

# Simulation of QPSK and OQPSK Modulation Technique Using Simulink and Calculating the Performance Metric 'BER' In Different Fading Channels

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**Abstract**— This paper presents the bit error rate (BER) performance of Quadrature Phase Shift Keying (QPSK) and Offset Quadrature Phase Shift Keying (OQPSK) over Rayleigh fading, AWGN and Rician channels. Bit Error Rate performance of QPSK modulation and OFDMQPSK System over AWGN and Rayleigh fading channel is analyzed. The performance of BER of QPSK over AWGN and Rayleigh channel is compared. OFDM is an orthogonal frequency division multiplexing to reduce inter symbol interference problem.

Simulation of QPSK signals is carried with both AWGN and Rayleigh channel. Finally simulations of OFDM signals are carried with Rayleigh faded signals to understand the effect of channel fading and to obtain optimum value of Bit Error Rate (BER) and Signal to noise ratio (SNR). The simulation results show that the simulated bit error rate is in good agreement with the theoretical bit error rate for QPSK modulation.

**Index Terms**— QPSK, OQPSK, BER, Rayleigh fading channel, AWGN channel, Rician channel

## 1 INTRODUCTION:

In digital modulation techniques a set of basis functions are chosen for a particular modulation scheme. Generally the basis functions are orthogonal to each other. Basis functions can be derived using "Gram Schmidt orthogonalization" procedure. Once the basis function are chosen, any vector in the signal space can be represented as a linear combination of the basis functions. In Quadrature Phase Shift Keying (QPSK) two sinusoids (sin and cos) are taken as basis functions for modulation. Modulation is achieved by varying the phase of the basis functions depending on the message symbols. In QPSK, modulation is symbol based, where one symbol contains 2 bits.

High data rate is desirable in many recent wireless multimedia applications. Traditional single carrier modulation techniques can achieve only limited data rates due to the restrictions imposed by the multipath effect of wireless channel and the receiver complexity. Rayleigh fading channel for QPSK modulation is a potential candidate to fulfil the requirements of current and next generation wireless communication systems.

In wireless, satellite, and space communication systems, reducing error is critical. Wireless medium is quite different from the counterpart using wires and provides several advantages, for example; mobility, better productivity, low cost, easy installation facility and scalability. On the other hand, there are some restrictions and disadvantages of various transmission channels in wireless medium between receiver and transmitter where transmitted signals arrive at receiver with different power and time delay due to the reflection, diffraction and scattering effects. Besides the BER (Bit Error Rate)

value of the wireless medium is relatively high. These drawbacks sometimes introduce destructive effects on the wireless data transmission performance. As a result, error control is necessary in these applications. During digital data transmission and storage operations, performance criterion is commonly determined by BER which is simply: Number of error Bits / Number of total bits. Noise in transmission medium disturbs the signal and causes data corruptions. Relation between signal and noise is described with SNR (signal-to-noise ratio). Generally, SNR is defined as signal power / noise power..

**QPSK:**

Quadrature Phase Shift Keying (QPSK) is a form of Phase Shift Keying in which two bits are modulated at once, selecting one of four possible carrier phase shifts (0, 90, 180, or 270 degrees). QPSK allows the signal to carry twice as much information as an ordinary PSK using the same bandwidth. QPSK is used for satellite transmission of MPEG2 video, cable modems. QPSK (Quadrature Phase Shift Keying) is one of the modulation schemes used in wireless communication system due to its ability to transmit twice the data rate for a given bandwidth. The mathematical analysis shows that QPSK can be used either to double the data rate compared with a BPSK system while maintaining the same bandwidth of the signal, or to maintain the data-rate of BPSK but halving the bandwidth needed.

**OQPSK:**

Staggered quadrature phase-shift keying (SQPSK), also known as offset quadrature phase-shift keying (OQPSK), is a method of phase-shift keying (PSK) in which the signal carrier-wave

phase transition is always 90 degrees or 1/4 cycle at a time. A phase shift of 90 degrees is known as phase quadrature.

In OQPSK, the data is placed alternately on two channels or streams called the I channel (for "in phase") and the Q channel ("phase quadrature"). A single phase transition can never exceed 90 degrees. This property contrasts OQPSK with conventional quadrature phase-shift keying (QPSK), in which the phase can sometimes change by 180 degrees (two 90-degree shifts in a single transition). The average magnitude of the phase transitions is smaller with SQPSK than with conventional QPSK. The result of the smaller average phase "jump" is an improved signal-to-noise ratio (SNR) and a reduced error rate.

## 2 LITERATURE SURVEY:

[1] Bit Error Rate Performance of QPSK Modulation and OFDM-QPSK with AWGN and Rayleigh Multipath Channel .Sanjeev Sanyal, Lingaya's University, Faridabad, India. In a popular variation of BPSK, Quadrature PSK (QPSK), the modulator produces two sine carriers 90° apart. The binary data modulates each phase, producing four unique sine signals shifted by 45° from one another. The two phases are added together to produce the final signal. Each unique pair of bits generates a carrier with a different phase [4]. QPSK is an expanded version from binary PSK where in a symbol consists of two bits and two orthonormal basis functions are used. A group of two bits is often called a „dibit“. So, four dibits are possible. Each symbol carries same energy [1]. On simple trigonometric expansion, the QPSK modulated signal  $s(t)$  can be expressed as:

$$S(t) = \sqrt{2} \left[ \cos(2\pi f_c t) \cos(2\pi f_m t) - \sin(2\pi f_c t) \sin(2\pi f_m t) \right]$$

[2] Quadrature Phase Shift Keying and Offset Quadrature Phase Shift Keying BER Performance Comparison .Amer Mohamed Daeri, Zawia University. Faculty of Engineering, Computer Eng. Department.

Quadrature Phase Shift Keying (QPSK) is a form of Phase Shift Keying in which two bits are modulated at once, selecting one of four possible carrier phase shifts (0, 90, 180, or 270 degrees). QPSK allows the signal to carry twice as much information as an ordinary PSK using the same bandwidth. QPSK is used for satellite transmission of MPEG2 video, cable modems, Videoconferencing, cellular phone systems, and other forms of digital communication over an RF carrier.

QPSK (Quadrature Phase Shift Keying) is one of the modulation schemes used in wireless communication system due to its ability to transmit twice the data rate for a given bandwidth. The mathematical analysis shows that QPSK can be used either to double the data rate compared with a BPSK system while maintaining the same bandwidth of the signal, or to maintain the data-rate of BPSK but halving the bandwidth needed.

[3] H. B. Jeon, J. S. and D. J. Shin (2011). "A Low-Complexity SLM Scheme Using Additive Mapping Sequences for PAPR Reduction of OFDM Signals", IEEE Transactions on Broadcasting. Vol. 57, No. 4, pp. 866-75.

Orthogonal Frequency Division Multiplexing (OFDM) has proven to be the most promising technique for high speed data transmission over a dispersive channel [6]. It provides high spectral efficiency, low implementation complexity [7], less vulnerability to echoes and non-linear distortion [8]. Orthogonal frequency division multiplexing (OFDM) transmission scheme is a type of a multichannel system. It does not require individual band limited filters and oscillators for each sub-channel and furthermore the spectra of the subcarriers are overlapped for bandwidth efficiency. Overlapped multiple orthogonal subcarrier signals can be produced by generalizing the single carrier Nyquist criterion into multi-carrier criterion.

[4] Sudipta Chattopadhyay, Salil Kumar Sanyal, "Comparison of Performance Metrics for QPSK and OQPSK Transmission Using Root Raised Cosine & Raised Cosine Pulse-shaping Filters for Applications in Mobile communication ", International Journal of Computer Science and Information Security (IJCSIS), Vol. 6, No.2, 2009

The bit error probability of QPSK is identical to BPSK, but twice as much data can be sent in the same bandwidth. Thus when compared to BPSK, QPSK provides twice the spectral efficiency with exactly the same energy efficiency. Similar to BPSK, QPSK can also be differentially encoded to allow non-coherent detection. Phase modulation with Quadrature offset is referred to as OQPSK. OQPSK has the same spectral properties as QPSK for linear amplification, but it has higher spectral efficiency under nonlinear amplification.

The maximum phase transition of the signal is 90°, corresponding to the maximum phase transition in either the in phase or Quadrature branch but not both simultaneously. This Quadrature offset makes the signals less sensitive to distortion during symbol transitions. Comparing the equation of QPSK and OQPSK, the offset QPSK has exactly same probability of symbol error in an AWGN channel as QPSK except the delay in the basis function. The equivalence in noise performance between these phase shift keying schemes.

## 3. OBJECTIVES:

This paper aims to deal with Quadrature Phase Shift Keying (QPSK) and Offset Quadrature Phase Shift Keying (OQPSK) modulation scheme in Rayleigh fading, AWGN and Rician fading channels. This is accomplished using MATLAB simulation scripts.

We aim to study the performance parameters or performance metrics of a digital communication system in Quadrature Phase Shift Keying (QPSK) and Offset Quadrature Phase Shift Keying (OQPSK) with the aid of a Simulink model. We compare the final resultant Rayleigh faded signal at the receiver with the input message signal to calculate the Bit Error Rate (BER) performance. The results obtained are studied thoroughly.

In MATLAB coding for Simulation of QPSK signals is carried with both AWGN and Rayleigh fading channel. Finally simulations of OFDM signals are carried with Rayleigh faded sig-

nals to understand the effect of channel fading and to obtain optimum value of Bit Error Rate (BER) and Signal to noise ratio (SNR).

To summarize the objectives of this paper include:

1. To design and evaluate QPSK and OQPSK in a Multipath Fading Channel using computer simulation (MATLAB)
2. To obtain and compare between the theoretical and simulation result for QPSK and OQPSK under different communication channel
3. To obtain and compare the Bit Error Rate (BER) Performance for different communication channel

This section must contain specific details about the materials studied, instruments used, specialized chemicals source and related experimental details which allow other research worker to reproduce the results. The journal will not be held responsible if any kind of plagiarism followed and the editor's decision would be final if any litigation arises

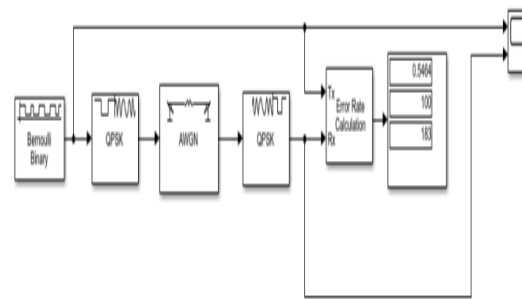


Fig 4.3 Simulink model for QPSK with AWGN channel:

#### 4. PROPOSED METHODOLOGY:

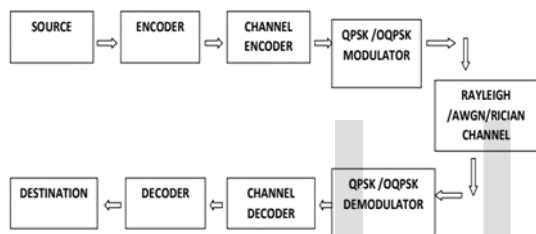


Fig 4.1 Main Block Diagram

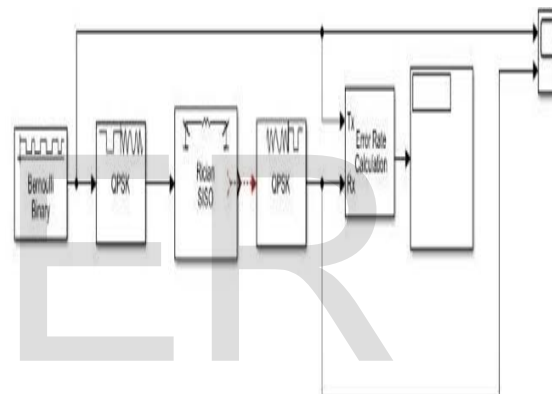


Fig 4.4 Simulink model for QPSK with Rician channel.

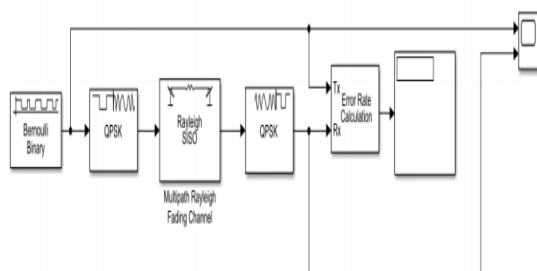


Fig 4.2 Simulink model for QPSK with Rayleigh fading channel:

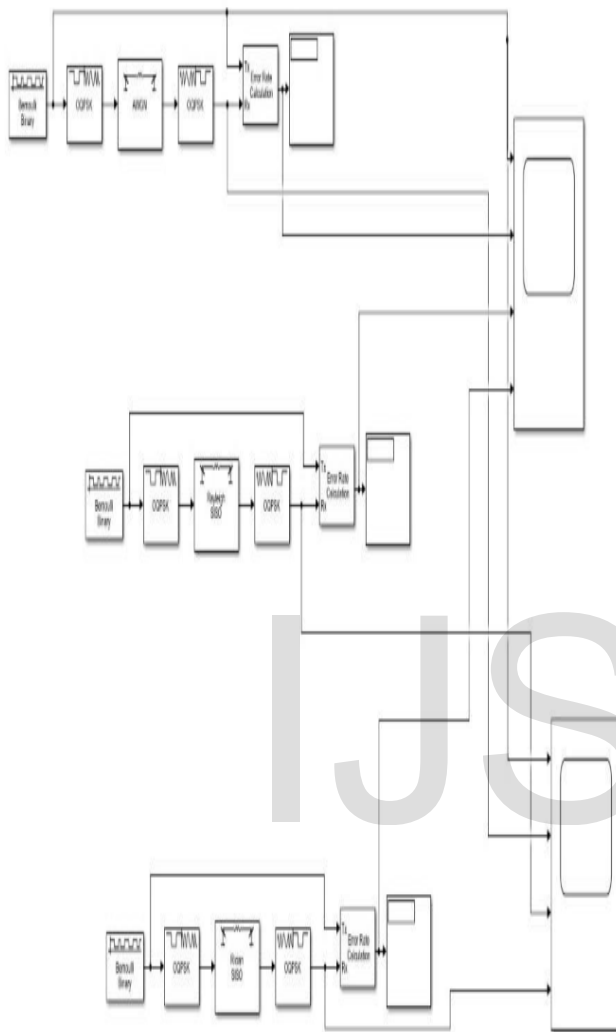


Fig 4.5 Simulink model of OQPSK with all the ch

## 5. BLOCK DESCRIPTION:

### 5.1 Bernoulli Binary Generator

The Bernoulli Binary Generator block generates random binary numbers using a Bernoulli distribution. The Bernoulli distribution with parameter  $p$  produces zero with probability  $p$  and one with probability  $1-p$ . The Bernoulli distribution has mean value  $1-p$  and variance  $p(1-p)$ . The Probability of a zero parameter specifies  $p$ , and can be any real number between zero and one.

### QPSK Modulator:

The QPSK Modulator Baseband block modulates using the

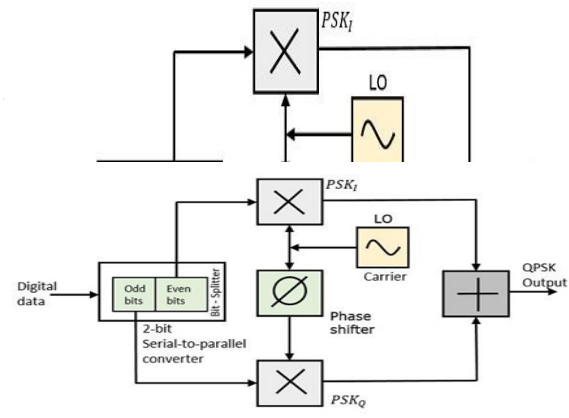


Fig 5.1.QPSK Modulator

At the modulator's input, the message signal's even bits and odd bits are separated by the bit splitter and are multiplied with the same carrier to generate odd BPSK (called as PSKI) and even BPSK (called as PSKQ). The PSKQ signal is anyhow phase shifted by  $90^\circ$  before being modulated.

**Rayleigh fading Channel:** Rayleigh fading is a statistical model for the effect of a propagation environment on a radio signal, such as that used by wireless devices.

Rayleigh fading models assume that the magnitude of a signal that has passed through such a transmission medium (also called a communications channel) will vary randomly, or fade, according to a Rayleigh distribution, the radial component of the sum of two uncorrelated Gaussian random variables. The Rayleigh pdf is  $y = f(x/b) = b^2 e^{-x^2/2b^2}$ .

### AWGN channel:

An AWGN channel adds white Gaussian noise to the signal that passes through it. a channel model in which the only impairment to communication is a linear addition of wideband or white noise with a constant spectral density (expressed as watts per hertz of bandwidth) and a Gaussian distribution of amplitude.

### Rician channel:

Rician fading channel is a stochastic model for radio propagation anomaly caused by partial cancellation of a radio signal by itself. Signal arrives at the receiver by several different paths (hence exhibiting multipath interference), and at least one of the paths is changing (lengthening or shortening). Rician fading occurs when one of the paths, typically a line of sight signal, is much stronger than the others. In Rician fading, the amplitude gain is characterized by a Rician distribution.

### QPSK Demodulator:

The QPSK Demodulator Baseband block demodulates a signal that was modulated using the quadrature phase shift keying method. The input is a baseband representation of the modulated signal.



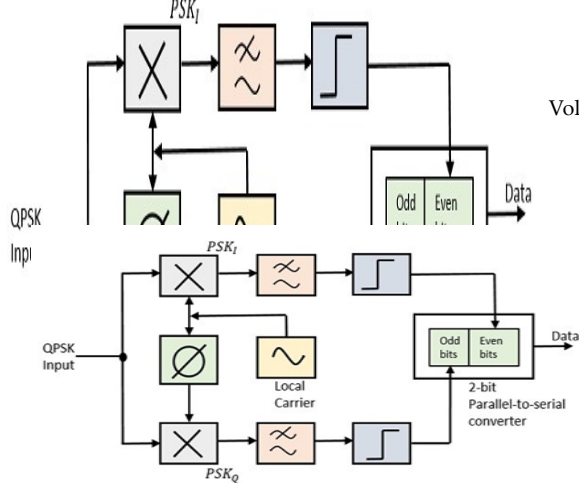


Fig 5.2 QPSK Demodulator

The QPSK Demodulator uses two product demodulator circuits with local oscillator, two band pass filters, two integrator circuits, and a 2-bit parallel to serial converter. The two product detectors at the input of demodulator simultaneously demodulate the two BPSK signals. The pair of bits are recovered here from the original data. These signals after processing, are passed to the parallel to serial converter.

**Error Rate Calculation:**

The Error Rate Calculation block compares input data from a transmitter with input data from a receiver. It calculates the error rate as a running statistic, by dividing the total number of unequal pairs of data elements by the total number of input data elements from one source.

**Scope:** Scopes provide several methods for displaying simulation data and capturing the data for later analysis. Symbols on your block diagram represent the various data display and data capture methods.

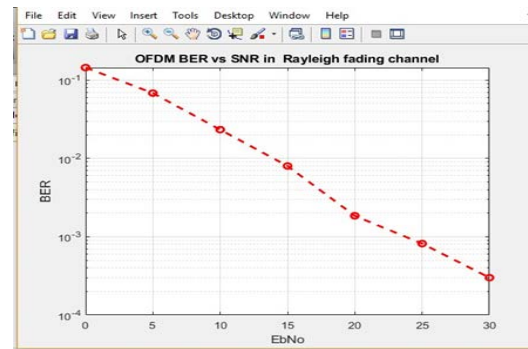


Fig 6.2 Ofdm Ber Graph

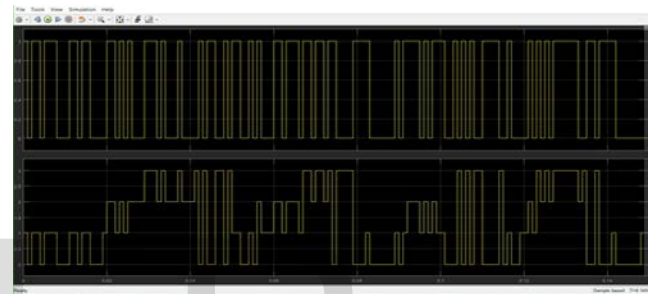


Fig 6.3 QPSK with Rayleigh fading channel



Fig 6.4 Simulation of QPSK with AWGN channel

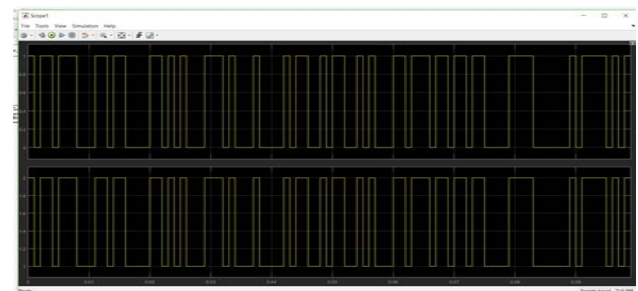


Fig 6.5 QPSK with Rician channel

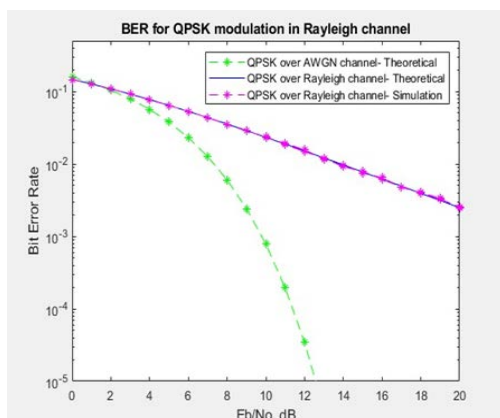


Fig 6.1 Ber Graph

## 6. SIMULATION RESULTS:

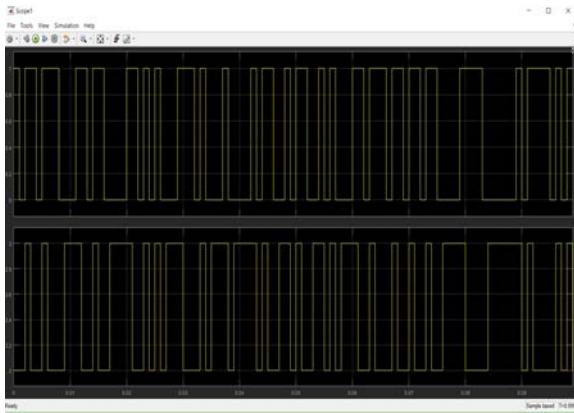


Fig 6.6 Simulation of OQPSK with Rayleigh fading channel

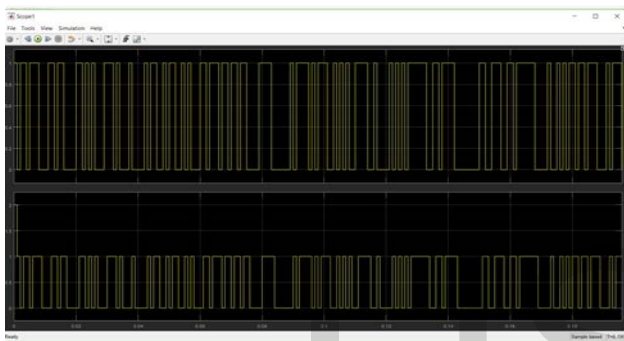


Fig 6.7 OQPSK with AWGN channel

## 8. REFERENCES:

- [1] Bit Error Rate Performance of QPSK Modulation and OFDM-QPSK with AWGN and Rayleigh Multipath Channel. Sanjeev Sanyal, Lingaya's University, Faridabad, India.
- [2] Quadrature Phase Shift Keying and Offset Quadrature Phase Shift Keying BER Performance Comparison. Amer Mohamed Daeri, Zawia University. Faculty of Engineering, Computer Eng. Department
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- [7] Simon Haykin, Communication Systems, John Wiley & Sons, Inc., 3rd edition, 1994.
- [8] <http://techiesms.blogspot.in/2016/04/practical->

## 7. CONCLUSION:

The performance of QPSK with Rayleigh fading channel was evaluated.

Graphical results show the improvement in QPSK with Rayleigh fading channel. The graphical results prove that simulated BER of QPSK is same as that of theoretical BER of QPSK. The reported BER can be further reduced by using channel estimation or suitable diversity scheme.

Furthermore, performance of QPSK and OQPSK was evaluated with Rayleigh fading channel, AWGN channel and Rician fading channel and a comparison of BER of all the channels were evaluated. The results show that Rayleigh fading channel has a considerably less Bit Error Rate when compared to the other channels with QPSK and OQPSK techniques.

From the obtained results it can be concluded that OQPSK performs better than QPSK modulation in terms of BER, which indicates that OQPSK has a better bandwidth efficiency and hence it can be used for systems with less power since it has a better channel frequency error.