

BER Performance of Digital Modulation Schemes With and Without OFDM Model for AWGN, Rayleigh and Rician Channels

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Abstract: OFDM is an Orthogonal Frequency Division Multiplexing. It is a multiplexing technique based on parallel transmission. OFDM is used in many of the present day wireless communication techniques. It is a digital modulation scheme and is used for encoding the digital data on multiple carrier frequencies. Each subcarrier is modulated using different modulation techniques. In the first part this paper the BER performance of all digital communication techniques on AWGN, Rayleigh and rician channels are studied and compared. In the second part the performance OFDM paired with different modulation schemes are analyzed for AWGN channel.

Keywords: BER, OFDM, AWGN, Rayleigh, Rician, QPSK, QAM, DPSK, OOFDM

1. Introduction

Health has become a serious issue. Analysis of health monitoring devices highly depends on the efficiency of the network systems. Health can be monitored on personal devices like mobile phone computer. This requires efficient transmission. Thus selection transmitter is crucial. Transmitter efficiency is measured in terms of BER or PER. Goals of digital communication systems to have least probability error and effective channel bandwidth.

2. Fading Channels

Fading is the distortion experienced by carrier modulated digital signal as it travels certain path. The multipath induced fading is most common in multipath propagation. The small scale fadings are Rayleigh, Rician and Nakagami. Additive white gaussian noise (AWGN), is a simplest noise that any signal can get.

$r(t) = s(t) + n(t)$ where

$s(t) = \text{Re} \{u(t) e^{j2\pi f_c t}\}$ and $n(t)$ is AWGN.

Gaussian PDF of AWGN is given by $p(x) = 1/\sqrt{2\pi\Gamma^2} e^{-(x-\mu)^2/2\Gamma^2}$ With $\mu = 0$ and $\Gamma^2 = N_0/2$

Rayleigh fading channel is the sum of the all the scattered signals received from many paths at the receiver and the reflected signals. It is used for modeling signals of ionosphere and troposphere. In urban environment this model is used for modeling various radio signals. Let us consider $y=x_1^2+x_2^2$ Gaussian PDF of Rayleigh fading channel is given by $P_y(y) = 1/2\Gamma^2$.

Rician fading channel, scattered signals from different paths are received, one of the signal changes-shortening/lengthening. Unlike Rayleigh fading channel, the rician channel is non-chi square centric. Consider the $s_2=m_{12}+m_{22}$, Gaussian PDF of rician fading channel is given by $P_y(y) = r/2\Gamma^2 e^{-(s_2+y)/2\Gamma^2} I_0(\sqrt{y} s/\Gamma^2)$

3. Digital Modulation Schemes

Various modulation schemes are explained below

3.1 BPSK Transmitter and Receiver

Simplest form of PSK and it also known as Phase reversal keying or 2-PSK. Phases are separated by 180° . the maximum rate of modulation is 1 bit/ symbol.

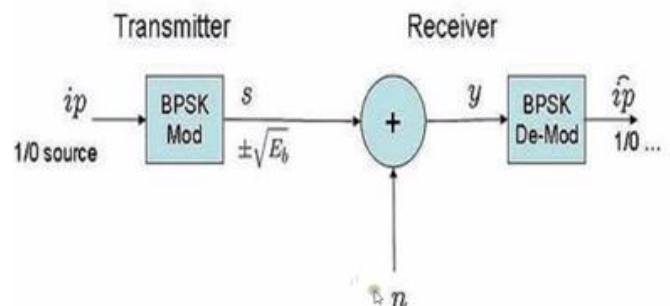


Figure 1: Block diagram of BPSK system

3.2 QAM Modulation

QAM supports both analog and digital modulation schemes, it transmits two message signals by changing the amplitude of the carrier signal.

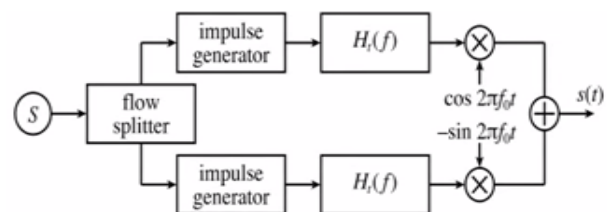


Figure 2: Block diagram of QAM Modulation

Carrier signals have phase difference of 180 hence the name quadrature. The final QAM output waveform is the sum of

PSK and ASK digital system and the sum of PM and AM form the analog system.

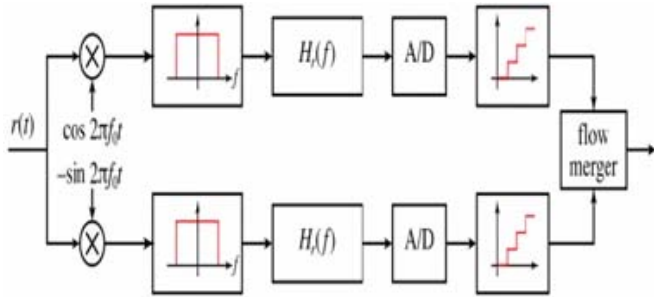


Figure 3: Block diagram of QAM demodulation

3.3 FSK, PSK, DPSK, QPSK and PAM Modulation

The signal transmitted by frequency modulation of the carrier signal. It is also called as binary FSK. PSK is the modulation of the phase of the signal. The constellation points are placed around the circle at a uniform angle. When the demodulator doesn't have the original signal to compare against, it is prone to erroneous modulation. The difference in the phase of the received signal is the differential phase shift keying. One of the PSK variants uses four phases of the signal to transmit odd and even bits are offset by 1 bit period. The pulse amplitude modulation (PAM) is an analog modulation technique.

4. Simulation and Results

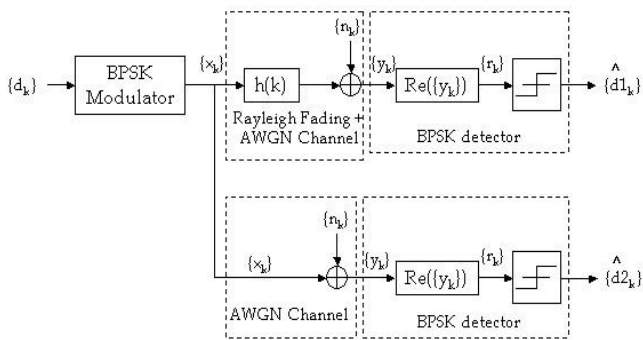


Figure 4: BPSK modulator in Rayleigh and AWGN channel

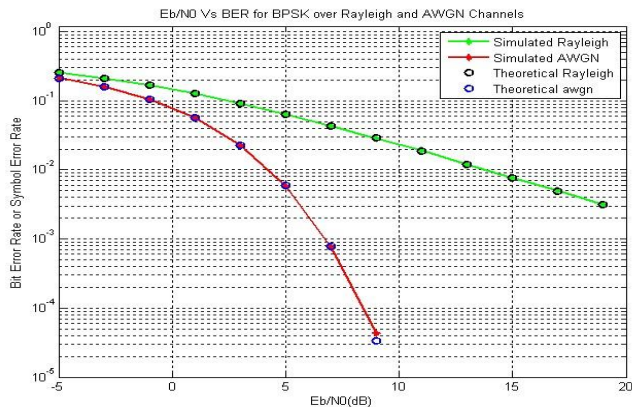


Figure 5: Eb/No Vs BER for BPSK over Rayleigh and AWGN Channels

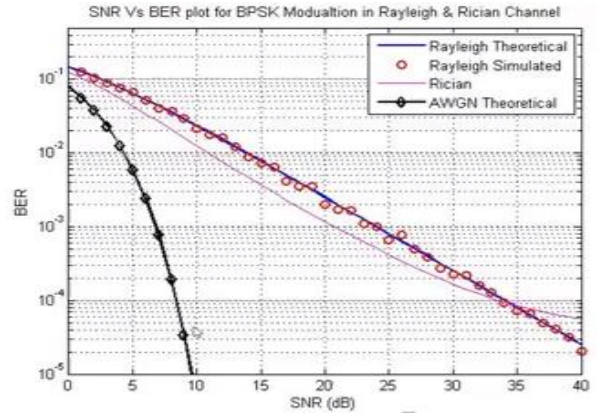


Figure 6: SNR Vs BER for BPSK over Rayleigh and AWGN Channels

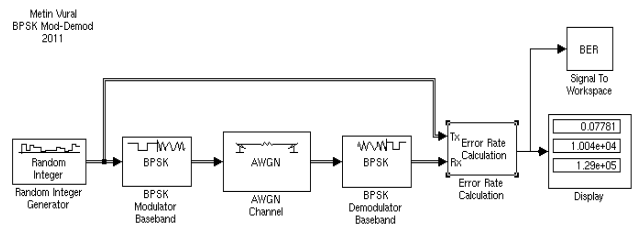


Figure 7: Block diagram of BPSK system using Simulink

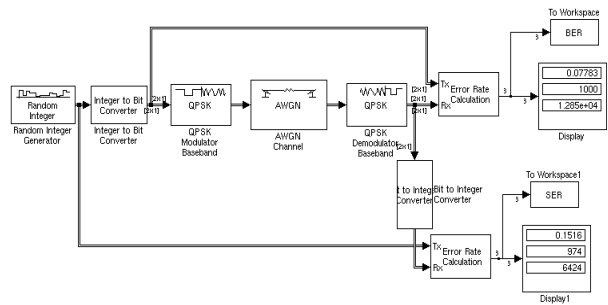


Figure 8: Block diagram of QPSK system using Simulink

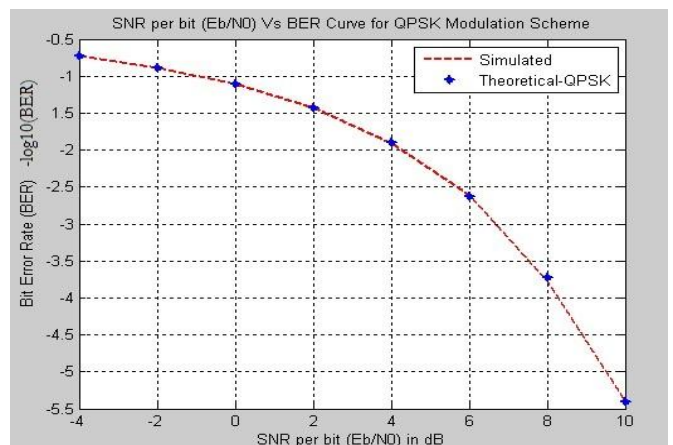


Figure 9: SNR per bit (Eb/No) Vs BER curve for QPSK modulation scheme

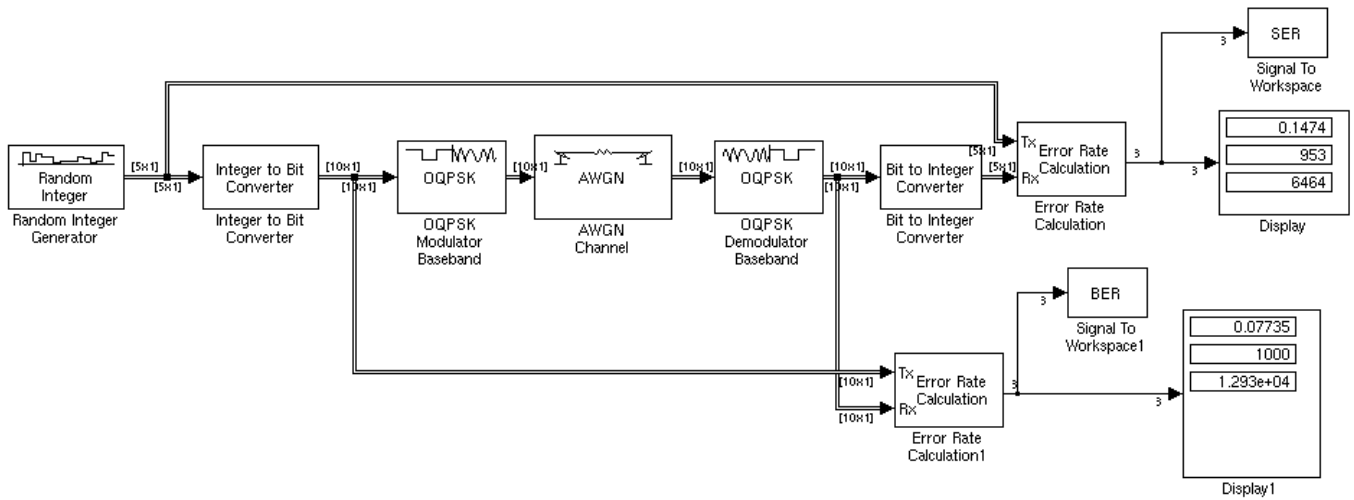


Figure 10: Block diagram of OQPSK system using Simulink Noise (AWGN)

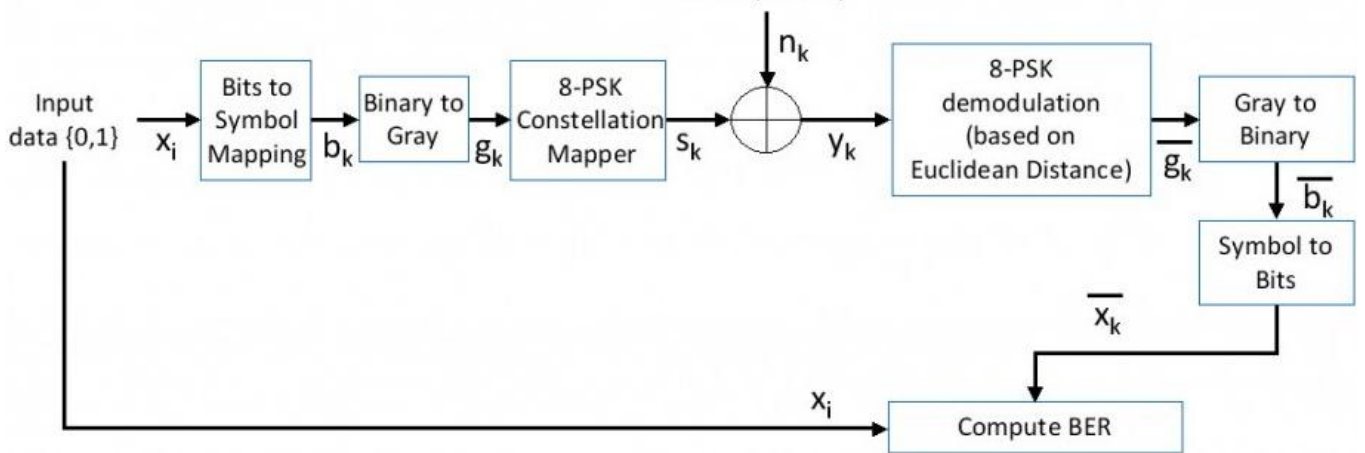


Figure 11: Block diagram of 8-PSK scheme

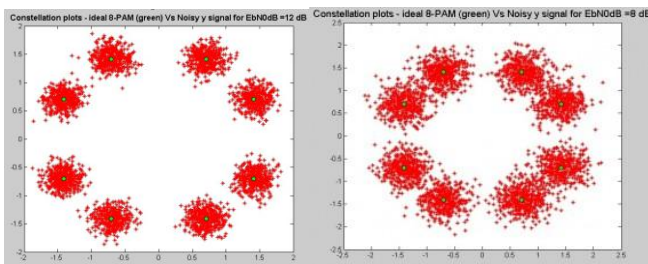


Figure 12: Constellation of 8-PSK before and after introducing noise

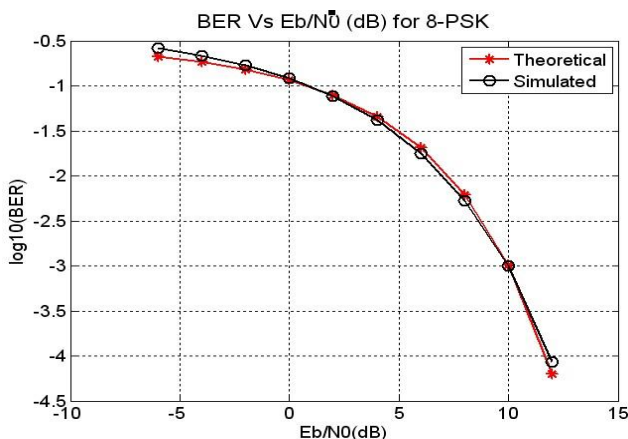


Figure 13: BER vs. Eb/No for 8-PSK

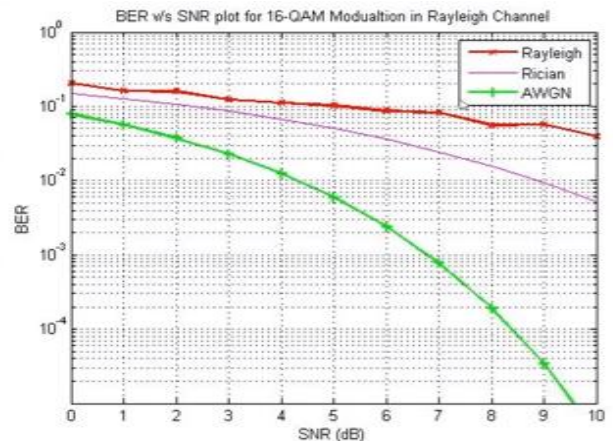


Figure 14: BER Vs. SNR plot for 16-QAM modulation in Rayleigh Channel

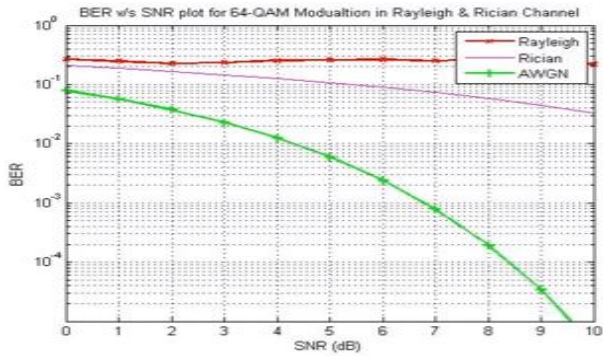


Figure 15: BER Vs. SNR plot for 64-QAM modulation in Rayleigh Channel

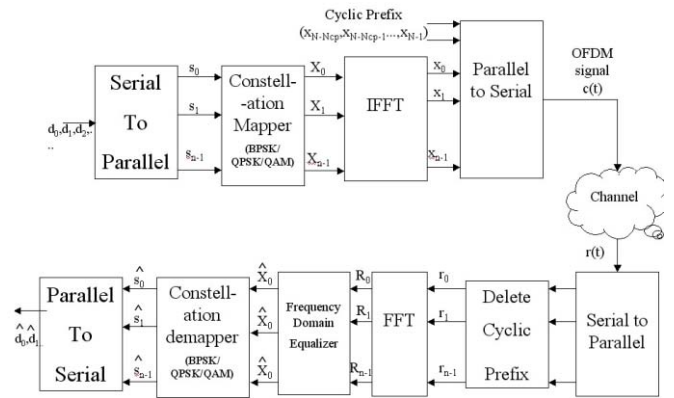


Figure 19: Block diagram of OFDM system

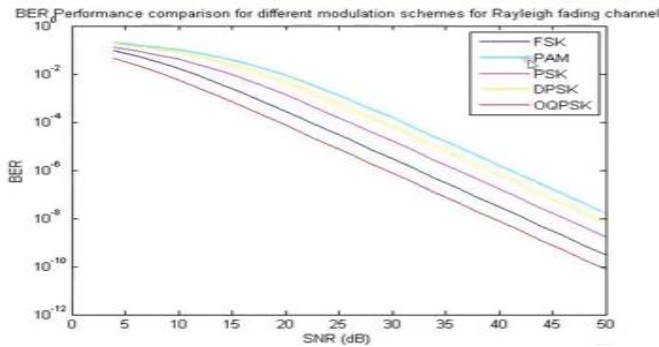


Figure 16: BER Performance comparison for different modulation schemes for Rayleigh fading channel

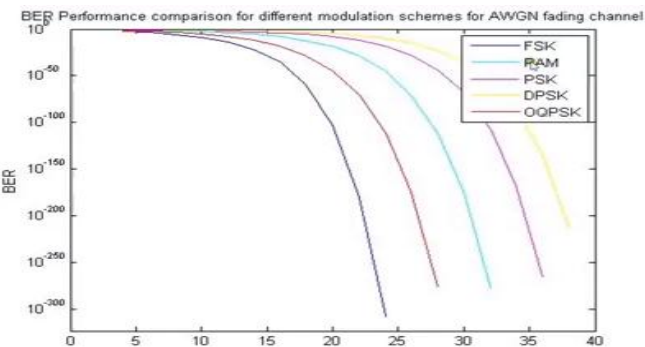


Figure 17: BER Performance comparison for different modulation schemes for AWGN fading channel

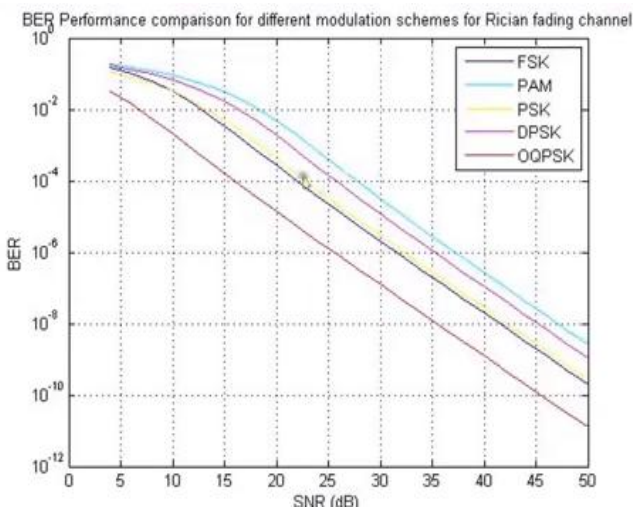


Figure 18: BER Performance comparison for different modulation schemes for Rician fading channel

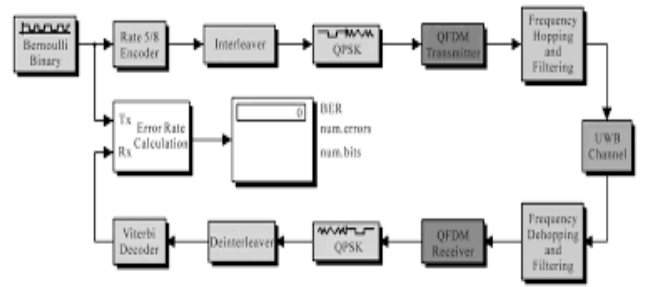


Figure 20: Block diagram of QPSK-OFDM system

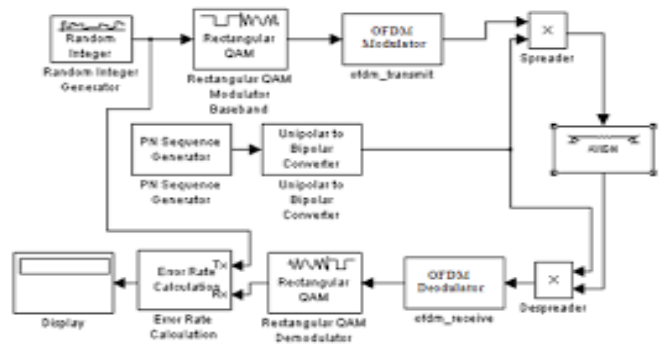


Figure 21: Block diagram of QAM-OFDM system in Simulink

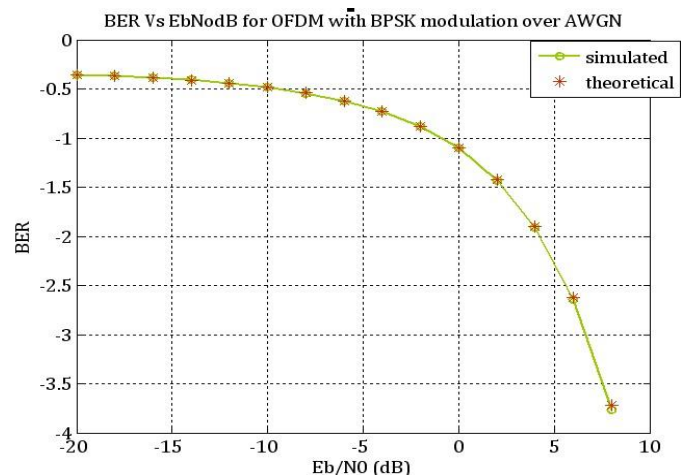


Figure 22: BER vs. Eb/No for OFDM with BPSK modulation over AWGN

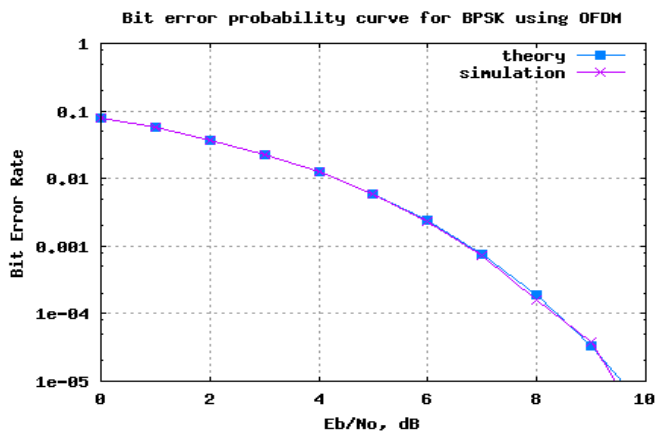


Figure 23: Bit error probability curve for BPSK using OFDM

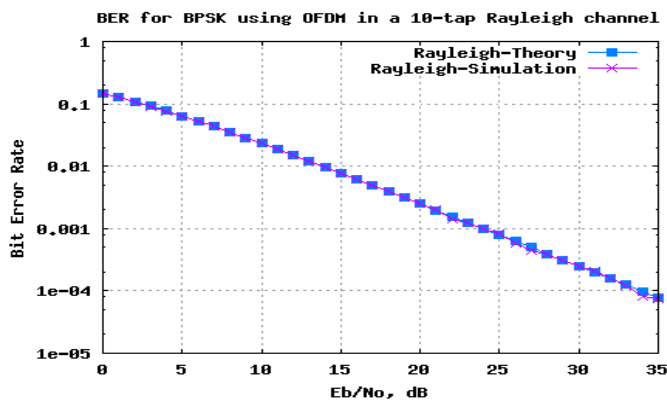


Figure 24: BER for BPSK using OFDM in a 10-tap Rayleigh channel

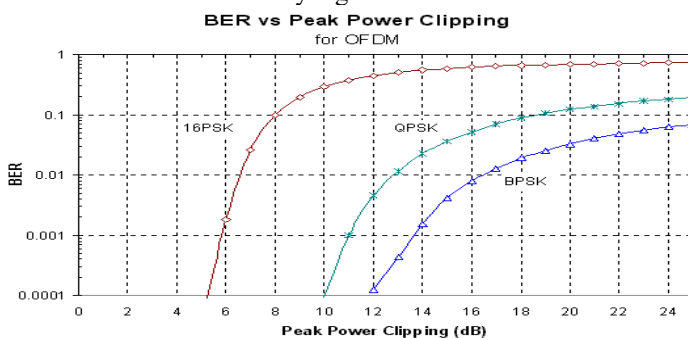


Figure 25: BER vs. Peak Power Clipping for OFDM

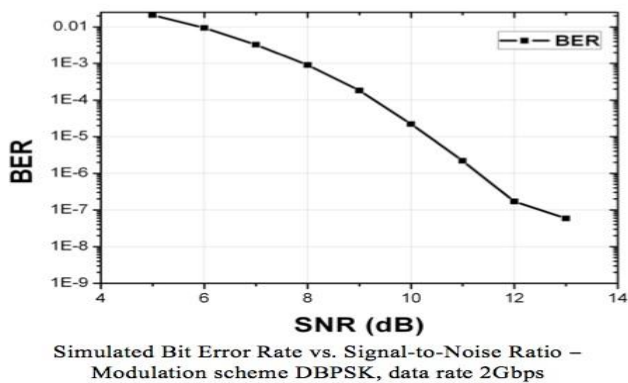


Figure 26: BER Vs. SNR plot for DBPSK modulation

5. Conclusion

BER performance for various digital modulation schemes

were analyzed for AWGN, Rayleigh and rician fading channels. Selection of modulation schemes depends on performance characteristics. Choice comes with a trade of in hardware and performance. AWGN gives better performance when compare to other two fading channels. BPSK and OQPSK gives better performance, when compared to other modulation schemes. The multiple digital modulation schemes effective when paired with OFDM, like BPSK, QPSK, 8PSK, 16QAM, 32QAM, 64QAM, and it is more robust to noise and ISI.

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Author Profile



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