PERFORMANCE COMPARISON OF EQUALIZATION SCHEMES FOR DUAL HOP OSTBC SYSTEM

K.Sujatha[1], S.Varadarajan[2]
[1]Research Scholar, JNT University, Anantapur, A.P., India
[2]Professor, S V University, Tirupati, A.P., India

ABSTRACT:
As wireless communication becomes more prevalent, the demand for higher data rates and uninterrupted connectivity is increasing. Future wireless systems are provisioned to be highly heterogeneous and interconnected. On one side, wireless adhoc networks are emerging for a wide range of new applications, on the other side, infrastructure based broadband wireless systems are expanding to provide increasing number of services with ubiquitous coverage. Space-time coding is a MIMO technique which is well known for its ability to combat fading, increased system performance and capacity. Space time coding uses specially designed code matrix which enhance overall system performance than single antenna systems. Furthermore cooperative communications can benefits single antenna systems with the benefits of MIMO systems. Conjunction of cooperative communication with space time coding can provide capabilities to mitigate fading with increased system performance to a single antenna system. With this motive this research work is focused towards the development of dual hop OSTBC scheme for non-regenerative (Amplify and Forward) and regenerative (Decode and Forward) relaying with receiver phase noise. To evaluate the system performance Rayleigh, Rician and Nakagami fading environments has been considered with the assumption that channel coherence time is greater than transmission period. The proposed system adapts Alamouti OSTBC architecture at relay end and uses BPSK, QPSK and QAM modulation techniques. Simulation has been carried out on MATLAB-2010a and performance evaluation is done on the basis of Bit Error Rate vs. Signal to Noise Ratio.

KEYWORDS: *STBC, AF Relay, DF Relay, Rayleigh fading channel, ZF, MMSE, MRC*

I. INTRODUCTION

Multiple Input Multiple Output (MIMO) systems are proven to eliminate the impact of fading and increase system reliability while maintaining low bit error rates with the cost of increased system hardware and complexity. Space time block coding (STBC) that employs multiple transmit antennas and single/multiple receive antennas has been regarded as promising technique being able o offer significant improvement in link reliability and spectral efficiency [1,2]. Unfortunately these benefits are obtained by deploying multiple antennas on a terminal, which causes an increase in size and power consumption [3, 4]. Recently, cooperative relaying has been attracting a great research interest [5-8]. It exploits the user diversity receiving both the relayed signal and direct signal at the destination node in contrast to direct transmission where a receiver receives and decodes only the direct signal. Several nodes equipped with one or more antennas form a group to cooperatively work as transmit antenna array. Therefore cooperative diversity can be regarded as an alternative to multiple antennas distributed among multiple source nodes. [10], the authors have founded that AF based schemes achieve higher diversity than DF-SC based cooperative diversity scheme. Equalization is techniques for DSTBC_AF system were derived by authors in [11], they have extended the equalization methods for conventional space time system to cooperative space time systems for frequency selective channel. The authors in [12] have investigated diversity for a system having multiple antennas at source and destination and single antenna relay terminal with no CSI available at the destination. In [13] authors have given frame work for cooperative diversity scheme using regenerative and non-regenerative relaying over slow Rayleigh fading channel. They have proposed simulation for cooperative downlink CDMA system and cooperative space time system with single antenna terminal and compare system performance for bit error rate. In [14], authors have considered a wireless relay network with multiple antenna elements deployed at relay nodes and imperfect channel state information is presented at the receiver end. They found that AF relaying techniques always achieves maximal diversity while in DF relaying diversity technique with the number of antenna at the relay nodes. Similar work for wireless multi hop is presented in [15]. This paper provides simulation framework for dual hop cooperative OSTBC protocol under different fading channels. Rest of the paper is arranged as follows.

II. SYSTEM MODEL

Let us consider a wireless network scenario with a source node, a destination node and a set of relaying nodes $R_i \in K$ as shown in fig-1 .Let $S \in \mathbb{C}^{1\times N}$ be a complex – valued M-point constellation data obtained from MPSK or MQAM modulation scheme. Let $Y_{Sri} \in \mathbb{C}^{1\times N}$ the received data at i[th] relay with H_{sri},. $H_{riD} \in \mathbb{C}^{1\times N}$ and n_{sri}, $n_{rid} \in \mathbb{C}^{1\times N}$ being complex valued channel coefficient and channel noise with zero mean and N_0 variance present between source and i[th] relay and destination phase noise Θ (n) considered for the simulation is modeled as zero mean continuous Brownian motion process with variance σ_Θ^2 [16, 17]

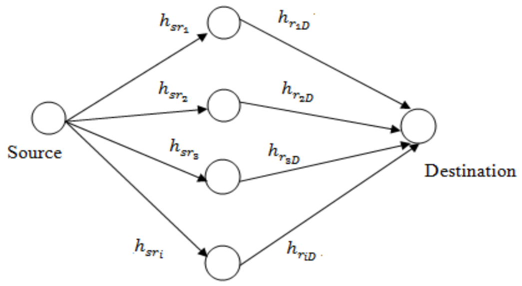

Fig1. Wireless Relay Model.

Let us consider H= $\begin{bmatrix} h_{sr_1} & h_{r_{1D}} \\ h_{sr_2} & h_{r_{2D}} \\ h_{sr_3} & h_{r_{3D}} \\ \vdots & \vdots \\ h_{sr_i} & h_{r_{iD}} \end{bmatrix}$ denotes the set of channel coefficients between source to relay and relay to destination. At the start of simulation first best S→R→D pair is selected among the set of relay nodes based on instantaneous channel conditions according to relay selection criteria given in [18]

- Under Policy I

$$h_i = \min\{|h_{si}|^2 |h_{id}|^2\} \tag{1}$$

- Under Policy II

$$h_i = \frac{2}{\frac{1}{|h_{si}|^2}+\frac{1}{|h_{id}|^2}} = \frac{2|h_{si}|^2|h_{id}|^2}{|h_{si}|^2+|h_{id}|^2} \tag{2}$$

The fading environment between source relay and destination is considered to be of Rayleigh, Rician and nakagami respectively. The channel coefficients can be given as:

2.1 Nakagami Fading

Nakagami-m fading arises due to multipath scattering with relatively larger time delay spreads and different clusters of reflected waves with envelope each cluster signal follows Rayleigh distribution.

Dual Hop OSTBC System with 2 single antenna relay nodes selected by eq.(1,2). Let us assume that the transmission link between source destination terminals is faulty and there is not any possibility of direct transmission. The data transmission between source to destination occurs in two phases i.e. source to relay transmission, relay to destination transmission. Let P be total transmission power available and N_0 denotes noise power spectral density.

In Phase I, the source sequentially transmits S to the selected relays, Hence the data received at i^{th} realy i€ {1, 2}, can be written as:

$$Y_{sr_i} = \sqrt{\frac{P}{N_0}} * H_{sr_i} * S + n_{sr_i} \forall i = 1,2 \quad (3)$$

Second phase of data transmission follows either regenerative or non regenerative transmission protocol with OSTBC encoding.

2.2 Non-Regenerative Relaying

In non regenerative amplify and forward relaying technique, received signal from first phase of data transmission is amplified with channel given as:

$$H_{Gain} = \sqrt{\frac{P_b}{|H_{sr_i}|^2 * P_a + N_0}} A = \pi r^2 \quad (4)$$

Then amplified signal will be

$$S_i = H_{Gain} * Y_{sr_i} \forall i = 1,2 \quad (5)$$

Where P_a and P_b are transmission power available for first and second phase respectively. S_i is then encoded by OSTBC with the code matrix given as [1]

$$x = \begin{bmatrix} s_1 & s_2 \\ -s_2^* & s_1^* \end{bmatrix} \quad (6)$$

Where x€$^{1\times N}$ being alamouti OSTBC encoded data. The Rayleigh phase starts with transmitting signals s_1 $s_2$during first symbol period followed by transmission of signals $-s_2^*$, s_1^* from relay 1, 2 respectively (fig-2)

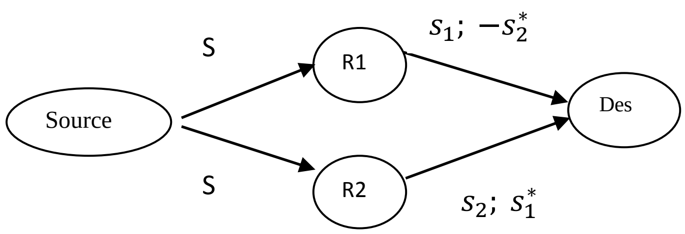

Fig-2. Dual hop Cooperative OSTBC

Assuming channel coherence time to be greater than symbol period , the received signals at the destination terminal from first relay is :

$$r_{r_1D} = (h_{r_1D}s_1 + h_{r_2D}s_2 + n_{r_1D}) * e^{i\theta} \quad (7)$$

Similarly, the second received signal from second relay will be

$$r_{r_2D} = (-h_{r_1D}s_2^* + h_{r_2D}\ s_1^* + n_{r_2D}\ ) * e^{i\theta} \quad (8)$$

Note that the additional term $e^{i\theta}$ in eq. (8, 9) accounts for the effect of phase noise at the receiver end.

Applying Maximum Ratio Combing at the receiver end, the combined signals will be;

$$\tilde{s}_1 = \{h_{r_1D}^* r_1 + h_{r_2D}r_2 = \left(\left|h_{r_1D}\right|^2 + \left|h_{r_2D}\right|^2\right) s_1 + h_{r_1D}^* n_{r_1D} + h_{r_2D}n_{r_2D}^*\} * e^{i\theta} \quad (9)$$

$$\tilde{s}_2 = \{h_{r_2D}^* r_1 - h_{r_1D}r_2^* = \left(\left|h_{r_1D}\right|^2 + \left|h_{r_2D}\right|^2\right) s_2 - h_{r_1D}n_{r_2D}^* + h_{r_2D}^* n_{r_1D}\} * e^{i\theta} \quad (10)$$

The combined detection estimates, $\tilde{s}_1$and $\tilde{s}_2$ depends on their corresponding signals. To recover s_1 and s_2 for each of the transmitted signal the receiver needs to perform MLD $s_i'(i = 1,2)$.

$$s_i' = min\{|\tilde{s}_i - (|h_1|^2 + |h_2|^2)s_i|^2\} \quad (11)$$

2.3 Regenerative Relaying

In regenerative relaying technique, received signal is first equalized through zero forcing or MMSE equalizer and the estimated signal is applied to OSTBC encoder Y_{sri}, being received signal from first phase, the equalized estimates can be given as:
From Zero forcing equalizer

$$\tilde{s}_1 = H^{\dagger}{}_{sr_i} * Y_{sr_i} = H^{\dagger}{}_{sr_i} *(\sqrt{\frac{P}{N_0}} * H_{sr_i} * S + n_{sr_i}) = \sqrt{\frac{P}{N_0}} * S + H^{\dagger}{}_{sr_i} * n_{sr_i} \quad (12)$$

Where $(.)^{\dagger}$ represents pseudo inverse, it is clear from eq-13 that the estimated signal contains of decoded signal S plus As the pseudo inverse of the channel matrix may have high power when the channel matrix is ill-conditioned, the noise variance is accordingly improved and the performance is corrupted.
MMSE equalizer eliminates the problem of noise power improvement by taking noise variance into consideration while construction of filter matrix. The estimated signal from MMSE equalizer will be

$$s_i' = [\ [(H^H H+\sigma^2 I)^{-1}]\ H^H] * Y_{sr_i} \quad (13)$$

Where σ^2 is the noise variance. The added term ($1/SNR= \sigma^2$, in case of unit transmit power) offers a trade –off between the residual interference and noise enhancement. These estimated signals are then OSTBC encoded [eq 9] and transmitted to the destination [eq.10-14].

Bit Error Probability:

The BER probability for proposed scheme can be calculated using the measurement of instantaneous SNR at destination node. Let P be total transmission power available and $\sigma_r^2 = \sigma_{sr}^2 + \sigma_{rd}^2$ be the variance of noise present between source to relay and relay to destination, then instantaneous SNR can be given as.

$$\gamma_\gamma = |h_{sr} * h_{rd}|^2 * P/\sigma_r^2 \quad (14)$$

Assuming channel coherence time to be greater than symbol period, the symbol error probability for instantaneous SNR γ_γ is given as[21]

$$P_0 = Q(\sqrt{2\gamma_\gamma}), \text{ where } Q(x) = \frac{1}{\sqrt{2\pi}}\int_x^\infty e^{-k^2/2}\,dk = \frac{1}{2}erfc(\frac{x}{\sqrt{2}}) \quad \text{for } x\geq 0 \quad (15)$$

III. SIMULATION

This research work is focused towards the development of dual hop cooperative diversity scheme based on the fusion of regenerative and non regenerative cooperative scheme with orthogonal space time block codes. Simulation of proposed scheme is carried out over Rayleigh, Rician and Nakagami fading environments under the influence of AWGN and Brownian phase noise. To evaluate the performance test scenarios has been used based on varying modulation scheme, equalization techniques and combining techniques. Simulation parameters and obtained results are given as follows.

Table 1: Simulation Parameter

Frame Length	256 bit
Modulation	BPSK,QPSK,QAM
Channel	Rayleigh,Rician, Nakagami
Combining Technique	SC,MRC,C-MRC
Equalizer	ZF,MMSE,ML
Relaying Technique	Non-regenerative(AF), regenerative (DF)

Case-1 Rayleigh Fading Environment

3.1 QPSK Modulation

3.1.1 Zero Forcing Equalizer

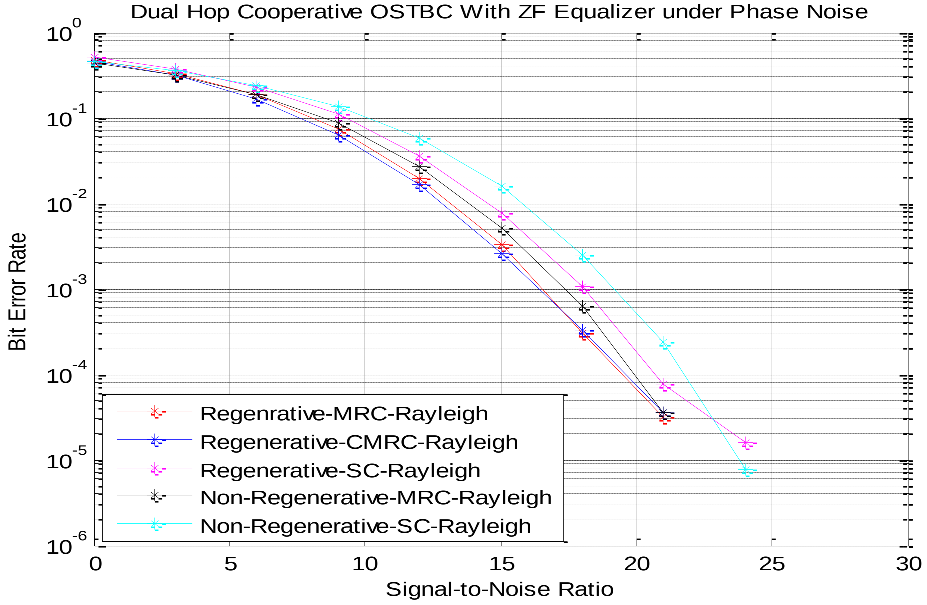

Figure 3: Dual hop cooperative OSTBC scheme with QPSK modulation and ZF Equaliser

3.1.2 Minimum Mean Square Error (MMSE) Equalizer

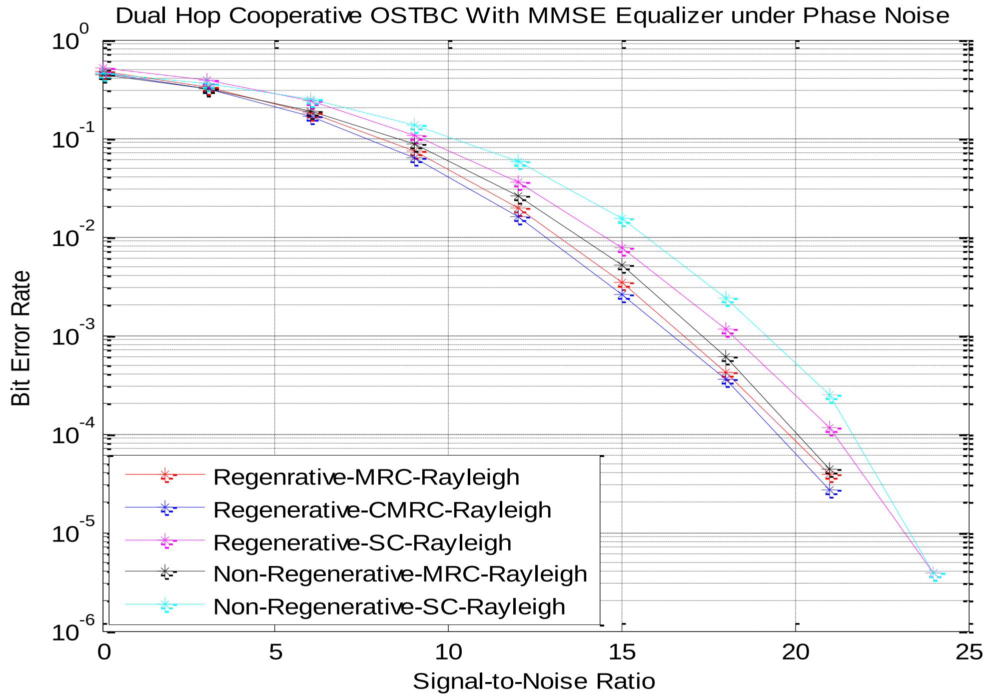

Figure 4.: dual hop cooperative OSTBC scheme with QPSK modulation and MMSE Equaliser

3.1.3 Maximum Likelihood

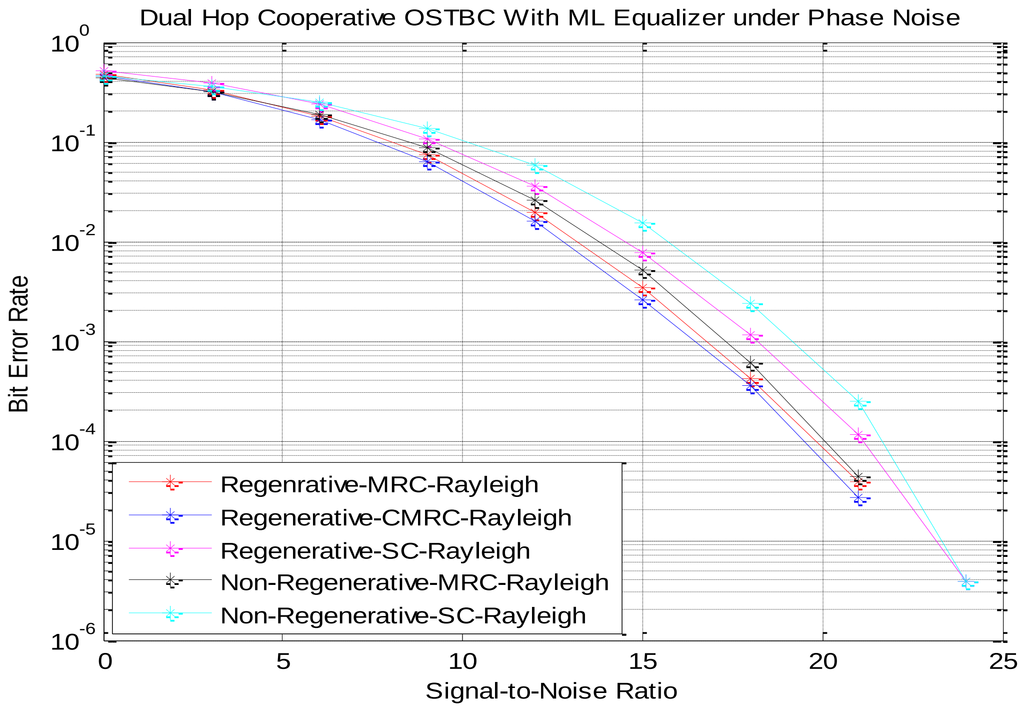

Figure 5: Dual hop cooperative OSTBC scheme with QPSK modulation and ML Equaliser

3.2 BPSK Modulation

3.2.1 Zero Forcing Equalizer

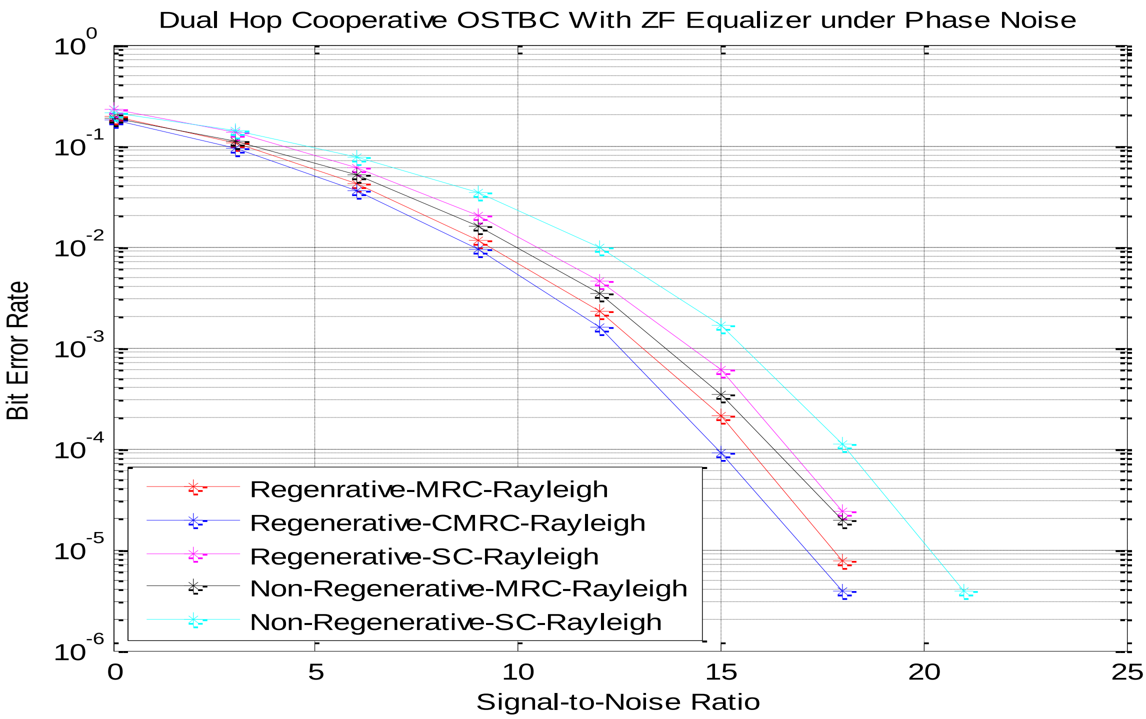

Figure 6: Dual hop cooperative OSTBC scheme with BPSK modulation and ZF Equaliser

3.2.2 Minimum Mean Square Error (MMSE) Equalizer

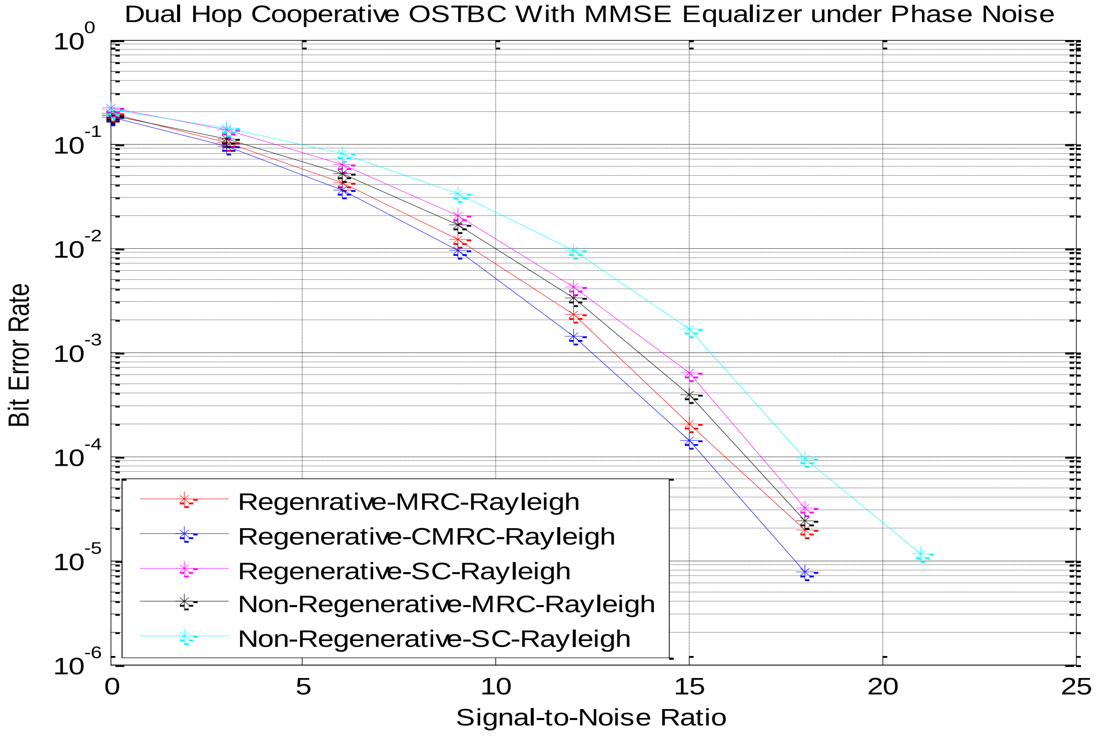

Figure 7 Dual hop cooperative OSTBC scheme with BPSK modulation and MMSE

3.2.3 Maximum Likelihood

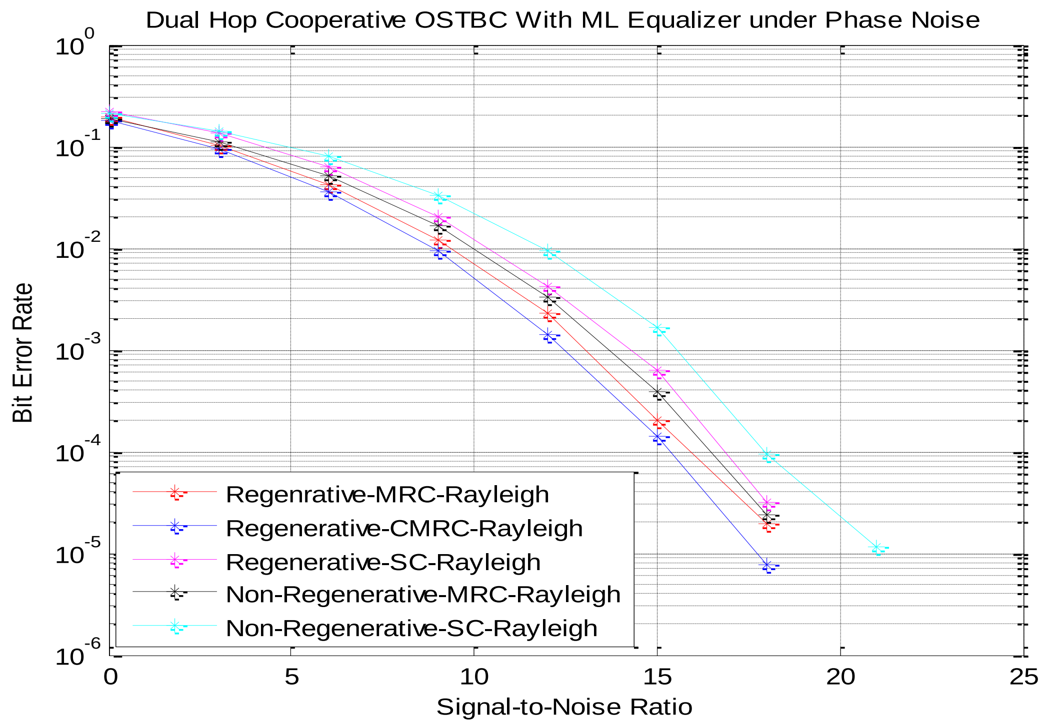

Figure 8: Dual hop cooperative OSTBC scheme with BPSK modulation and ML Equaliser

3.3 QAM Modulation

3.3.1 Zero Forcing Equalizer

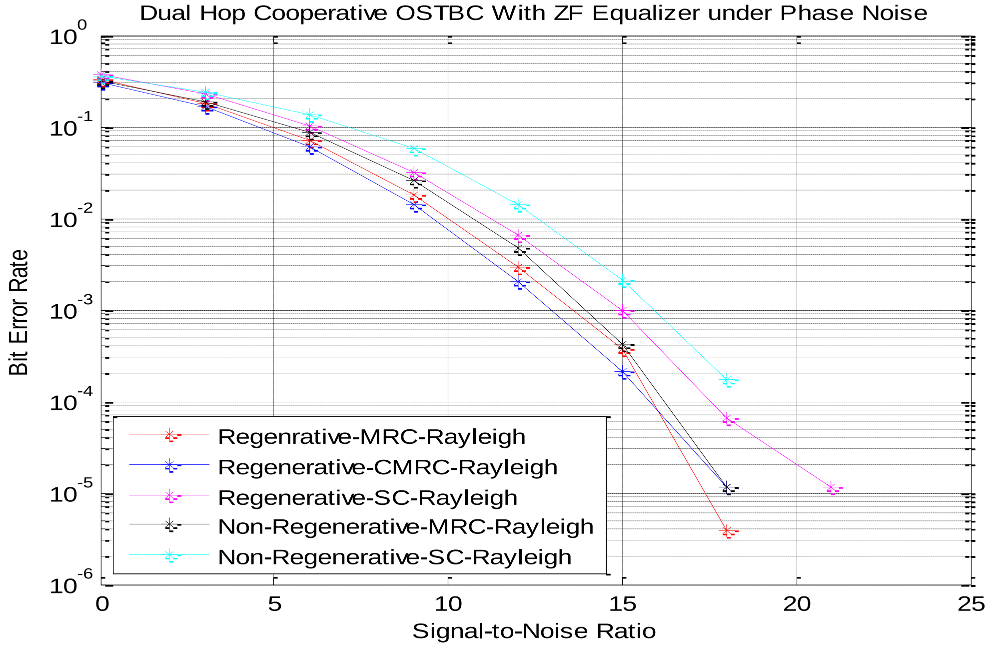

Figure 9: Dual hop cooperative OSTBC scheme with QAM modulation and ZF Equaliser

3.3.2 Minimum Mean Square Error (MMSE) Equalizer

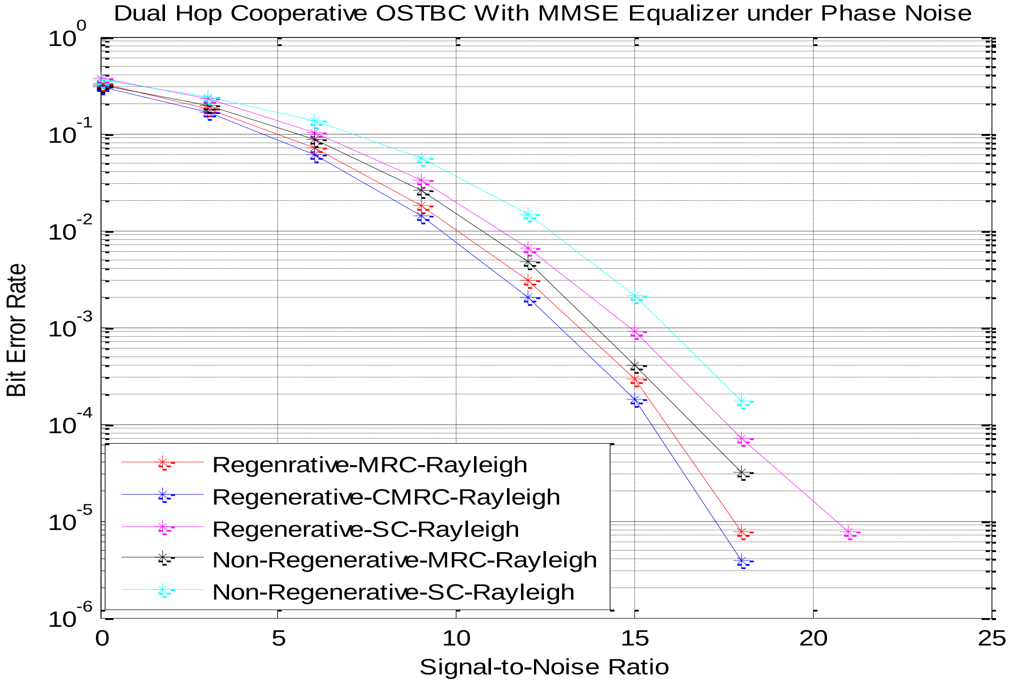

Figure 10: Dual hop cooperative OSTBC scheme with QAM modulation and MMSE Equaliser

3.3.3 Maximum Likelihood

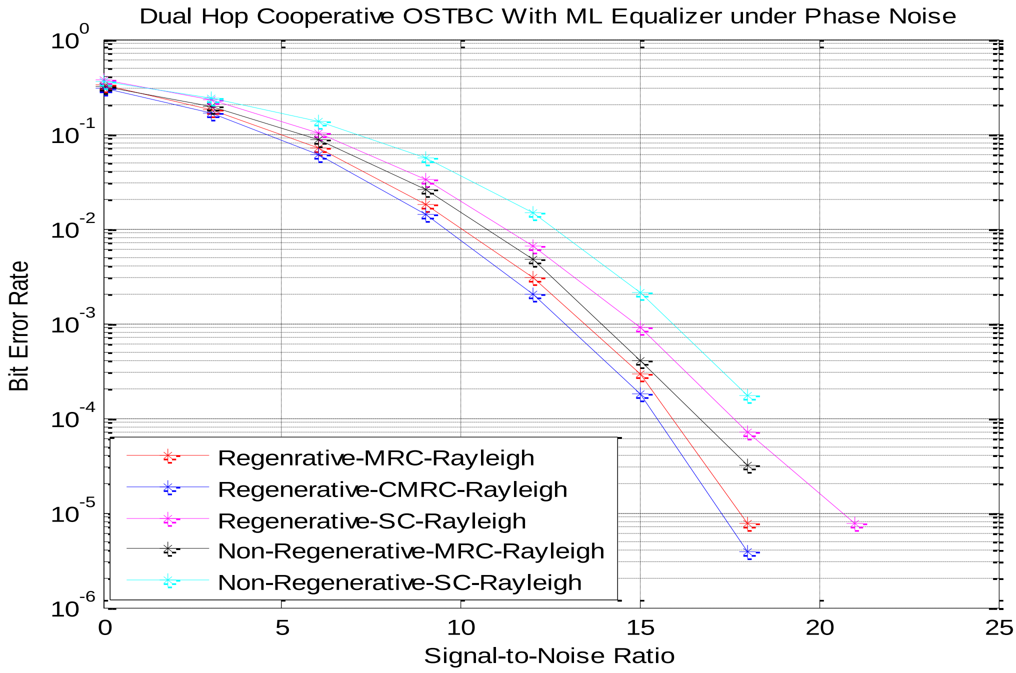

Figure 11: dual hop cooperative OSTBC scheme with QAM modulation and ML Equaliser

Case. 2 Rician Fading Environment

3.1 QPSK Modulation

3.1.1 Zero Forcing Equalizer

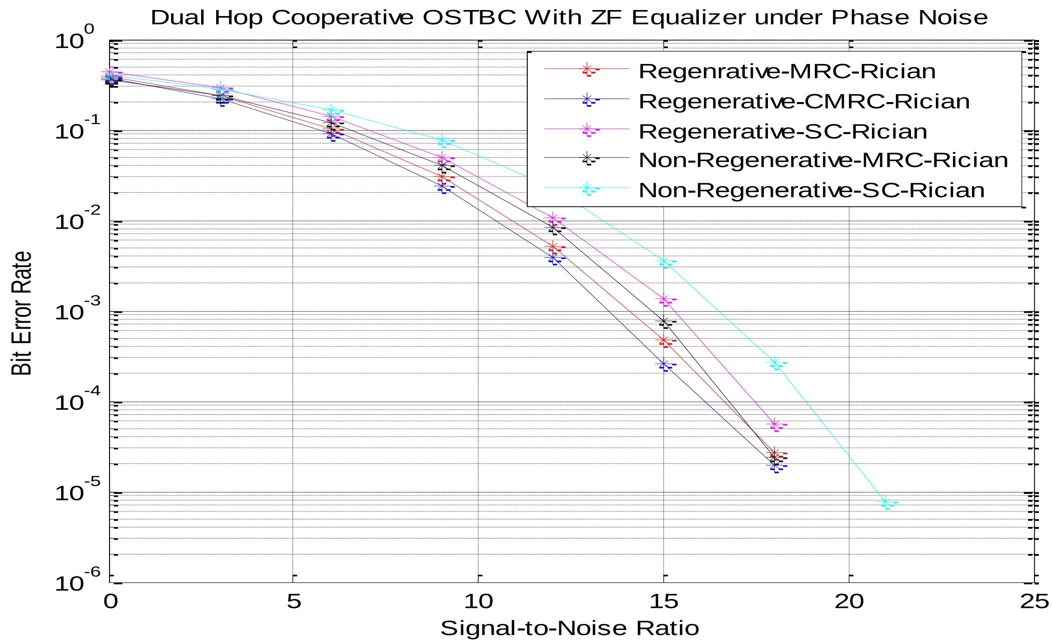

Figure 12: Dual hop cooperative OSTBC scheme with QPSK modulation and ZF Equaliser

3.1.2 Minimum Mean Square Error (MMSE) Equalizer

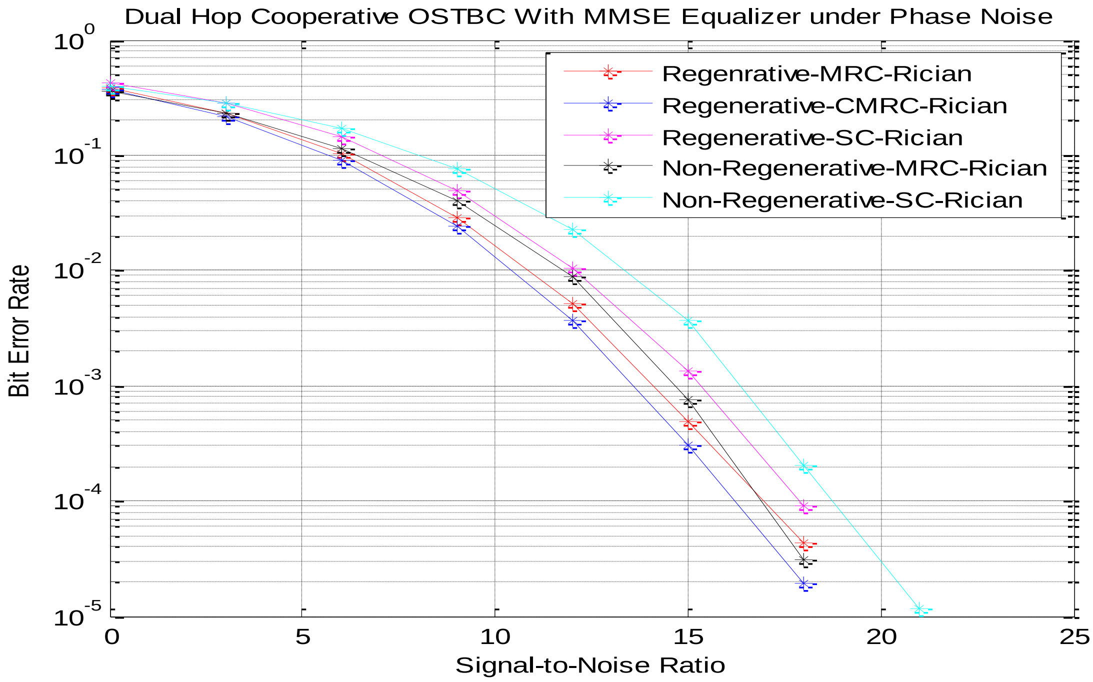

Figure 13: Dual hop cooperative OSTBC scheme with QPSK modulation and MMSE Equaliser

3.1.3 Maximum Likelihood:

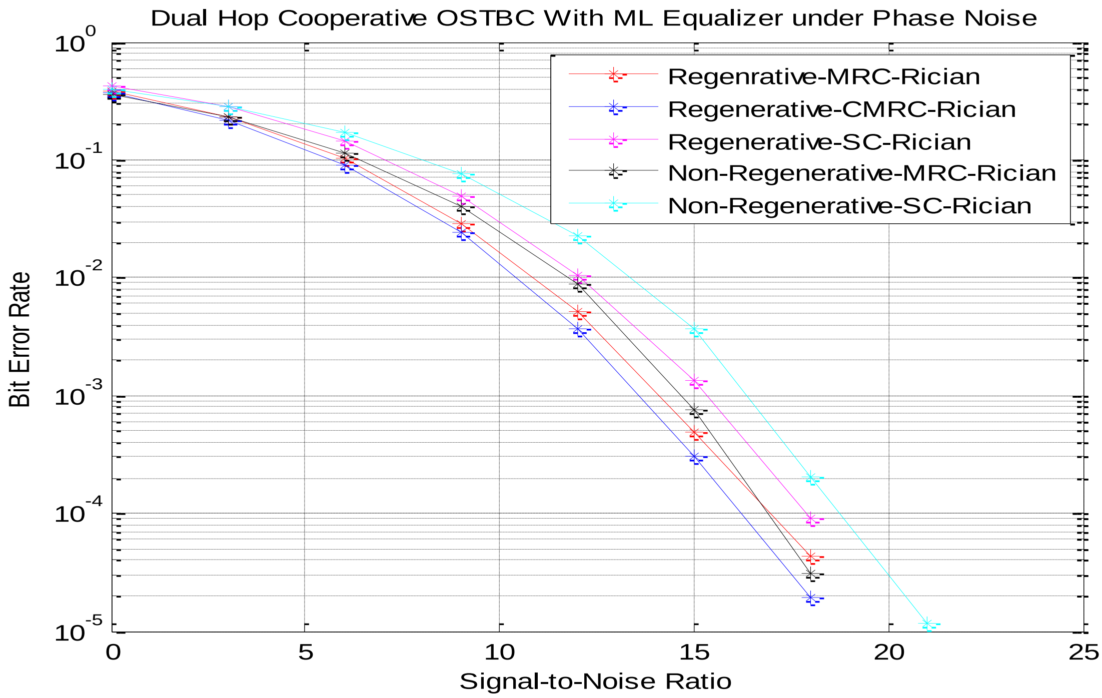

Figure 14: Dual hop cooperative OSTBC scheme with QPSK modulation and ML Equaliser

3.2 BPSK modulation

2.2.1 Zero Forcing Equalizer

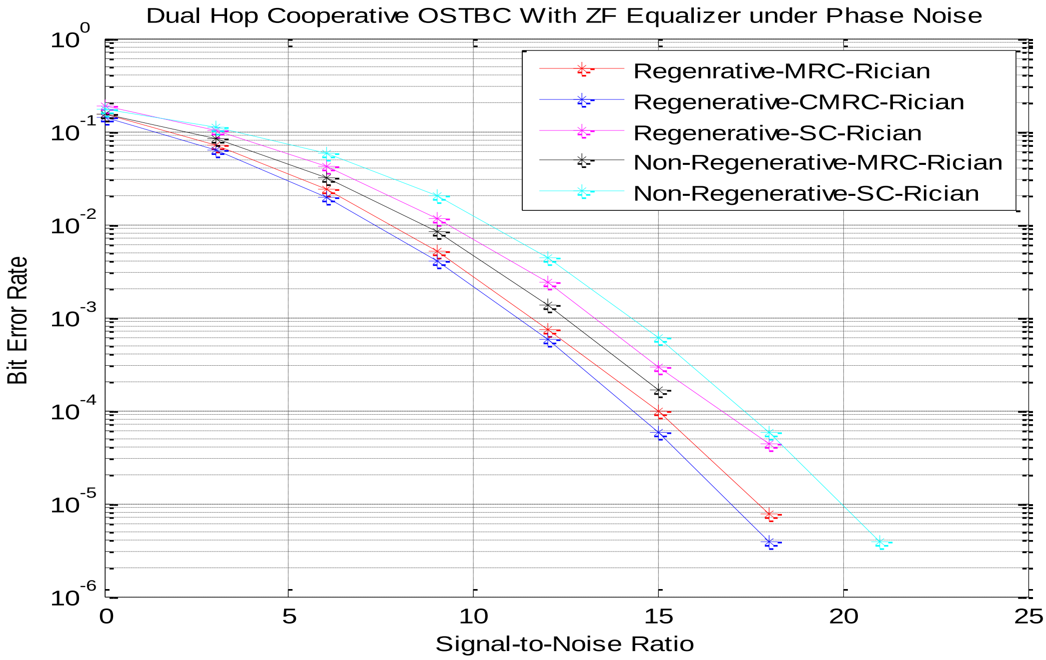

Figure 15: Dual hop cooperative OSTBC scheme with BPSK modulation and ZF Equaliser

3.2.2 Minimum Mean Square Error (MMSE) Equalizer

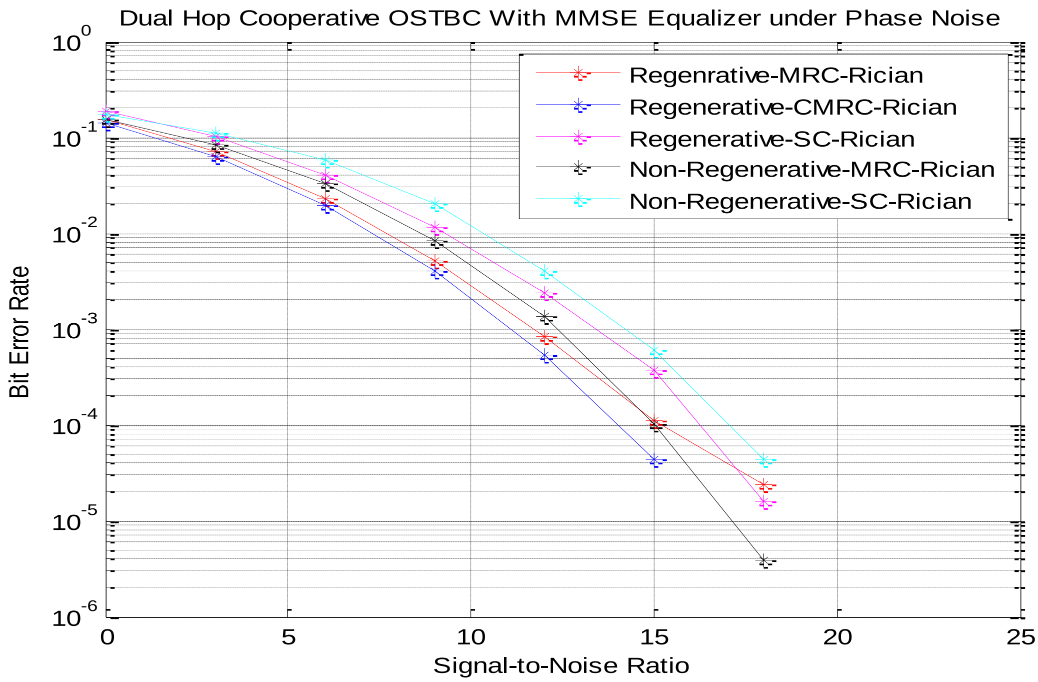

Figure 16: Dual hop cooperative OSTBC scheme with BPSK modulation and ZF Equaliser

3.2.3 Maximum Likelihood

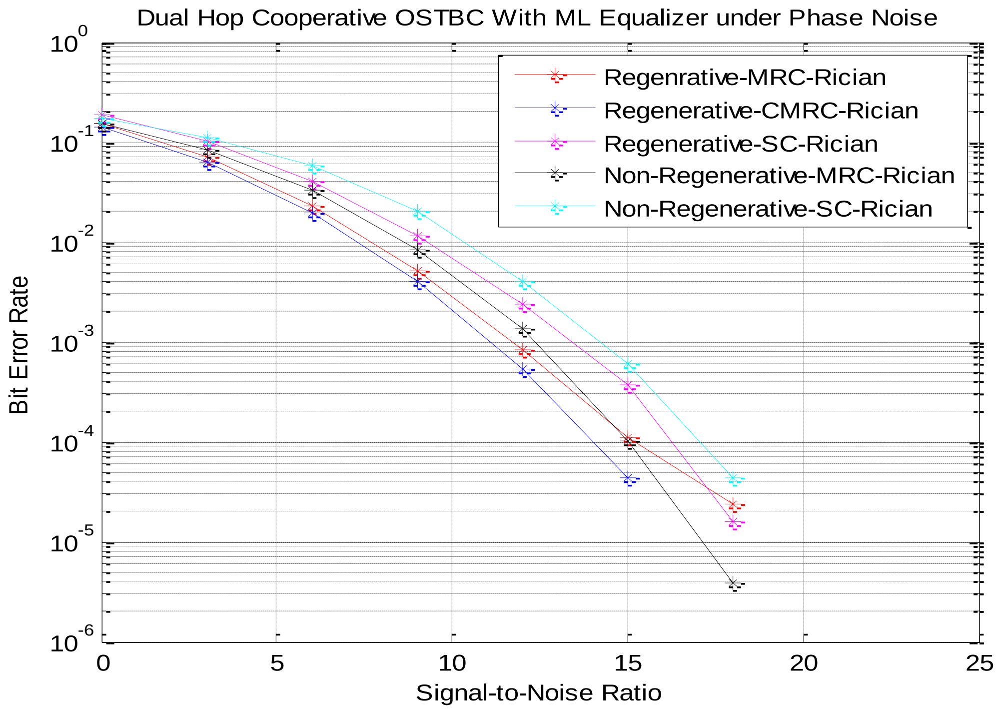

Figure 17: Dual hop cooperative OSTBC scheme with BPSK modulation and ML Equaliser

3.3 QAM Modulation

3.3.1 Zero Forcing Equalizer

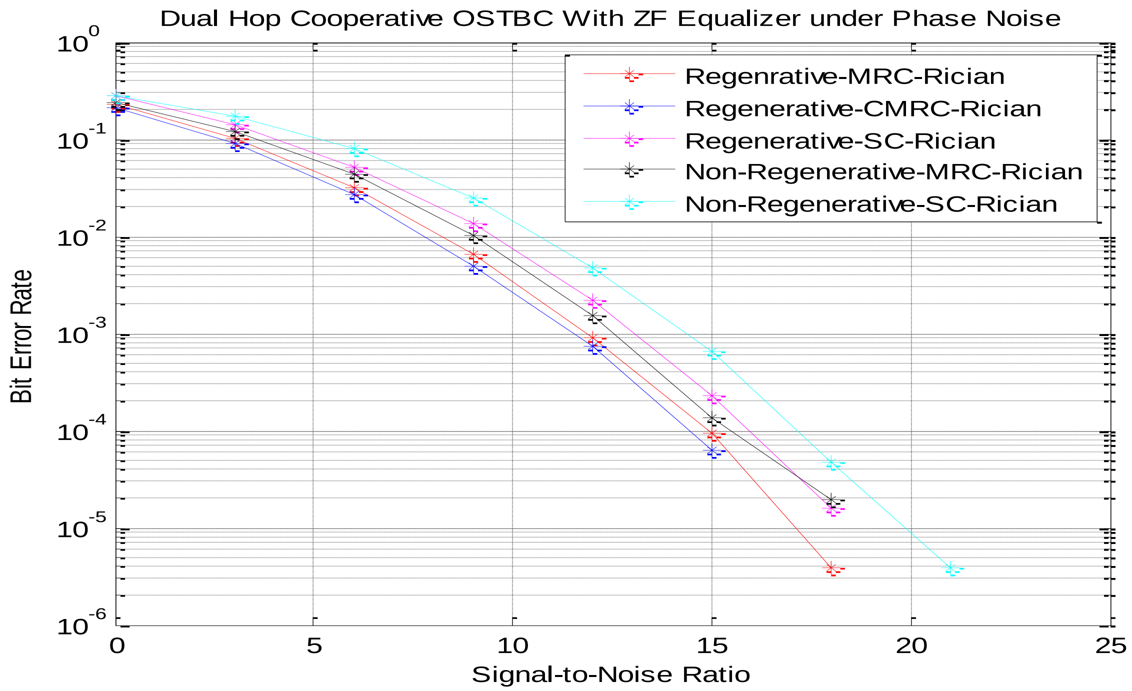

Figure 18: Dual hop cooperative OSTBC scheme with QAM modulation and ZF

3.3.2 Minimum Mean Square Error (MMSE) Equalizer

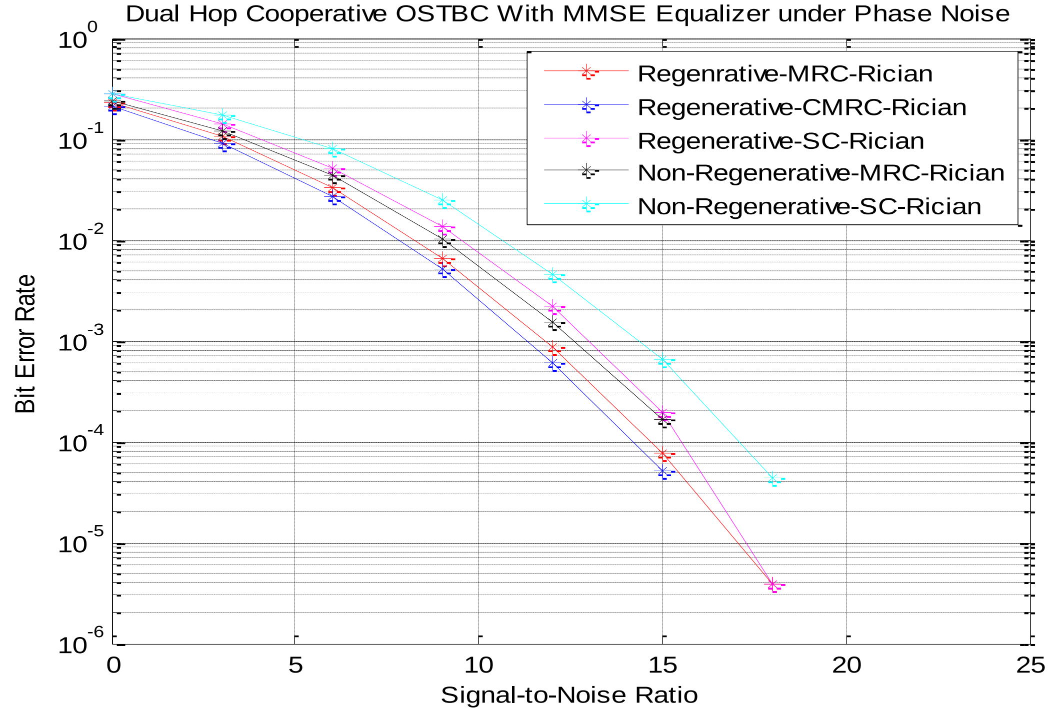

Figure 19: Dual hop cooperative OSTBC scheme with QAM modulation and MMSE Equaliser

3.3.3. Maximum Likelihood Equalizer

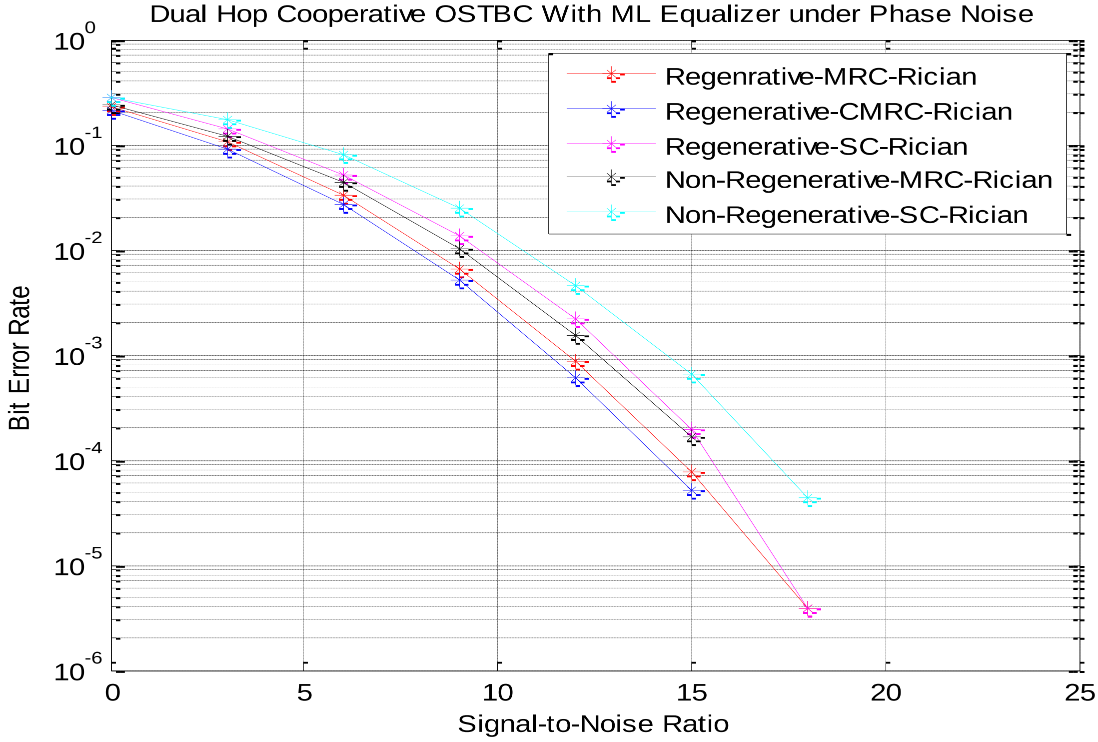

Figure 20: dual hop cooperative OSTBC scheme with QAM modulation and ML Equaliser

Case.3 Nakagami Fading Environment

3.1 QPSK Modulation

3.1.1 Zero Forcing Equalizer

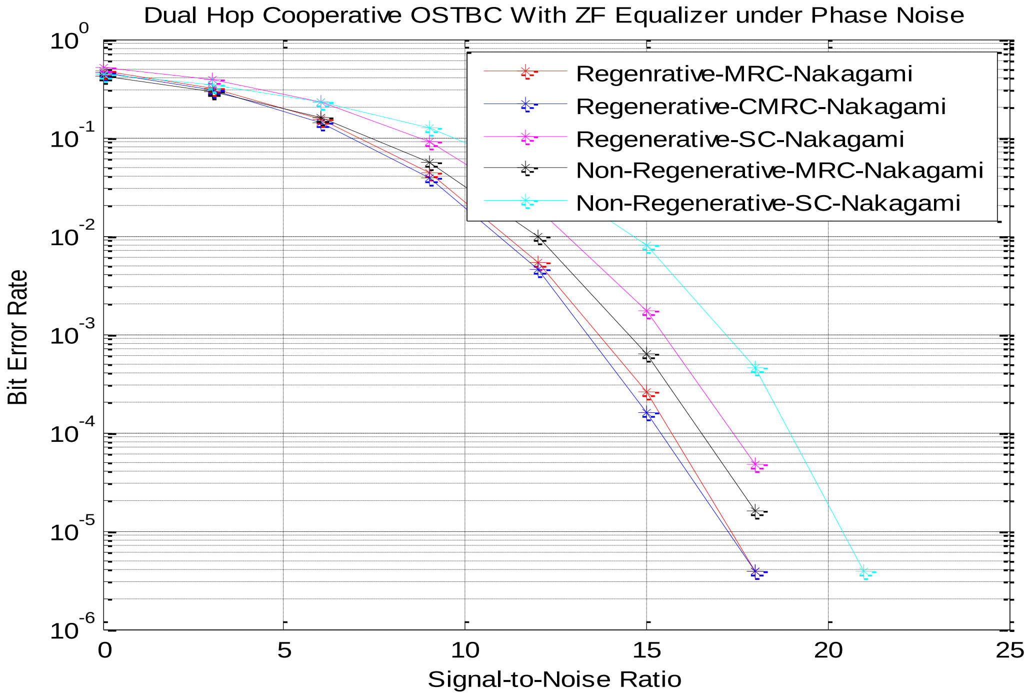

Figure 21: Dual hop cooperative OSTBC scheme with QPSK modulation and ZF

3.1.2Minimum Mean Square Error (MMSE) Equalizer

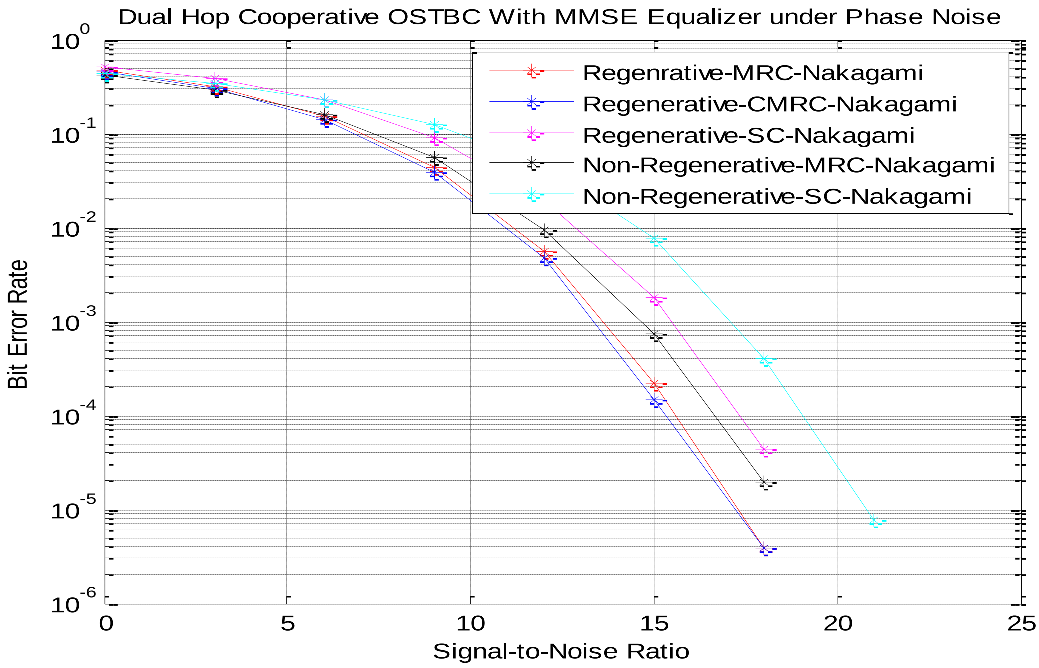

Figure 22: Dual hop cooperative OSTBC scheme with QPSK modulation and MMSE Equaliser

3.1.2 Maximum Likelihood

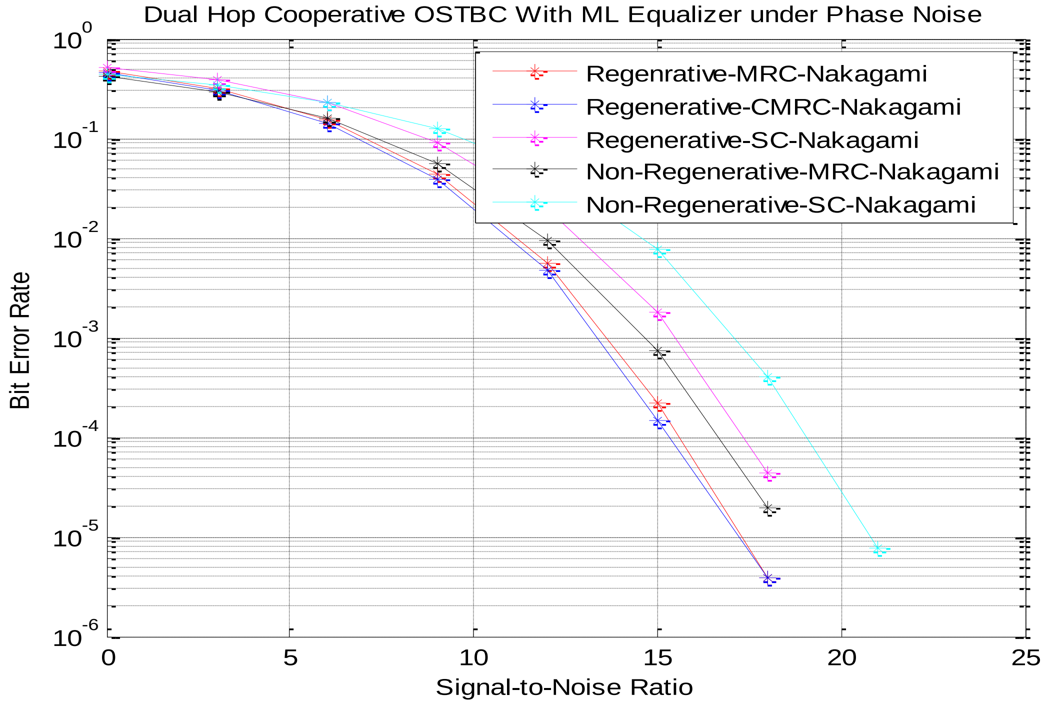

Figure 23: Dual hop cooperative OSTBC scheme with QPSK modulation and ML Equaliser

3.2 BPSK Modulation

3.2.1 Zero Forcing Equalizer

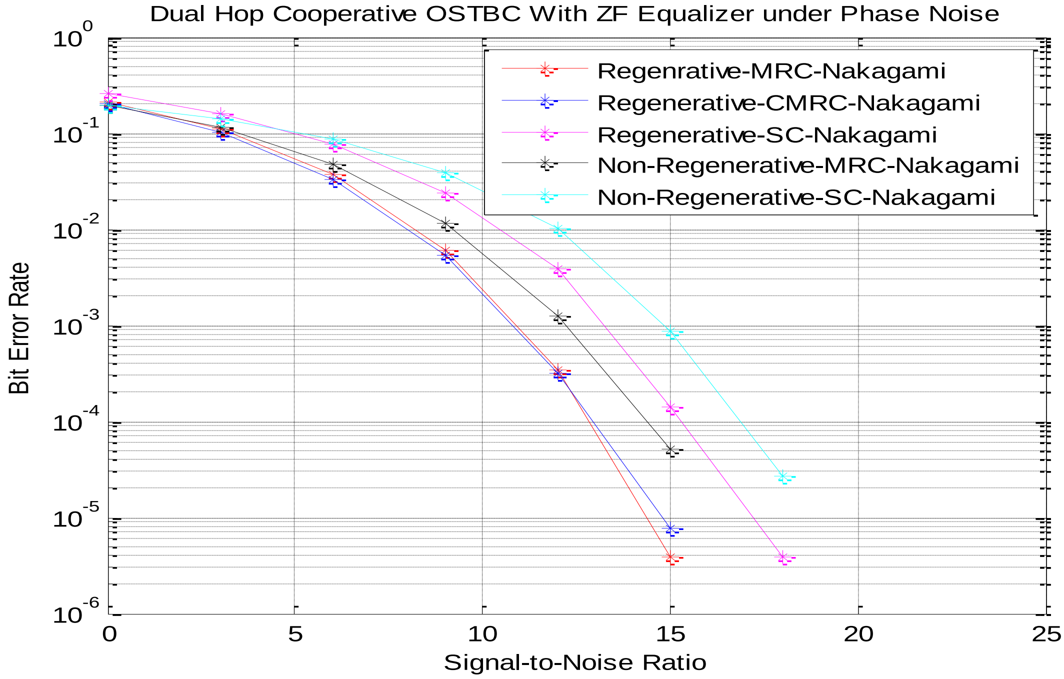

Figure 24: Dual hop cooperative OSTBC scheme with BPSK modulation and ZF

3.2.2 Minimum Mean Square Error (MMSE) Equalizer

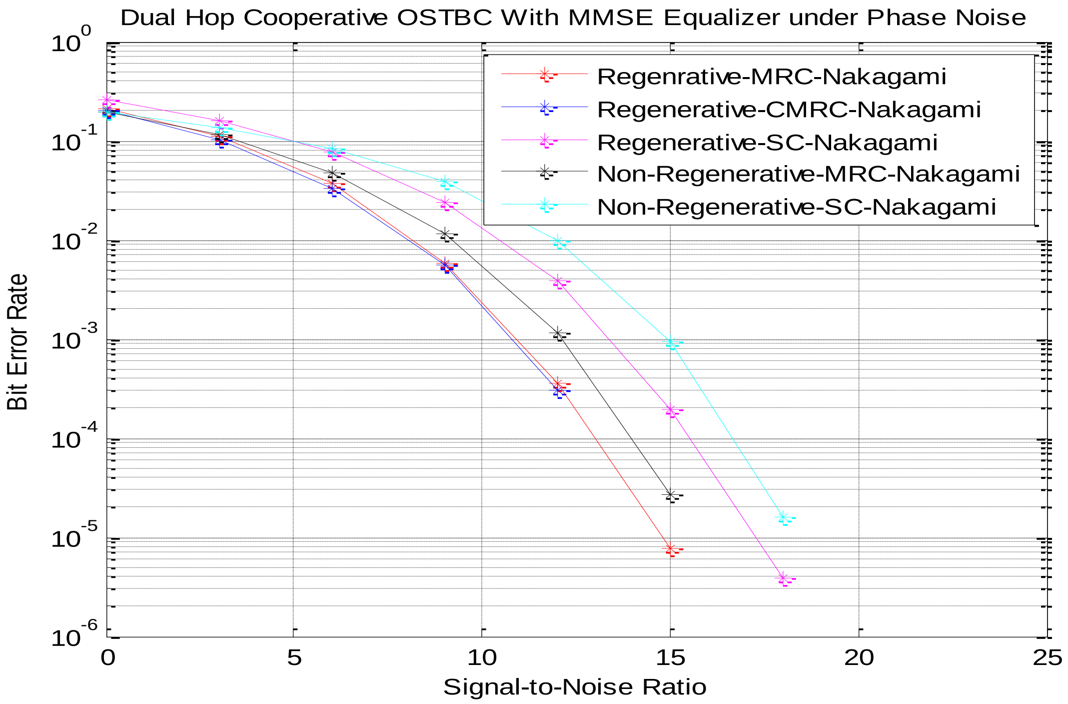

Figure 25: Dual hop cooperative OSTBC scheme with BPSK modulation and MMSE Equaliser

3.2.3 Maximum Likelihood

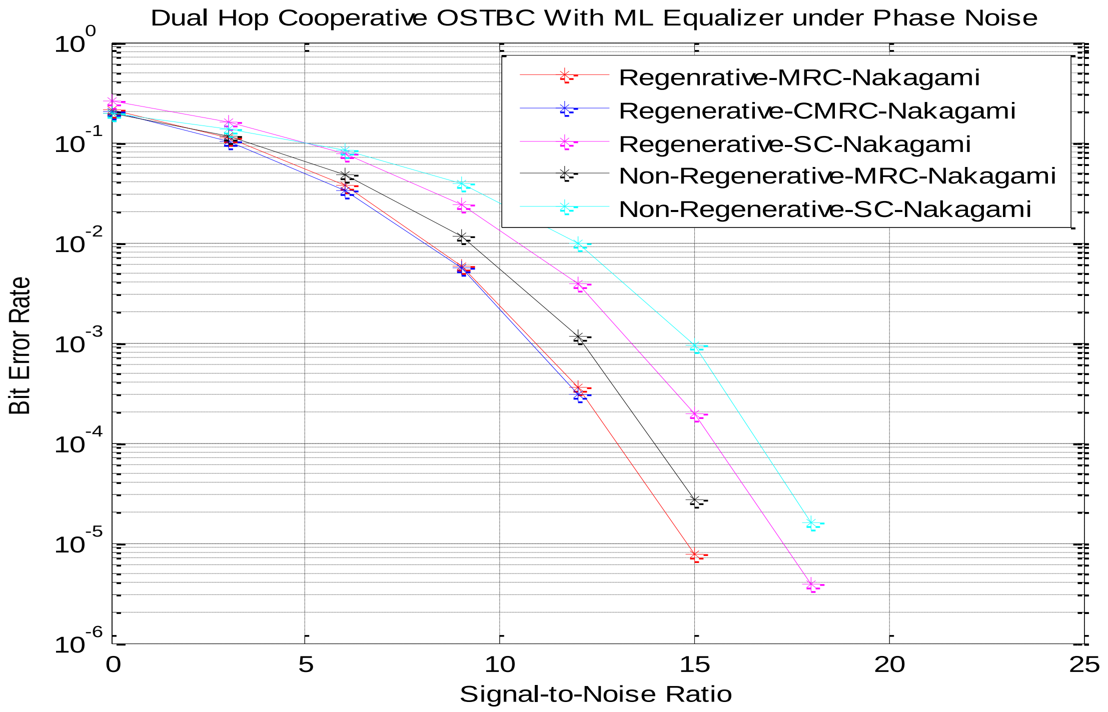

Figure 26: dual hop cooperative OSTBC scheme with BPSK modulation and ML Equaliser

3.3 QAM Modulation

3.3.1 Zero Forcing Equalizer

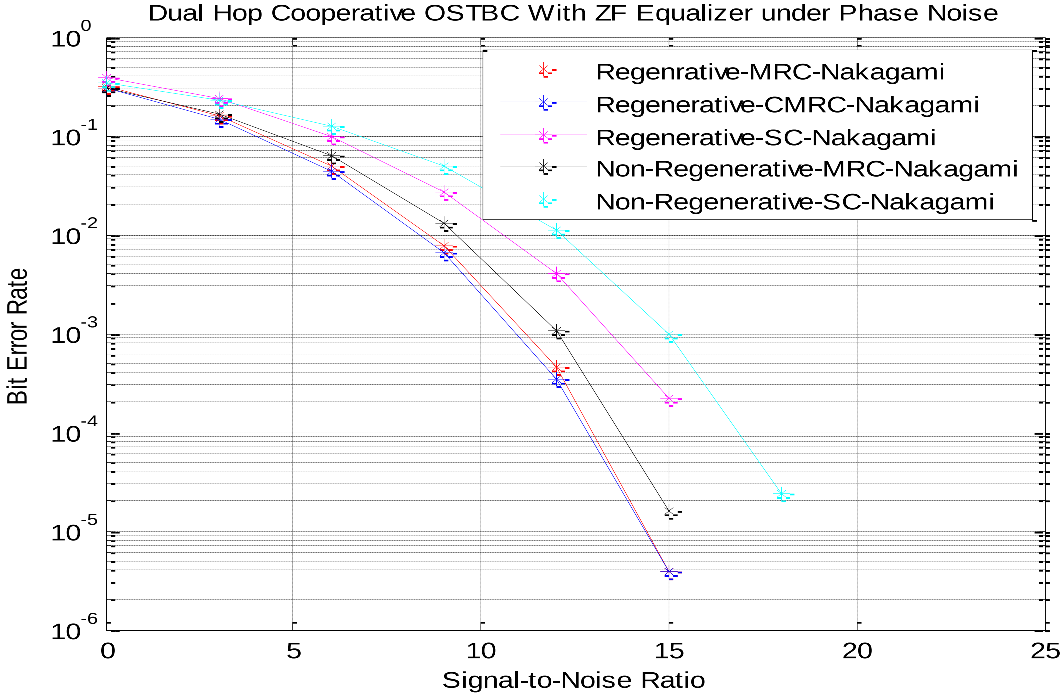

Figure 27: Dual hop cooperative OSTBC scheme with QAM modulation and ZF Equaliser

3.3.2 Minimum Mean Square Error (MMSE) Equalizer

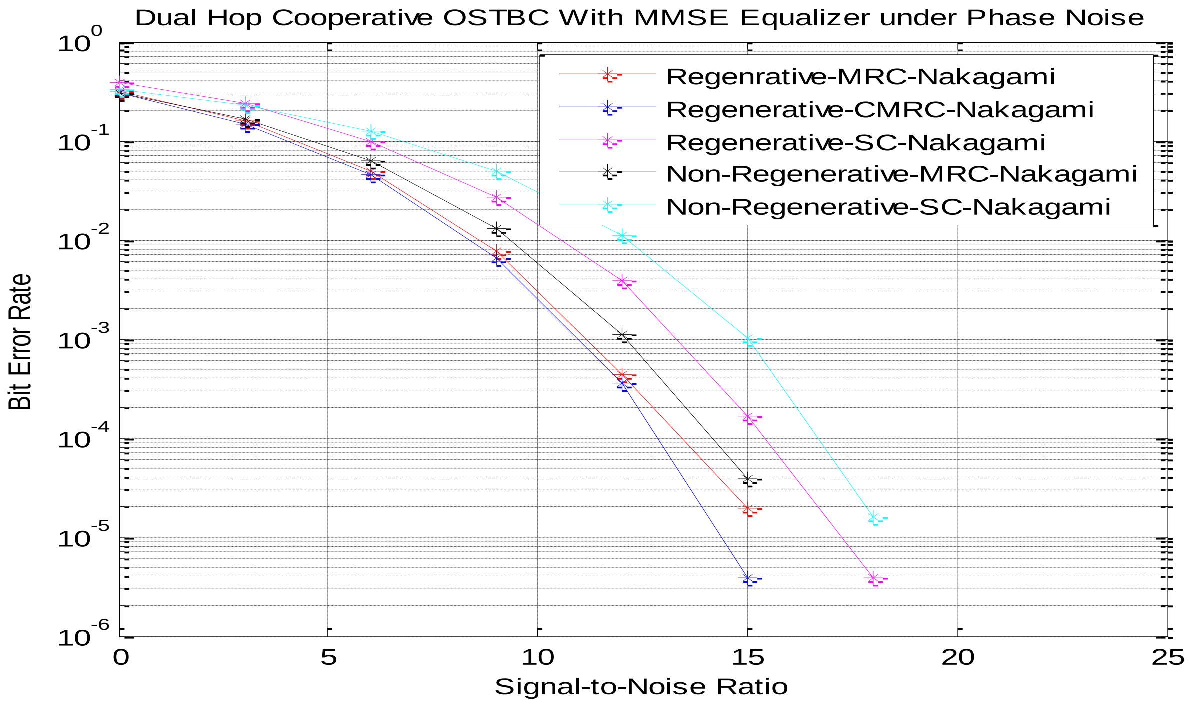

Figure 28: Dual hop cooperative OSTBC scheme with QAM modulation and MMSE Equaliser

3.3.3 Maximum Likelihood

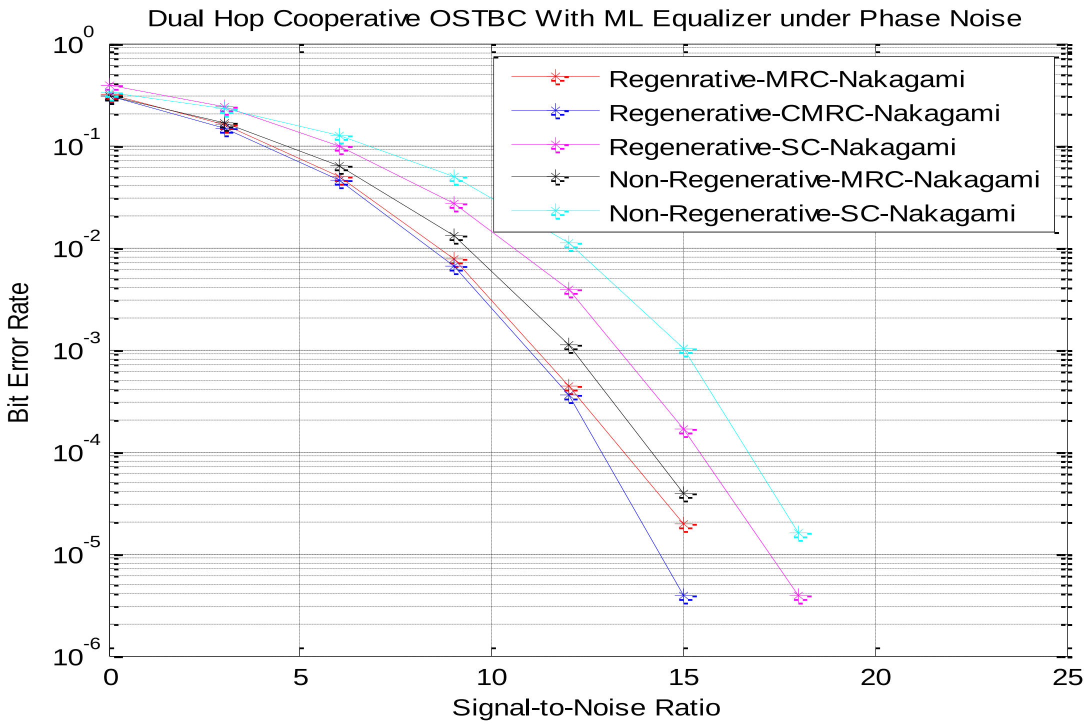

Figure 29: Dual hop cooperative OSTBC scheme with QAM modulation and ML Equaliser

IV. Conclusion

In this research Dual Hop Cooperative OSTBC system is developed for regenerative (decode and forward) and non-regenerative (amplify and forward scheme). The proposed scheme utilizes the benefits of cooperative communication and space time coding to provide array gain and diversity gain in single antenna communication system. The proposed system architecture enhances bit error rate performance while keeping same spectral efficiency. Literature shows that spectral efficiency and bit error rate are inversely proportional to each other and there is a trade-off present between them. Receiver phase noise which is generated at the receiver oscillator circuitry has severe impact on communication system; the proposed system uses Brownian receiver phase noise along with AWGN noise. To evaluate the system performance Rayleigh, Rician and Nakagami fading environments has been considered with the assumption that channel coherence time is greater than transmission period. The proposed system adapts Alamouti OSTBC architecture at relay end and uses BPSK, QPSK and QAM modulation techniques. Simulation has been carried out on MATLAB-2010a and performance evaluation is done on the basis of Bit Error Rate vs. Signal to Noise Ratio. The proposed system also uses Selection Combining, Maximal Ratio Combining and Cooperative Maximal Ratio Combining to compensate the impact of multipath. Simulation scenario is created on the basis of varying modulation techniques with ZF, MMSE and ML equalizer and SC, MRC and C-MRC combining for Rayleigh, Rician and Nakagami fading channels. Simulation shows that BPSK modulation technique provides best BER performance for all channels with C-MRC combining technique and regenerative relaying scheme. Error free transmission is obtained at SNR equals 18 dB for Rayleigh Fading, 15 dB for Rician fading and 12 dB for Nakagami fading environments.

References

[1] Alamouti S.M. “A simple transmit diversity technique for wireless communication”, IEEE J. Sel, Area commun, 1998, 16,(8),pp.1451-1458.

[2] Tarokh, V.,Seshadri,N., Calderbank,A.R.” Space time codes for high data rate wireless communication performance criterion and code construction’, IEEE Trans.Inf.Theory,1998,44,(2),pp.744-765.

[3] S. Cui, A. J. Goldsmith, and A. Bahai (August, 2004). "Energy-efficiency of MIMO and Cooperative MIMO in Sensor Networks". IEEE J. Select. Areas of Commun. 22 (6): 1089–1098.
[4]Holtkamp H, Auer, G, Bazzi, S., Hass, H.”Minimizing base station power consumption’, IEEE J. Sel, Area commun, 2014, 2,(2), pp.297-306.
[5] A. Sendonaris, E. Erkip, and B. Aazhang, “Increasing uplink capacity via user cooperation diversity," Information theory, 1998 proceedings IEEE International Symposium on IEEE 1998.
[6] A. Sendonaris, E. Erkip, and B. Aazhang,”User cooperation diversity Part I: System description," IEEE Transactions on Communications, vol. 51, pp. 1927-1938, Nov. 2003.
[7] Laneman, J. Nicholas, and Gregory W. Wornell. "Distributed space-time-coded protocols for exploiting cooperative diversity in wireless networks." Information Theory, IEEE Transactions on 49.10 (2003): 2415-2425.
[8] N. Laneman, D. Tse, and G. Wornell, “Cooperative diversity in wireless networks: Efficient protocols and outage behavior," IEEE Transactions on Information Theory, vol. 50, pp. 3062-3080, Dec. 2004.
[9] Jing, Yindi, and Babak Hassibi,” Distributed Space time coding in wireless Relay networks” Wireless Communications, IEEE Transactions on 512 (2006) 3524-3556.
[10] Jing, Yindi, and Babak Hassibi,” Using orthogonal and quasi orthogonal design in wireless relay networks,” Information Theory, Ieee Transactions on 53.11(2007), 4106-4118.
[11] Mheidat, Hakam, Murat Uysal, and Naofal Al-Dhahir. "Equalization techniques for distributed space-time block codes with amplify-and-forward relaying."Signal Processing, IEEE Transactions on 55.5 (2007): 1839-1852
[12] Oggier, Frederique, and Babk Hassibi, “A coding scheme for wireless networks with multiple antenna nodes and no channel information” Acoustics speech and signal Processing, 2007, ICASSP 2007, IEEE International Conference on Vol.3, IEEE, 2007.
[13] Bai, Zhiquan, Dongfeng Yuan, and Kyungsup Kwak. "Performance evaluation of STBC based cooperative systems over slow Rayleigh fading channel."Computer Communications 31.17 (2008): 4206-4211.
[14] Jaafar, Wael, Wessam Ajib, and David Haccoun. "Performance evaluation of distributed STBC in wireless relay networks with imperfect CSI." Personal, Indoor and obile Radio Communications, 2009 IEEE 20th International Symposium on. IEEE, 2009.
[15] Jaafar, Wael, Wessam Ajib, and David Haccoun. "On the performance of distributed-STBC in multi-hop wireless relay networks." Wireless Conference (EW), 2010 European. IEEE, 2010.
[16] Petrovic, Denis, Wolfgang Rave, and Gerhard Fettweis. "Intercarrier interference due to phase noise in OFDM-estimation and suppression." Proc. IEEE VTC Fall. 2004.
[17] Jalloh, Mohamed, Mishal Al-Gharabally, and Pankaj Das. "Performance of OFDM systems in Rayleigh fading channels with phase noise and channel estimation errors." Military Communications Conference, 2006. MILCOM 2006. IEEE. IEEE, 2006.
[18] A. Bletsas, A. Lippman, and D. P. Reed, “A simple distributed method for relay selection in cooperative diversity wireless networks based on reciprocity and channel measurements,” in Proc. 61st IEEE Semiannu. Vech. Technol. Conf, vol. 3, Stockholm, Sweden, May 30–Jun, 1 2005, pp. 1484–1488.
[19] Tiwari, Keerti, and Davinder S. Saini, “BER Performance comparison of MIMO system with STBC and MRC over different fading channels,” High performance computing and Applications (ICHPCA), 2014 International Conference on IEEE, 2014.

AUTHOR’S PROFILE

K. Sujatha, received the B.Tech degree in Electronics and Communication Engineering from Kuppam Engineering College in 2005 and M.Tech from Dr.M.G.R University in 2008.Currently pursuing PhD from Jawaharlal Nehru Technological University, India. Research interests include wireless Communications and Wireless Networks

S. Varadarajan received the B.Tech degree in Electronics and Communication Engineering from Sri Venkateswara University in 1987 and M.Tech from NIT, Warangal He did his PhD in the area of Radar Signal Processing. He is fellow of Institute of Electronics and Communication Engineers (IETE) and member of IEEE. Currently working as Professor in the department of ECE, Sri Venkateswara University, Tirupati, Andhra Pradesh India