Performance Analysis of BPSK-OFDM and DQPSK-OFDM Schemes for Wireless Communication System

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Abstract-The mobile communication system is interfered with multipath fading. At transmitter end, the signals are received from different angle and time. This result in, delay in the signal of reflections from the different obstructions. In order to solve this problem, Orthogonal Frequency Division Multiplexing (OFDM) is introduced. In this paper, OFDM technology is used that gives the best Bit Error Rate (BER) performance in a multipath fading environment using computer simulation. The system implements using two different phase modulations which are, Differential Quadrature Phase Shift Keying (DQPSK) and Binary Phase Shift Keying (BPSK). Subsequently, ideal and worst cases of the communication channel models are also demonstrated. The system is designed using MATLAB coding for BPSK-OFDM and DQPSK-OFDM are written under various physical path conditions such as; Additive White Gaussian Noise (AWGN) and Rayleigh multipath fading channel. It is defined that using proposed technique, the Eb/No=6, the BER is $0.00259x10^{-2}$ is achieved for under AWGN. The Eb/No=6 is $0.05302x10^{-1}$ is attained for Rayleigh, Eb/No=6dB is $0.00259x10^{-2}$recorded while for fultipath Rayleigh. The result shows that the BER performance for BPSK-OFDM is better than DQPSK-OFDM.

Keywords-Bit Error Rate (BER), Orthogonal Frequency Division Multiplexing (OFDM), Differential Quadrature Phase Shift Keying (DQPSK), Binary Phase Shift Keying (BPSK), Multipath Fading

I. INTRODUCTION

Wireless communication system is approved to be the fastest growing sector in telecommunication system that use different technologies such as; GSM, GPRS, UMTS, and other wireless communication technologies [i]. Now it is approaching the fourth-generation (4G) of broadband stage. The highlighted features of wireless communication systems are high data rate and broadband data transmission [ii]. These wireless communication technologies offers different schemes for transmission. Among these OFDM is popular for high speed wireless communication [iii]. The technology has grown fast and leading the wireless communication systems as the advantages are so attractive [iv]. Due to the factors, OFDM is said to be the best candidates for future broadcasting and wireless LAN systems [v]. Since wireless technologies are having a high demands, OFDM is chosen to be the subject of study by many researchers in order to develop it [vi]. OFDM is termed as Discrete Multi-tone Modulation that is totally based on Frequency Multiplexing via digital modulation scheme [vii]. The transmitted data stream is divided into parallel data streams. The Frequency spectrum in OFDM is divided into sub-channels. The data stream is transmitted over sub channel by modulating sub-channel by modulating a sub-carrier using a standard modulation scheme such as DPSK and BPSK. [viii]. The sub-carrier frequencies modulates data streams cross talk is mitigated [ix]-[x].Anis Salwa Osman discussed the BER Performance for OFDM for multipath fading for ideal and worst case of communication channel models and it used QPSK as a modulation technique. Mohd Fuad Abd Kadirdiscussed the OFDM comparison between AWGN and One Path Rayleigh with application for subcarrier of 256 is not practical compared to 64. The higher subcarrier brings bigger size of data allocation for a transmission.Ng Chang Kuodefined the Investigation of Channel Performance in OFDM System Using Matlab Simulink for analyzing performance improvement by setting the parameters such as delay vector, gain vector and input signal power. Karen Lynn Ak Sulimstates the Investigation on Guard Interval Based Synchronization for the OFDM System by defining the interference elimination and time-spreading can be conducted more efficiently.

Mobile communication systems are functioning under challenging channel conditions [xi]. The channel for wireless system is very unpredictable as it has to encounter with variability which is introduced by the mobility of the consumer and the different obstacles such as; multipath fading, Doppler spread, dispersion and etc. [xii]. Multipath phenomena in the wireless communication, results in radio signals arrival at antenna by two or more paths [xiii]. Each of the reflected signals will arrive at the user's receiver with different random offsets and this will cancels part of the energy signal for brief periods of time [xiv]. This paper identifies the best BER performance of OFDM by using DQPSK and BPSK under AWGN and Rayleigh fading multipath channels. BER performance of 4QAM-OFDM will be used as a guideline as it is the most frequent modulation technique used. A comparison will be made between modulation systems in order to come out with the best BER performance.

II. METHODOLOGY

In this paper, the development of OFDM system is demonstrated using MATLAB. The research methodology for designing the OFDM system design is executed as shown in Fig. 1.

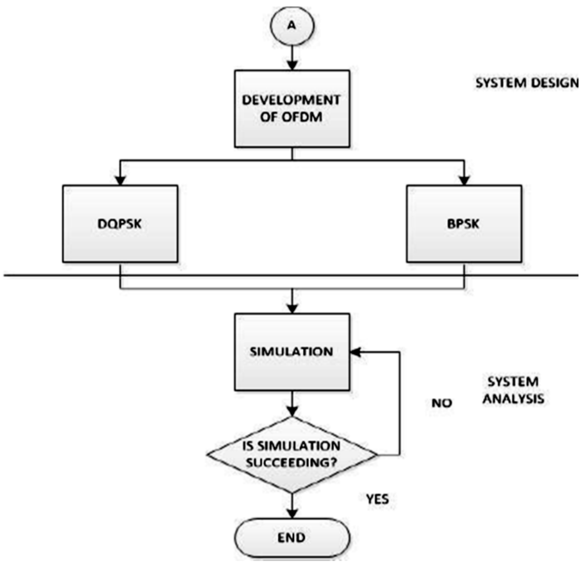

Fig. 1. System Designed Methodology

The system design is carried out by designing the OFDM system using DQPSK and BPSK for two different types of communications channels, AWGN and Rayleigh.

A. Modeling and simulation

The modeling and simulation is carried out using communications channels via AWGN and Rayleigh fading channel. In the second stage, the system is designed using phase modulations i.e. BPSK, and DQPSK.

B. Orthogonal Frequency Division Multiplexing (OFDM)

The parameter for OFDM system has been defined as in Table I. The coding is for modulator block. The output data from modulator will enter channel block as an input. In this block, it consists of AWGN channel and Rayleigh multipath fading channel.

TABLE I
MATLAB CODING FOR OFDM SYSTEM AND THE FUNCTIONALITY

Coding	Functionality
nbitpersym = 52;	Number of bits per OFDM symbol. The value is similar to the number of subcarriers for BPSK.
nsym = 10^4;	Number of symbols.
len_fft = 64;	Fast Fourier Transform size.
sub_car = 52;	Number of data subcarriers.
EbNo = 0: 2: 12;	X-axis represents EbNo. The value of each EbNo is 2 units and starts at 0 and ends at 12.
EsNo = EbNo+10*log10(52/64) +10*log10(64/80);	Formula for symbol to noise ratio.
snr = EsNo-10*log10(52/64);	Signal to Noise Ratio.
t_data=randint(nbitpersym*nsym,1);	The data is generated by multiplying number of bits per symbol and number of symbols.
mod_data = modulate(M,t_data);	The data is being modulated.
par_data= eshape(mod_data,nbitpersym,nsym).';	Returns the bit per symbol-by-number of symbol with the data modulated.
IFFT_data= (64/sqrt(52))*ifft(fftshift(pilot_ins_data.')).';	Fft convert time domain data and normalizing the data.
cylic_add_data= [IFFT_data(:,[49:64]) IFFT_data].';	Addition cyclix prefix.
ser_data= reshape(cylic_add_data,80*nsym,1);	Convert parallel data to serial data. The number of symbol is multiplied with 80.

C. Additive White Gaussian Noise (AWGN) Channel

AWGN channel is added to OFDM by applying the coding in Table II.

TABLE II
MATLAB CODING FOR AWGN AND THE FUNCTIONALITY

Coding	Functionality
n = 1/sqrt(2)*[randn(1,N/2) + j*randn(1,N/2)];	The formula used to calculate n. 1 2 [*randn* 1, *N*2 + *jradn* 1, *N*2] N is value of 106
y_dqpsk = dqpsk_symbols + 10^(-(EsN0(ii))/20)*n;	The calculation is for DQPSK. Thus the calculation is for AWGN in DQPSK is *DQPSKsymbol*+ (10 −*EsN*0 (*EbN*0)20)*n*
chan_awgn = sqrt(80/52)*awgn(ser_data, snr(ii), 'measured');	The calculation is for BPSK. The calculation caused AWGN to measure the power of serial data and adding noise to produce SNR.

D. Rayleigh Multipath Fading Channel

The input variable for the multipath fading simulator is shown in Table III.

TABLE III
MATLAB CODING FOR RAYLEIGH AND THE FUNCTIONALITY

Coding	Functionality
tstp = 0.5.*10.^(-6);	Minimum time resolution is 0.5 times (array multiply) 10−6.
itau = [0, floor(1.*10.^(-6)/tstp), floor(1.5.*10.^(-6)/tstp), floor(2.*10.^(-6)/tstp)]; = [0, 2, 3, 4];	itau is the delay time for each multipath fading.
dlvl = [0, 10, 20, 25];	dlvl is attenuation level for each multipath fading.
nsamp = 50.*10.^(-6)/tstp= 100;	nsamp is total number of symbols 50 *x* 10−6

E. Binary Phase Shift Keying (BPSK)

For BPSK, the coding development are divided into two sections, first is for modulator circuit and the second one is for demodulator circuit. The coding for both circuits is shown in Table IV.

TABLE IV
MATLAB CODING FOR BPSK AND THE FUNCTIONALITY

Coding	Functionality
Modulator	
hModulator = comm.DQPSKModulator (pi/8,'BitInput',true);	The coding will create a DQPSK modulator system
modData = step(hModulator, data);	Modulated data will use the DQPSK modulator
Demodulator	
hDemod =comm.BPSKDemodulator ('PhaseOffset',pi/2);	BPSKD demodulator demodulate using set to π 2
hAWGN = comm.AWGNChannel ('NoiseMethod', ... 'Signal to noise ratio (SNR)','SNR',15);	AWGNChannel add white Gaussian noise to input signal.
hError = comm.ErrorRate; for counter = 1:100	Create an error rate calculator for counter ratio 1 to 100.
data = randi([0 1],50,1);	The system will transmit a 50 symbol frame.
modSignal = step(hMod, data);	Modulated signal will uses the data for simulation hMod.
noisySignal = step(hAWGN, modSignal);	Signal noise will uses the modulated hAWGN.
receivedData = step(hDemod, noisySignal);	Data received will uses the signal noise Demod.
errorStats = step(hError, data, receivedData);	The errors will use the signal noise for simulation hDemod.

F. Differential Quadrature Phase Shift Keying (DQPSK)

DQPSK or differential quadrature phase shift keying, also has two sections in the coding development. First is for modulator circuit and the second one is for demodulator circuit. The coding for both circuits is shown in Table V.

TABLE V
MATLAB CODING FOR DQPSK AND THE FUNCTIONALITY

Coding	Functionality
Modulator	
data = randi([0 1],400,1);	Creating binary data for 100, 4 bit symbols
hMod=comm.DQPSKModulator (pi/8,'BitInput',true);	Create a DQPSK modulator System object with bits as inputs, phase rotation of pi/8, and Gray-coded constellation.

hMod Phase Offset=pi/8;	Phase Offset for modulator is set to π 8
modData= step(hModulator,data);	Modulated data will use the DQPSK
Demodulator	
hDemod = comm.DQPSKDemodulator(pi/8);	DQPSKDemodulator demodulate using DQPSK method H, with Phase Offset set to π 8
hAWGN = comm.AWGNChannel('Noise Method', ... 'Signal to noise ratio (SNR)','SNR',15);	AWGNChannel add white Gaussian noise to input signal. This creates an AWGN channel object, H, with Noise Method, Signal to Noise Ratio (SNR) and SNR in order and set to 15.
hError = comm.ErrorRate	Compute bit or symbol error rate of input
for counter = 1:100	data with name set to Computation Delay and the value is set to 1.
data = randi([0 3],50,1);	The system will transmit a 50 symbol frame.
modSignal = step(hMod, data);	Modulated signal will uses the data for simulation of hMod.
noisySignal = step(hAWGN, modSignal);	Signal noise will uses the modulated signal for simulation and plot the step response of the dynamic system of hAWGN.
receivedData = step(hDemod, noisySignal);	Data received will uses the signal noise for simulation of hDemod.
errorStats = step(hError, data, receivedData);	The errors will use the signal noise for simulation and plot the step response of the dynamic system of hDemod.

The simulation in MATLAB for modulator circuit produced scatter plot through the filter. The technique alternates between two quadrature symbol constellations which are offset by π 4 radians every other symbol period. In the next, the results attained for designed system are discussed.

III. Results and Discussion

In this section, results and analysis for simulation process that has been conducted. The simulations were perform in five parameters conditions, which is BER Vs SNR for BPSK-OFDM under AWGN and Rayleigh, DQPSK-OFDM under AWGN and Rayleigh and lastly a comparison between BPSK, DQPSK and 4QAM under AWGN.The analysis is simulated under two different communication channels. For the first part, OFDM has been simulated under AWGN which is known as the ideal communication channel. The Fig. 2 shows the simulation of BER Vs Eb/No for the system. At Eb/No=6, the BER is 0.00259×10^{-2}.

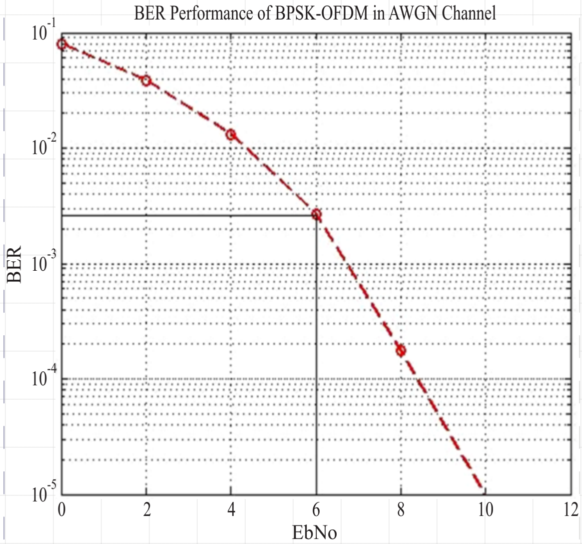

Fig. 2. BER Vs Eb/No for BPSK-OFDM (AWGN Channel)

The number of parallel channel was fixed into 128. The value of Fast Fourier Transform is similar to the value of parallel channel. The modulation level was set to 1 for the BPSK level. The parameters for BER performance of BPSK-OFDM under Rayleigh are set to be the same like before. However the calculation for AWGN channel and Rayleigh is completely different. Thus, the graph produced is not like in AWGN channel. Rayleigh shows the lower value of bit rates scheme. From Fig. 3 the value of Eb/No for Rayleigh channel at Eb/No=6 is 0.05302×10^{-1}.

BER performance for BPSK-OFDM under AWGN channel shows better result compared to Rayleigh multipath fading channel. The comparison is made from the value of BER taken at Eb/No=6dB. For AWGN, the value at Eb/No=6dB is 0.00259×10^{-2} while for Rayleigh shows 0.05302×10^{-1}.

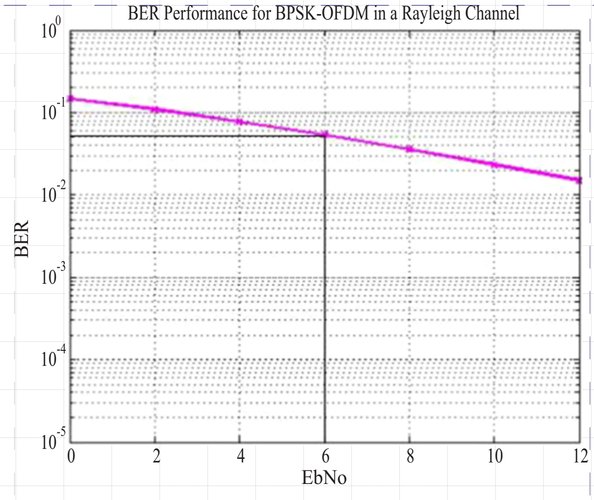

Fig. 3. BER Vs Eb/No for BPSK-OFDM (Rayleigh channel)

Based on theoretical, the performance is better when the value of BER is smaller. Thus this proved that AWGN channel is an ideal case for BPSK-OFDM and Rayleigh multipath fading channel is a worst case.

A. DQPSK-OFDM

1) DQPSK-OFDM under AWGN channel

The analysis for DQPSK-OFDM is performed under two different communication channels. For the first part, OFDM has been simulated under AWGN. Fig. 4 shows the graph of BER Vs Eb/No for the system. When Eb/No=6dB, the BER is $0.001715x10^{-1}$.

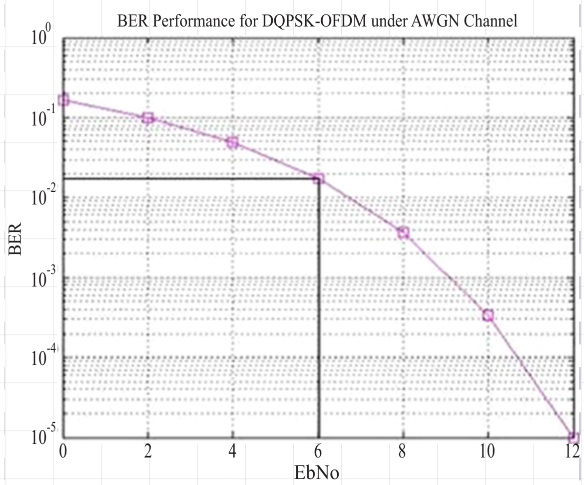

Fig. 4. BER Vs Eb/No for DQPSK-OFDM (AWGN channel)

The number of parallel channel was fixed into 128. The value of Fast Fourier Transform is similar to the value of parallel channel. The symbol rate for the modulation is 250000 and to calculate the bit rate per carrier, symbol rate will be multiply to modulation level.

B. DQPSK-OFDM under Rayleigh

The parameters for BER performance of DQPSK-OFDM under Rayleigh are set similar like in AWGN as shown in Fig. 5.

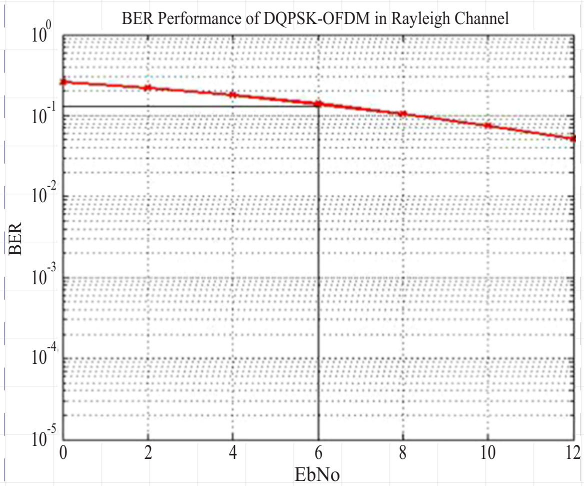

Fig. 5. BER Vs Eb/No for DQPSK-OFDM (Rayleigh channel)

The graph produced in Rayleigh shows a bit lower value of bit rates scheme compare to AWGN. However the value of Eb/No for Rayleigh channel is far too higher than the value in AWGN channel. From Fig. 5, the simulation shows when Eb/No=6dB, the value of BER is 0.1381.

BER performance for DQPSK-OFDM under AWGN channel shows better result compared to Rayleigh multipath fading channel. This is similar to BPSK-OFDM. The comparison is made from the value of BER taken at Eb/No=6dB. For AWGN, the value at Eb/No=6dB is $0.001715x10-1$ while for Rayleigh shows 0.1381. From the result, AWGN channel is the ideal case for DQPSK-OFDM compared to Rayleigh multipath fading channel.

C. Comparison between BPSK, DQPSK and 4QAM

For this section, the graph for BPSK-OFDM and DQPSK-OFDM is combined in a one graph together with 4-QAM-OFDM. The simulation is done under AWGN channel. The parameter is set; 128 number of carriers, 6 number of OFDM symbol for one loop, symbol rate for 250000 and length of guard interval is 32. BER performance for BPSK-OFDM is proved to be the best amongst others. It has a lower bit rate per symbol and the value of dB is also the lowest.

Simulation in Fig. 6 shows the comparison between three modulation techniques used for OFDM system. The comparison is done by taking the values of each modulation techniques at Eb/No=6dB. For BPSK-OFDM, the value of BER at Eb/No=6dB is $0.00259x10-2$.

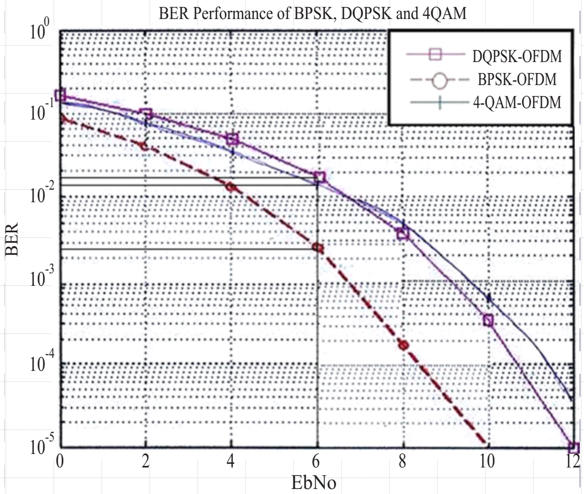

Fig. 1. BER Vs Eb/No for BPSK-OFDM, DQPSK-OFDM and 4-QAM-OFDM

Meanwhile for DQPSK-OFDM, the value produced is 0.01715×10^{-1} which highest than BPSK-OFDM and 4-QAM-OFDM. For 4-QAM, the value is 0.01904x10−1. From the simulation, a conclusion can be made. The best performance among all the modulation techniques for OFDM is BPSK as it has the lowest value of BER.

IV. CONCLUSION

In this work, BER performance of OFDM for Binary Phase Shift Keying and Differential Quadrature Phase Shift Keying (DQPSK) under two different types of communication channels, Additive White Gaussian Noise (AWGN) and Rayleigh, in wireless communications. From the comparison made between BPSK, DQPSK and 4QAM, the system performance is better for BPSK-OFDM as it has the lowest value of BER Vs SNR. This is due to the fact that BPSK has fewer bits per symbols and more area to distinguish. When the bit rate schemes are higher, the performance would be poor. However, BPSK are not suitable to be widely used as it is not suitable for high data-rate applications because of it can only able to modulate at 1 bit per symbol.

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