bit synchronization errors [6]. The presence of The error in data lowers down the performance of the system. So, in order to calculate the errors detected during transmission, bit error rate is used and calculated by:

$$BER = \frac{\text{Number of bit errors occur during transmission}}{\text{Total number of transferred bits}} \quad (1)$$

The Additive White Gaussian Noise (AWGN) channel block improves white Gaussian noise to an actual or complex input signal. Once the input signal remains real, this block adds real Gaussian noise in addition to produces a real output signal. While the input signal stands complex, this block adds complex Gaussian noise and produces a complex output signal. This block receives its sample time from the input signal.

A. Modulation Techniques

The various techniques used for digital modulation technique in OFDM system are BPSK, QPSK and QAM are describes as follows:

I. Binary Phase Shift Keying (BPSK)

In this modulation technique, two phases are generated in the form of two-bit information that is 0 or 1. When the transmission of '1' bit takes place, the phase is shifted by 0 degrees and for '0' bit transmission, the phase is shifted by 180 degrees. It can be represented as

$$s(t) = A\, m(t)\cos 2\pi f_c t \quad \text{and} \qquad 0 \le t \le T \quad (2)$$

where, A is constant, m (t) = +1 or -1, f_c = is the carrier frequency, T= is the bit duration. Whereas signal power can be represented as $P = \frac{A^2}{2}$

Putting the values of above variable in equation (2)

$$s(t) = \pm\sqrt{PT}\sqrt{\frac{2}{T}}\cos 2\pi f_c t \quad (3)$$

where, E= PT is the energy contained in a bit duration and,$\sqrt{\frac{2}{T}}\cos 2\pi f_c t$ as the orthonormal basis function.

II. Quadrature Phase Shift Key (QPSK)

It is also known as quadric phase PSK or 4-PSK, in which there are 4 states involved where two bits are sent at a time and is represented by only one symbol. The original data stream is- $d_k(t) = d_0, d_1, d_{2,\ldots}$ is dividing into equal stream having in-phase stream $d_I(t) = d_0, d_2, d_4 \ldots$ and a quadrature stream is $d_q(t) = d_1, d_3, d_5 \ldots$. The equation for QPSK can be

$$S(t) = cos[2\pi f_0 t + \theta(t)] \quad (4)$$

where, $\theta(t)$ can be taken from one of the four possible from $0^\circ, \pm 90^\circ$, and 180°.

III. Quadrature Amplitude Modulation (QAM)

It is a combination of shift keys i.e. Amplitude shift key (ASK) and Phase shift key (PSK). The generation of the QAM signal can be done by generating two signals that are 90° out of phase with each other and then summing up them [8]. Using the equation of $A\cos(2\pi ft+\varphi)$ for the carrier signal-

$$A\cos(2\pi ft+\varphi) = I\cos(2\pi ft) - Q\sin(2\pi ft) \quad (5)$$

where I and Q signals can also be denoted I= A $\cos(\varphi)$ and Q= $\sin(\varphi)$

III. SIMULATION

This section describes the various modeling of digital modulation techniques through the Simulink tool. In figure 2, a Bernoulli binary generates a set of random numbers which feeds into the BPSK modulator and it is further passed through OFDM modulator [9]. An AWGN channel is transmission medium between transmitter and receiver.

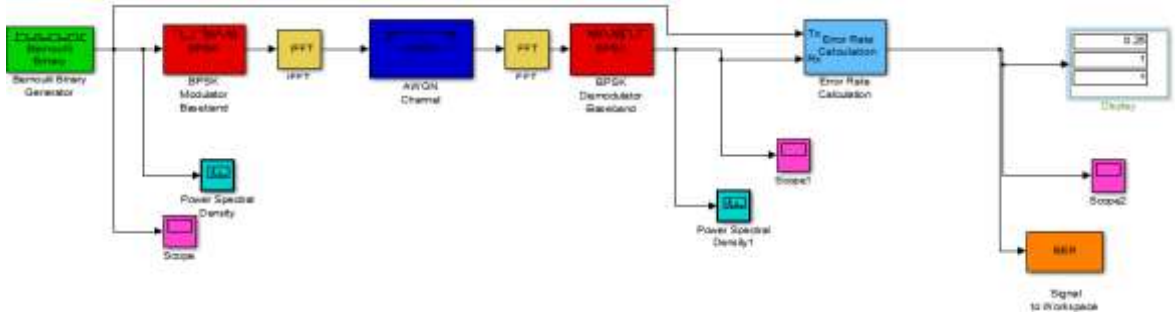


Figure 2. OFDM System using BPSK Modulation

Similarly, figure 3 and 4 demonstrates the QPSK and QAM-based OFDM system respectively. The power spectral density shows the frequency spectrum whereas, time domain representation is done through scopes block.

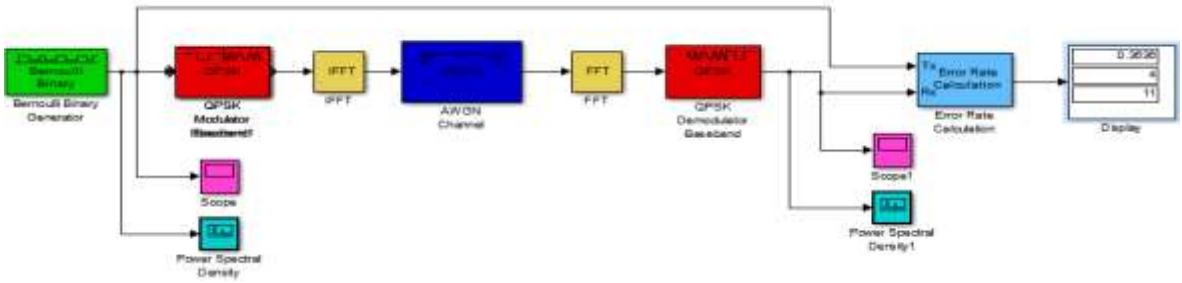


Figure 3. QPSK Modulation in OFDM

Moreover, error rate calculation provides the difference of bits between the transmitted and received OFDM symbols. At the same time, BER visualize through display

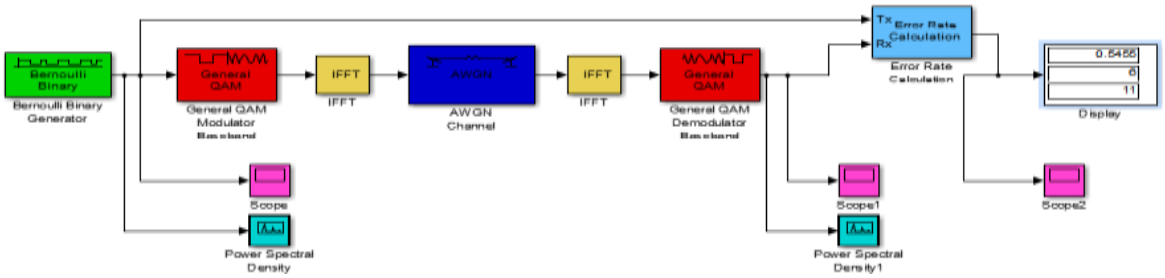


Figure 4. OFDM system through QAM

IV. RESULT

Using various modelling, figure 5, 7 and 9 illustrate the scope of BPSK, QPSK and QAM modulation. It is observed that both the 5(a) demonstrates the random number whereas demodulation is represented through figure 5(b).

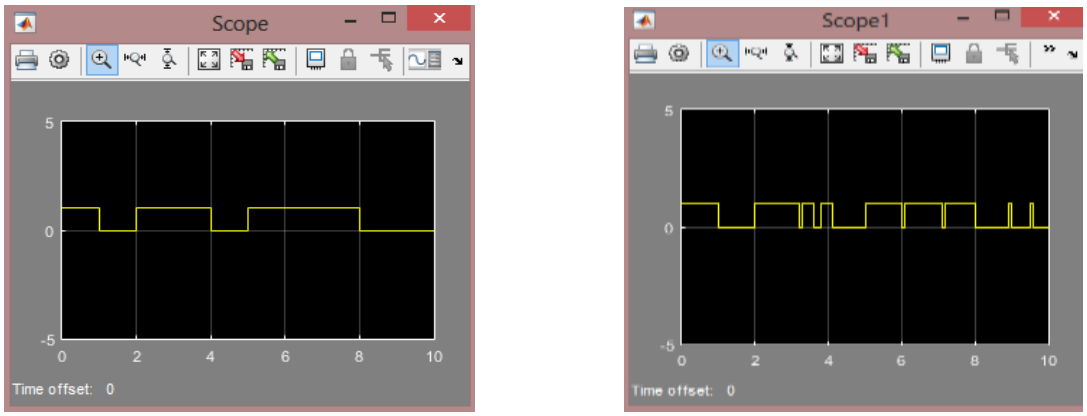


Figure 5(a), (b) BPSK scope

Using several demonstrating show figure 6, 8 and 10 illustrate the power spectral density BPSK, QPSK, and QAM. It is observed that the 6(a) and 6(b).

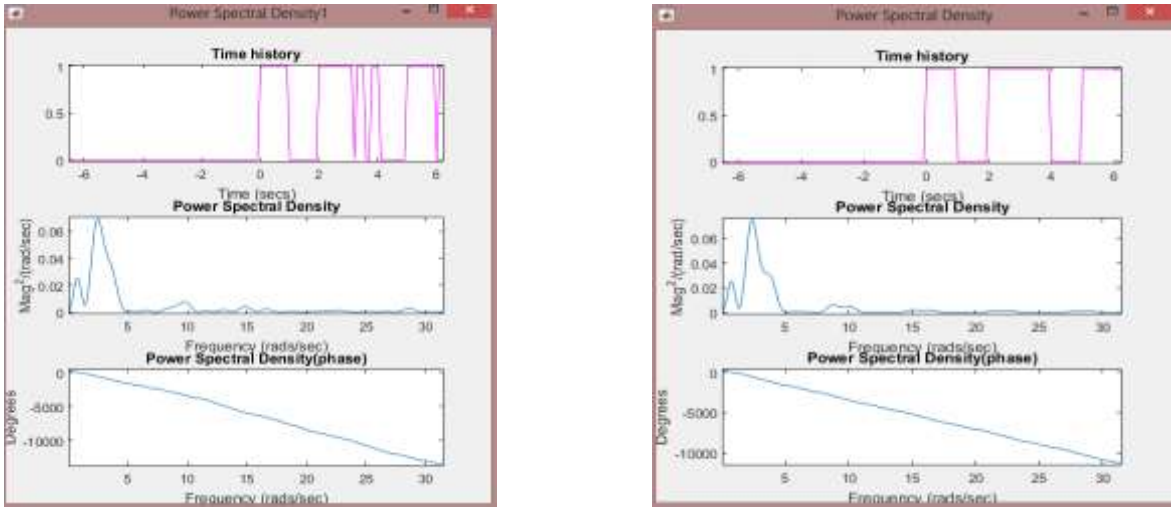


Figure 6(a), (b) BPSK POWER SPECTRAL DENSITY

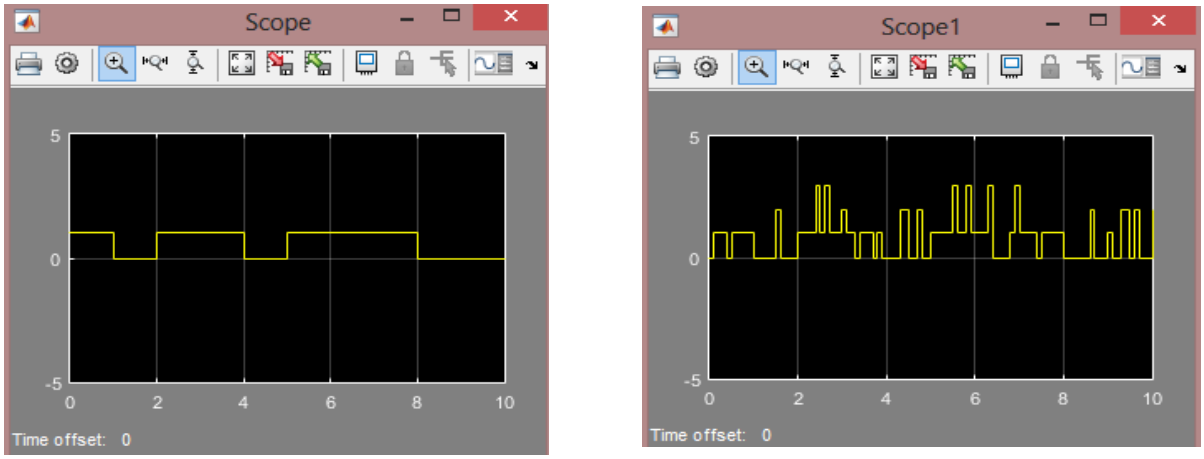


Figure 7 (a),(b) QPSK scope

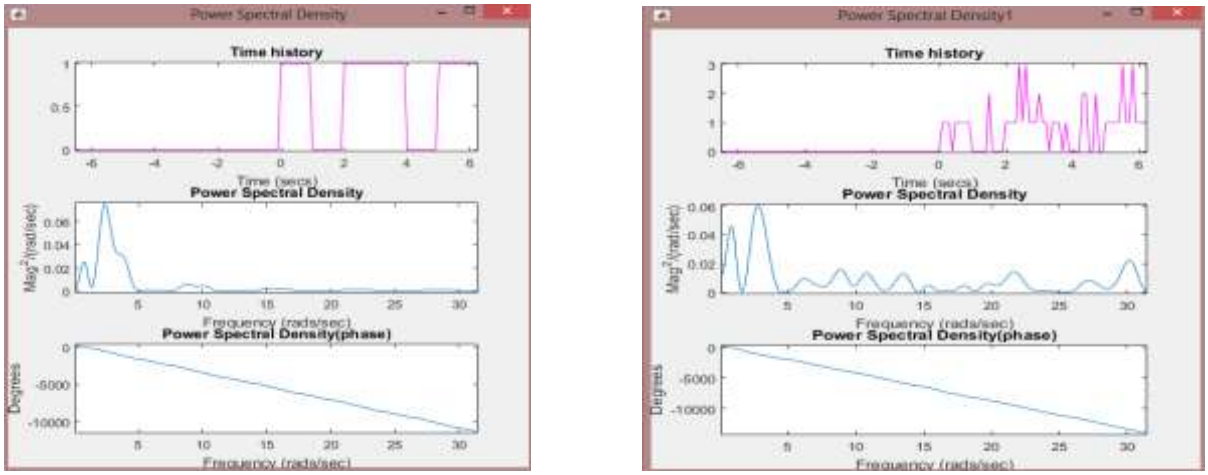


Figure 8 (a), (b) BPSK POWER SPECTRAL DENSITY

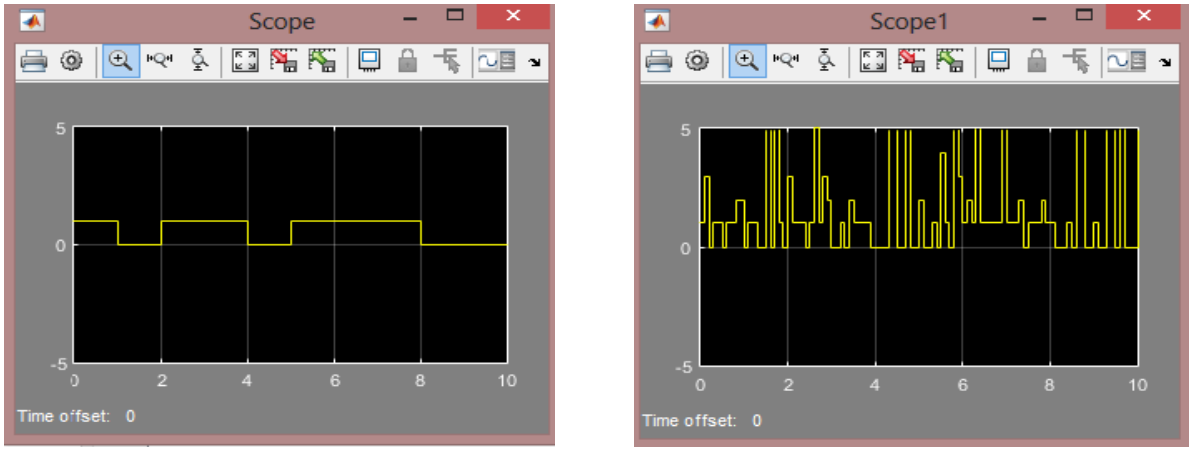


Figure 9 (a), (b) QPSK scope

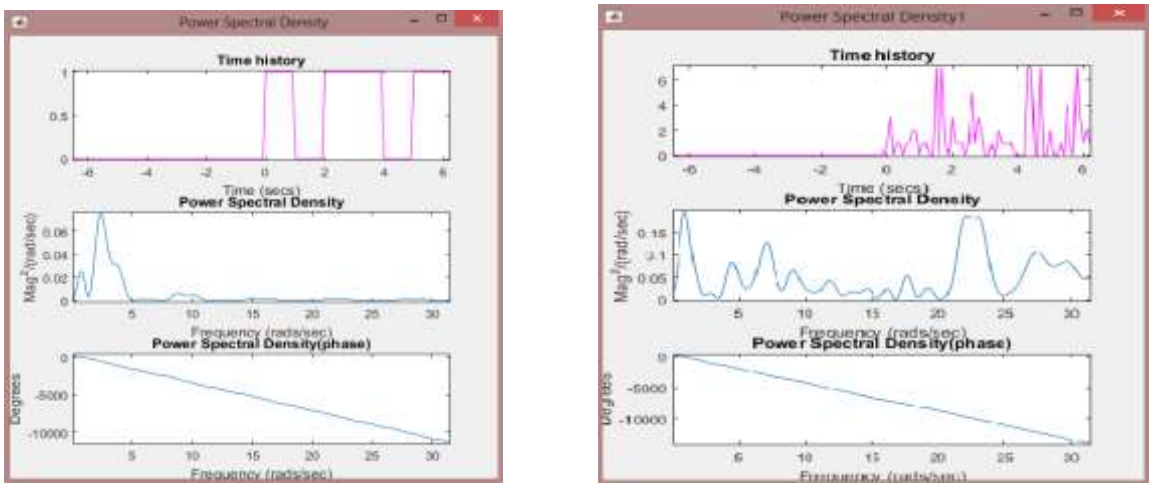
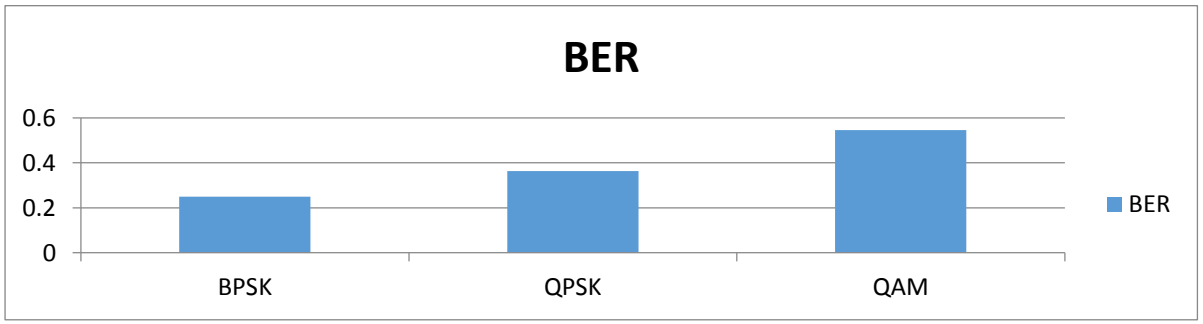


Figure 10(a), (b) BPSK POWER SPECTRAL DENSITY

From Table1, it can be concluded that the BER value in the case of BPSK modulation is less and higher in a case of QAM system. As SNR (Signal to Noise Ratio) is used to measure the quality of transmission channel. Also, BER is inversely proportional to SNR. So, if the value of BER is less, then the value of SNR will be high.

TABLE I. BER CALCULATION



Higher the SNR value, less will be the noise in the signal and therefore, the minimum value of BER is required to enhance the performance and efficiency of OFDM system. Hence the performance is summarized with the output of OFDM system using various modulation techniques (i.e. BPSK, QPSK, QAM) on the basis of BER estimation [10].

V. CONCLUSION

This OFDM interconnected technique has been familiarized terminated 40 years ago. This technique has stayed chosen for various current and future communication systems all over the world in many applications. In this paper, we discussed the different modulation technique (BPSK, QPSK, QAM) which has been applied on OFDM system using AWGN channel. A simulation study is implemented using MATLAB Simulink tool to study the BER performance parameter on AWGN channel. It is observed that BPSK based OFDM system has least BER value compared to other digital modulation techniques. Thus, the performance of BPSK based system is better than other modulation techniques. In a future work, many difference techniques are used like MSK, FSK and different fading channels are used rayleigh fading or rician fading.

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