BER Performance Analysis of SSB-QPSK over AWGN and Rayleigh Channel

Rahul Taware
ME Student
EXTC Department,
DJSCOE Vile-Parle (W) Mumbai – 056

T. D Biradar
Associate Professor
EXTC Department,
DJSCOE Vile-Parle (W) Mumbai – 056

ABSTRACT
In digital communication, transmission of binary data based on bandwidth & modulation/demodulation techniques. Probability of bit error will increase if more no. of bits transmitted over limited bandwidth. This error decreases the overall spectral efficiency. To improve spectral efficiency and to minimize the BER probability SSB-QPSK is used. This project shows the comparative study of bit error rate (BER) and performance analysis of SSB-QPSK transmission over AWGN channel & Rayleigh channel with error correcting codes and also shown the effect of noise on received symbol using constellation diagrams with the help of MATLAB simulation.

Keywords
Single Sideband, Quadrature phase shift keying, AWGN channel, Rayleigh fading channel, Convolution code & Turbo code.

1. INTRODUCTION
A binary data transmitted through channels using modulation techniques. At receiver same data expected idealy but due to channel properties noise added in the transmitted signal and noisy data received at receiver i.e. some data bits changes. The changes in bits represent the bit error and the rate at which bits are changing called as bit error rate (BER). While analyzing the system performance BER plays important role. Each modulation techniques give different performance which is affected by channel noise.

1.1 Quadrature Phase Shift Keying
In this modulation technique, four symbol transmitted over four different phases 0,π/2,π,3π/2 respectively [1]. Each symbol consists of two bits binary data shown by basic QPSK signal equation.

$$SQPSK(t) = \{\sqrt{Es}Cos[(\mathrm{i}-1)\prod/2]\phi 1(t) - \sqrt{Es}Sin[(\mathrm{i}-1)\prod/2]\phi 2(t)\}$$
$$\mathrm{i} = 1,2,3,4$$

Grouping of bits per symbol reduces the bit rate. Hence requirement of channel bandwidth is less.

1.2 Performance Parameters
Following parameters are used to analyze the system performance.

1.2.1 Bit Error Rate (BER)
The error generated in received data represent by probability of error using following formula [1].

$$\text{Bit Error Rate (Pb)} = \frac{\text{Number of bit in error}}{\text{Total number of transferred bits}}$$

This parameter affected by signal to noise ratio, transmission speed, bandwidth and channel properties.

1.2.2 Signals to Noise Ratio
This parameter related to transmitted signal power and received signal power which is decreases up to certain amount due to noise [6]. SNR in dB shown by following formula,

$$\text{SNR} = 10\log_{10}\left(\frac{\text{Signal Power}}{\text{Noise Power}}\right)\text{ dB}$$

1.3 Transmission Channels
1.3.1 Additive White Gaussian Noise
When signal transmitted through air, then unwanted noised i.e. Gaussian noise added with the original signal [2]. This noise shown by equation

$$p(z) = 1/\sigma\sqrt{2\prod}\exp[-1/2\{\mathrm{z}-\mathrm{a}/\sigma\}^2]$$

Where σ^2 is the variance of *n*.

1.3.2 Rayleigh Channel
Transmitted signal affected by atmosphere, clutters and free space loss [2]. These factors reduce the signal strength called as signal degradation or multipath propagation. This effect fluctuate the signal in magnitude and phase at receiver. Multipath effect high nearer to earth surface. Due to unwanted movable object during transmission and reception create frequency shift in received signal frequency. This is called as Doppler shift and represent by following formula.

$$fd = \frac{v}{\lambda}$$

2. BER PERFORMANCE ANALYSIS IN AWGN CHANNEL
A received data affected by Gaussian noise and error will generated while recollecting original data [2]. If data length is too long then total number of error will increase. To reduce this error, one way is increase SNR or Eb/No of the signal [4]. Simulation result for evaluation on BER vs. SNR when the number of data is 10,000 shown in fig 1. In this simulation, the BERs are obtained by varying the values of Eb/No in the range of -3 to 7. The iteration is done 1000 times where the total number of data transmitted is 10000. From simulation result it is found that if an Eb/N0 value varies BER

probability will decrease and total no. of error also decrease. Using constellation diagram for 1st iteration we can observed that for lesser values of Eb/N0, four symbols related to four phases not clearly identify due to large amount of noise present. If we increase the SNR values & no. of iterations upto 10th or more then maximum amount of noise will minimize and four symbols clearly identify shown in constellation diagram.

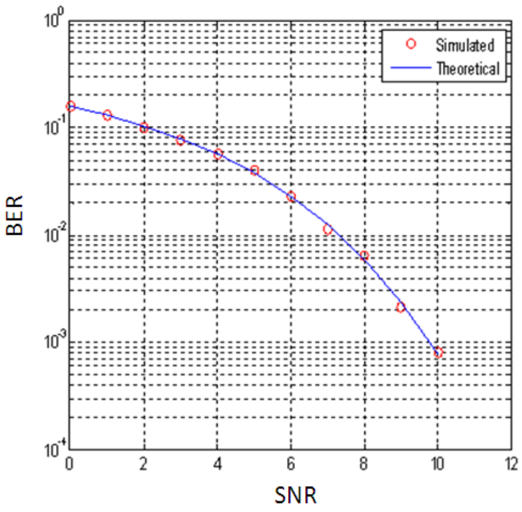

Fig 1: SNR Vs BER plot

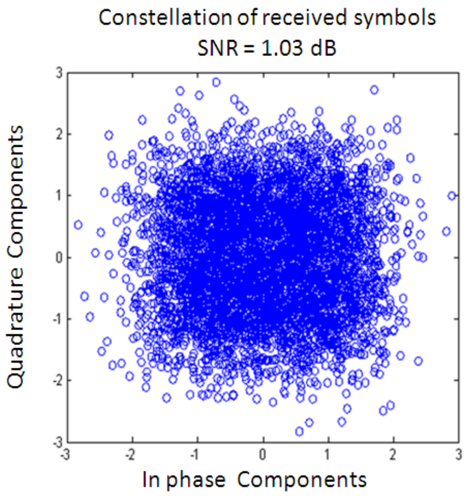

Fig 2: Constellation Diagram for 1st Iteration

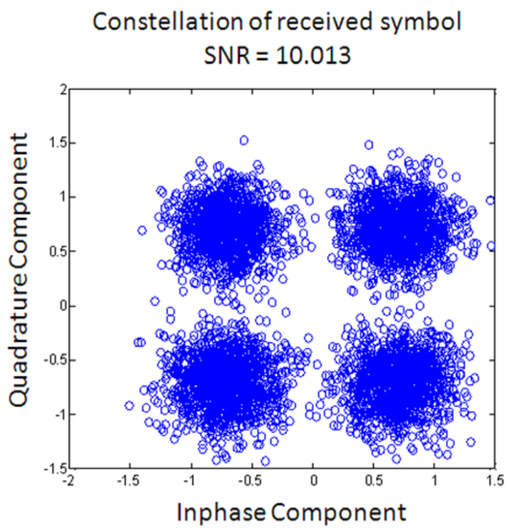

Fig 3: Constellation Diagram for 10th Iteration

3. BER PERFORMANCE ANALYSIS IN RAYLEIGH CHANNEL

In this channel received data affected by the Doppler shift and multipath fading effect. This effect creates error while receiving data and BER performance will be reduce at receiver [3]. Simulation result for evaluation on BER vs. SNR with constellation diagram shown in below figure, when the number of data is 10,000 and the values of Eb/No in the range of -3 to 7. Using constellation diagram for 1st & 10th Iteration we can observed that still there is a noise present and we cannot observe the four symbols. If we select SNR value 30 or more than 30 then we get four symbols on constellation diagram and total errors at receiver also decreases as compare to SNR value 10. But energy required for each bits in symbol is more due to higher SNR values.

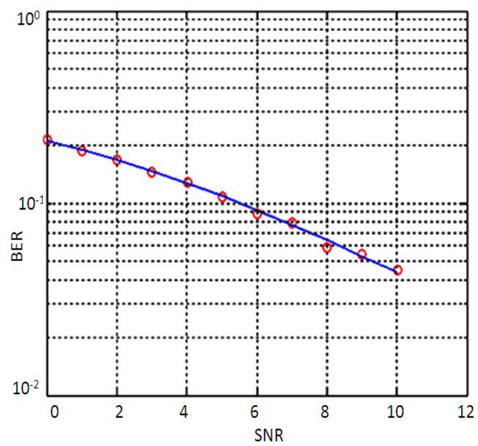

Fig 4: SNR Vs BER Plot

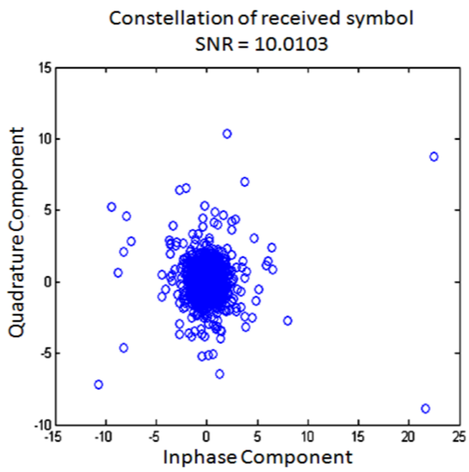

Fig 5: Constellation Diagram for 10th Iteration

If Eb/No varies from -3 to 30 then SNR values is 33dB, total error decreases up to 47 and BER is 2.473e-4, hence performance is better than previous shown by below figure.

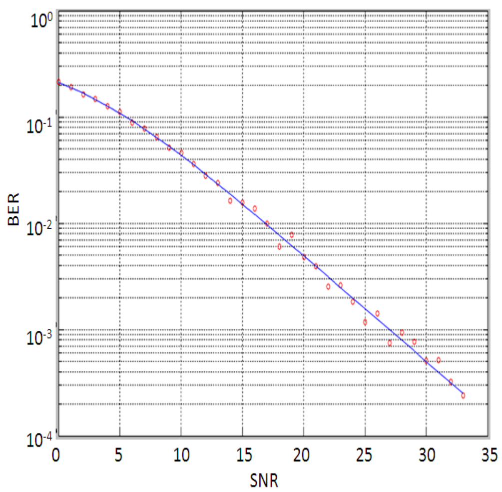

Fig 6: SNR Vs BER plot

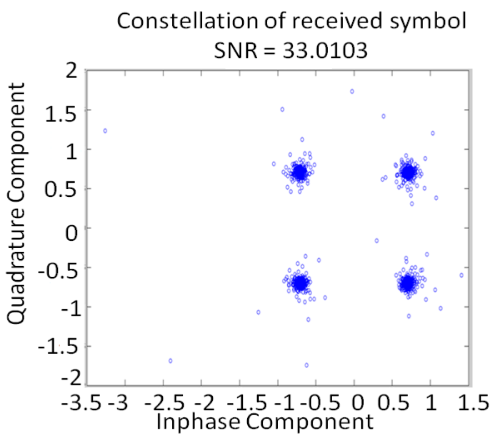

Fig 7: Constellation Diagram for 30th Iteration

4. COMPARISION BETWEEN AWGN & RAYLEIGH CHANNEL

From simulation results at SNR values 15 and the value of Eb/N0 Range is -3 to 12, we observed that SSB-QPSK modulation techniques gives better BER performance in AWGN & lower BER probability as compared to Rayleigh channel. In AWGN channel for minimizing the error, required value of SNR is less hence required less energy for bits in symbols. But in Rayleigh channel for reducing the error, required value of SNR is high i.e. 30 dB. Hence more energy will required for each bits in symbols.

4.1 Simulation Result

Table 1: BER result for different Eb/No ranges

Eb/N0 Range	SNR(dB)	QPSK with AWGN channel		QPSK with Rayleigh Channel	
		Total Error	BER	Total Error	BER
-1 to 3	6.01029	263	2.63E-02	925	9.25E-02
-3 to 7	10.01029	104	8.00E-04	467	4.67E-02
-4 to 8	11.01029	101	1.98E-04	373	3.73E-02
-3 to 9	12.01029	81	3.42E-05	309	3.09E-02
-6 to 10	13.01029	50	3.98E-06	224	2.24E-02
-1 to 13	14.01029	15	2.97E-07	199	1.99E-02
-3 to 12	**15.01029**	**10**	**9.64E-09**	**139**	**1.39E-02**

5. BER PERFORMANCE ANALYSIS IN AWGN CHANNEL USING CONVOLUTION CODE & TURBO CODE

From simulation we found that BER is low in AWGN as compare to Rayleigh for higher values of SNR. Hence minimum errors occur in received data for AWGN channel compare to Rayleigh. Practically higher values of SNR not possible to implement in communication. To improve SNR one way is design match filter, but using match filter we can improve the SNR up to certain values only. Hence it is necessary to find such method which gives lower BER in Lower SNR values. For lower SNR a value, where maximum noise is present gives the maximum error in received data. To avoid maximum error and to get actual transmitted data at receiver in noisy condition, efficient method is “Error Correcting Codes” used in receiver side. The error correcting codes used in digital communication are Linear Block Codes, Hamming codes, Reed-Solemn codes, Convolution code, and Turbo code. Out of these codes convolution codes is better for high SNR and turbo codes is better for low SNR [5] .As the SNR values goes increasing , the BER values goes decreasing for AWGN channel. This means maximum error gets corrected at receiver using convolution code. But convolution code is not efficient at lower values of SNR where maximum noise will be present. Convolution code is used to correct error in one symbol at a time. Hence to correct four symbols this method takes more time at receiver. To avoid the disadvantages of convolution code recently turbo coding is used in digital communication [7].

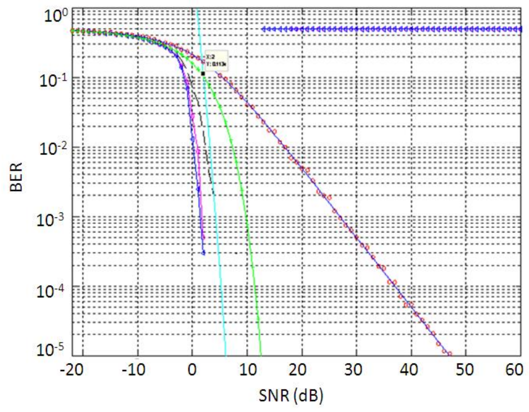

Fig 8: SNR Vs BER plot

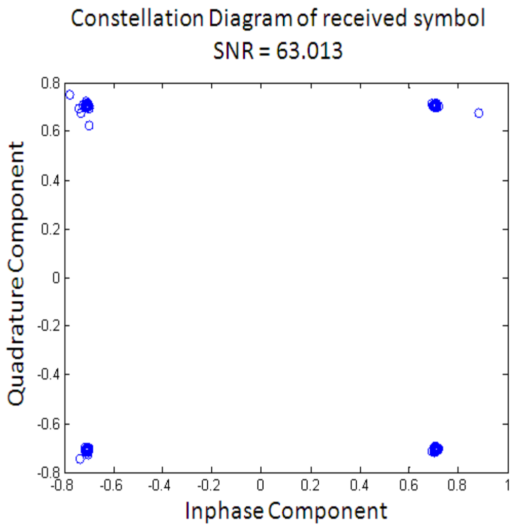

Fig 9: Constellation Diagram for -25 to 60 Eb/No

From simulation we can found that BER is low as compare to convolution for lower SNR (upto 3.8 dB). From simulation we also found that BER values for turbo & convolution code are almost equal at 3.8dB. From comparison graphs it is seen that if SNR values increases beyond 3.8dB then convolution code gives better BER as compare to turbo codes. Convolution code gives better error correcting and BER for higher values of SNR i.e. less noisy channel. Turbo code gives better error correcting and BER for lower values of SNR i.e. maximum noisy channel. For analysis we are trying to change Eb/No range, number of bits and different phases of QPSK.

5.1 Simulation Result

From the simulation results, the Bit Error Rate probability & number of errors will decreases as increasing the SNR. By implementing the QPSK modulation techniques, it is observed that the BER is minimum for AWGN as compared to Rayleigh channels [9]. It is observed for higher data rate as we increase the E_b/N_0 range instead of -3 to 7 i.e. -25 to 60 then QPSK performance is better & BER is decreasing in all fading channels for different modulation schemes.

Table 2: BER analysis at -25 to 60 Eb/No range

Eb/no	SNR in dB	BER AWGN	BER Rayleigh	BER AWGNCon	BER AWGN Turbo
-6	-3	0.239	0.276	10e0.	0.224
-5	-2	0.213	0.2549	10e0.	0.178
-4	-1	0.186	0.2332	10e0.	0.1263
-2	1	0.130	0.189	0.706	0.0444
-1	2	0.103	0.1673	0.113	0.0165
0	3	0.078	0.1464	0.015	0.0044
0.8	3.8	0.067	0.1311	0.001	0.0015
1	4	0.056	0.1267	0.001	0.0019
2	5	0.037	0.1085	0.000	0.0021
3.1	6.1	0.042	0.0647	0.000	0.0027
7	10	0.000	0.0434	0	0.0032
10	13	0.000	0.0239	0	0.4953
12	15	0	0.0167	0	0.4953
13	16	0	0.0089	0	0.4953
17	20	0	0.0049	0	0.4953
22	25	0	0.0018	0	0.4953
27	30	0	0.0004	0	0.4953
32	35	0	0.00017	0	0.4953
44	47	0	0.00001	0	0.4953

6. CONCLUSION

Using SSB-QPSK modulation techniques, BER performance is better in AWGN as compared to Rayleigh channel over noisy environment. Turbo coding gives better error correction for received data bits, if more noise present at receiver. Due to QPSK, more no. of data can be transmitted using different phases & single carrier, hence bandwidth requirement & power requirement is less.

7. FUTURE WORK

We can analyze performance of BER, SNR & Improvement in spectral efficiency using different modulation technique like OQPSK, Pi/4 QPSK & DQPSK with AWGN channel and Rayleigh fading channel by generating binary data source for various data rates, images and other information signals. Also we can implement error correction scheme such as convolution coding and turbo coding particularly with higher modulation technique.

8. REFERENCES

[1] Sklar, B. "Digital Communications: Fundamentals and Applications", Prentice-Hall, 2nd Edition, pp. 30-33, 2001.

[2] Dr. K V sambasiva Rao, A Sudhir Babu, " Evolution of BER for AWGN, Rayleigh and Rician fading channels under various modulation schemes" IJCA journal, volume 26, No. 9, pp. 0975-8887, 8th Nov. 2011.

[3] Sakshi Gupta, Himanshu Sharma, " Performance Investigation for different modulation techniques in WCDMA with multipath fading channels" IJARCSSE Journal, volume 2, Issue 7, ISSN No. 2277128, July 2012.

[4] Dr. K G Maradia, " Performance analysis of modulation techniques in GA assisted CDMA wireless communication system with AWGN and Rayleigh fading channel" IJSTR Journal, Volume 1, Issue 4, ISSN 2277-8616, May 2012.

[5] Charles Jeon, Edin Kadric, "Analysis of Turbo and Convolution codes in BPSK-AWGN system" 29th April 2012.

[6] Haykin, S.; Moher, M., "Introduction to Analog & Digital Communications", John Wiley & Sons, Inc., 2007.

[7] Himanshu Saraswat, Sudhir kumar Mishra, Govind Sharma, " Performance Evolution and comparative analysis of various concatenated error correcting codes using BPSK modulation for AWGN channel", IJECE Journal, Volume 5, pp. 235-255, ISSN 0974-2166, 3rd Nov. 2012.

[8] Masud, A.; Samsuzzaman, M., Rahman, M. A., "Bit Error Rate Performance Analysis on Modulation Techniques of Wideband Code Division Multiple Access" Journal of Telecommunications, Vol 1, Issue 2, 2010.

[9] James E Gilpy, "Bit Error rate simulation using MATLAB", Transcript International Inc. August 2003.

[10] Strelnitskiy, O.O.; Strelnitskiy, O.E.; Shokalo, V.M.; Yagudina, O.V.; Kharkiv Nat. Univ. of Radioelectron., Kharkiv, Ukraine "The method for calculating channel digital communication systems with a given probability of detection," Microwave and Telecommunication Technology (CriMiCo), 21th International Crimean Conference, 2011.