BER Analysis of Alamouti and Silver Space Time Block Coded 2x2 MIMO Systems Using Rayleigh and Dent Channel Models

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Abstract-The quickly developing interest for the remote transmission of video, discourse and data is driving the communication innovation to be more productive and more solid. MIMO has turned out to be one of the key advances for remote communication frameworks. One of the promising transmit diversity plan is Alamouti space time block codes (A-STBC). In this paper, ways to deal with enhance the data rate over the multiple radio wire channels for dependable communication has been implemented. Dissimilar to, the vast majority of the strategy exists to accomplish full assorted qualities and full rate, we expect to build the data rate over the channel by utilizing mark channel display. Furthermore, we studied Alamouti and Silver STBC-MIMO system performance under different mobile radio channel such as dent channel model and Rayleigh channel model. It is clearly observed by the simulation result that the system performance enhances using dent channel model.
Keywords:MIMO, Space Time Block Codes, Alamouti STBC, Rayleigh Channel, Dent Channel and Silver STBC

I. INTRODUCTION

Because of blast of interest for high speed remote administrations, for example, remote web, email, cell video applications, remote communication has turned out to be a standout amongst the most energizing fields in advanced building .However, improvement of such administrations faces critical difficulties to bolster the high data rates and limit required for these applications with the extremely confined assets in remote communication channel. The obstructions associated with remote situations are hard to overcome. Impedance from other clients and bury image obstruction (ISI) from multipath of one's own flag are not kidding types of twisting. Furthermore, when transmit and get reception apparatuses are in relative movement, the Doppler impact will spread the frequency range of got signs furthermore there are greatly restricted data transmissions. To save transmission capacity assets, we augment unearthly productivity by pressing however much information as could reasonably be expected into a given transfer speed. An answer for the transfer speed and power issue is the cell idea, in which frequency groups are allocated to little, low power cells and reused at cells far away. In any case, this thought done is insufficient. The answer for this issue is multiple receiving wires both for transmission and gathering in remote communication framework, famously known as MIMO innovation. A powerful and useful approach to approach these requests of MIMO remote channel is to utilize Space Time (ST) Coding. It is a coding procedure intended for use with multiple transmits radio wires, to build data rate, limit and unearthly proficiency. MIMO framework utilize multiple transmit and get receiving wires to create multiple spatial channels between the transmitter and the receiver, which shapes the premise to build the data rate without expanding the transfer speed. On the off chance that immaculate channel state information (CSI) is accessible at the receiver, the normal limit develops straightly with littler of the quantities of transmit and get radio wires under certain channel conditions. The real potential preferred standpoint of MIMO is that either the quality regarding bit blunder rate (BER) or the data rate of the framework can be moved forward. The execution change of MIMO frameworks can be surveyed by utilizing differing qualities pick up and spatial multiplexing pick up. It is unrealistic to accomplish most extreme differing qualities and multiplexing all the while in light of the fact that there is exchange off between them. Differing qualities pick up is accomplished by transmitting a similar flag over multiple free blurring situations, e.g., in time, frequency and spatial spaces. Space Time Coding transmits motion over the spatial and time area all the while to accomplish differing qualities pick up without expanding data transmission. High data rate can be accomplished by utilizing multiple transmit and get radio wires. In any case, utilizing multiple get receiving wires at the portable units appears to be less functional because of the size and power limitations. In this way, transmit differing qualities method turns into a promising way to deal with accomplish differences for the downlink (from base-stations to mobiles) transmissions. Since, the primary full-rate full-differing qualities orthogonal code proposed by Alamouti for frameworks with two transmit radio wires, there has been broad work on an assortment of space-time transmission plans. Space time piece codes (STBCs) have been proposed to understand the improved unwavering quality of multi-radio wire frameworks. At the point when the transmitter has two recieving wires, Alamouti codes accomplish the full-differences execution with an image rate of 1 (rate-one).There is no channel state information at the transmitter (CSIT) however idealize channel state information at the receiver (CSIR). A way to deal with enhance the data rate over the multiple radio wire channels for dependable communication. Not at all like, the majority of the method exists to accomplish full assorted qualities and full rate, we mean to expand the data rate over the channel by utilizing scratch channel display. We misuse the time and space differing qualities at the same time to enhance the execution of the framework under versatile radio channel. Furthermore, simulations and analysis results are completed utilizing imprint's channel demonstrate as a part of terms of BER and the coding techniques is proposed for 2x2 Alamouti STBC MIMO frameworks. Simulation results are completed with extremely basic interpreting method i.e. ML unraveling at the receiver. Despite the fact that, the method of two transmit radio wires is the principle center of this paper, a similar thought can be specifically connected to Alamouti STBC codes with more than two transmit receiving wires.

II. MIMO SYSTEM

ArogyaswamiPaulraj and Thomas Kailath proposed the idea of Spatial Multiplexing utilizing MIMO as a part of 1993. Their US Patent No. 5,345,599 issued in 1994 on Spatial Multiplexing stressed applications to remote communicate. In 1996, Greg Raleigh and Gerard J. Foschini refine new ways to deal with MIMO innovation, which considers configurations where multiple transmit receiving wires are co-located at one transmitter to enhance the connection throughput adequately. Ringer Labs was the first to demonstrate a laboratory model of spatial multiplexing (SM) in 1998, where spatial multiplexing is a primary innovation to enhance the execution of MIMO communication frameworks.

A. Requirement for MIMO Systems

MIMO innovation has attracted attention in remote communications, since it offers huge increments in data throughput and connection go without extra transmission capacity or transmit control. It accomplishes this by higher ghostly proficiency (more bits every second per hertz of data transfer capacity) and connection dependability or differing qualities (diminished blurring). In light of these properties, MIMO is an ebb and flow theme of international remote research. Indicate point (single client) MIMO communication guarantees expansive additions for both channel limit and unwavering quality, basically by means of the utilization of space-time codes (differences increase arranged) consolidated with stream multiplexed transmission (rate maximization situated). Multiuser MIMO (MU-MIMO) information theory advocates for the utilization of spatial sharing of the channel by the clients. Such a multiple access convention infers an additional equipment cost (radio wires and filters) yet does not include any transfer speed development, not at all like say time-division (TDMA) or code-division (CDMA) multiple access.

B. Architecture

In this area, the utilization of multiple-input multiple-output (MIMO) design for remote communication frameworks is considered. By utilizing MIMO engineering, design in which transmission and gathering are helped out through multiple reception apparatuses, one can plan a better remote communication framework with deference than unwavering quality, throughput, and power utilization. Lately, remote communication gadgets have turned out to be increasingly prevalent. In any case, in the meantime, the plan of speedier, more solid, and power-productive remote communication frameworks has turned out to be significantly more troublesome.

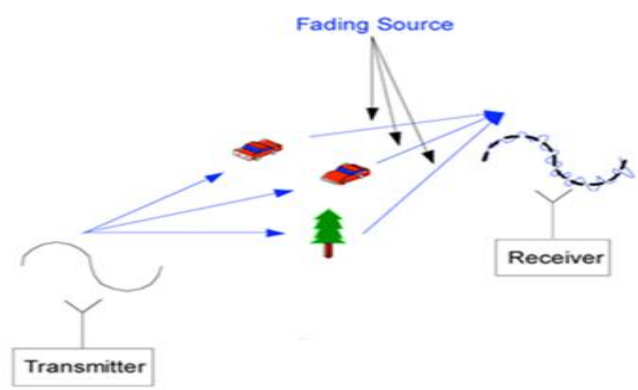

Fig.1 MIMO architecture

Remote channels, rather than wired channel, display highly unpredictable adequacy conduct because of blurring. The blurring, basically brought about by the gathering of multiple impressions of the transmitted flag, illustrated in Figure, is a key intrinsic issue of remote channels, which, unfortunately, can't be maintained a strategic distance from. Blurring causes the got flag energy to change quickly in time, making the undertaking of information extraction from the got flag a genuinely complicated attempt. Enhanced unwavering quality is not by any means the only result of utilizing multiple reception apparatuses. Around ten years back, an amazing theoretical outcome with respect to the limit of MIMO channels recommended that the transmission rate over remote channels can be dramatically expanded when utilizing multiple reception apparatuses. Things being what they are the capacity to transmit and get through multiple reception apparatuses does not just reject blurring; even better, it really bridles the blurring itself for expanded throughput. We exhibit the limit of remote MIMO channels, indicating it to be greater than that of the wired SISO channel. Additionally, the limit recipe is utilized to demonstrate how one can decrease transmission control by utilizing multiple radio wire frameworks.

III. SPACE TIME BLOCK CODING

A space time code is a strategy utilized to enhance the unwavering quality of data transmission in remote communication frameworks utilizing multiple transmit reception apparatuses. Basically, two distinctive space-time coding techniques, to be specific space-time trellis codes (STTCs) and Space time square codes (STBCs) have been proposed. STTC has been presented as a coding strategy that guarantees full assorted qualities and generous coding pick up at the cost of a very high disentangling multifaceted nature. To keep away from this burden, STBCs have been proposed by the spearheading work of Alamouti. Space–time piece coding is a system utilized as a part of remote communications to transmit multiple duplicates of a data stream over various radio wires and to abuse the different got variants of the data to enhance the dependability of data-exchange. The way that the transmitted flag must cross a conceivably troublesome environment with scattering, reflection, refraction thus on and may then be further adulterated by thermal commotion in the receiver implies that a portion of the got duplicates of the data will be "better" than others. This repetition brings about a higher possibility of having the capacity to utilize at least one of the got duplicates to accurately interpret the got flag. Truth be told space time coding consolidates every one of the duplicates of the got motion in an ideal approach to remove however much information from each of them as could be expected.

A. Alamouti Code

To introduce Space Time Block Codes, we present The Alamouti code, an early space time code and still one of the most commonly used.

1) Alamouti 2x1

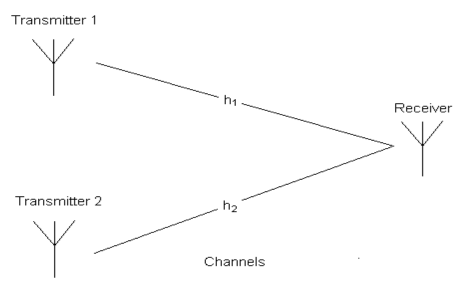

Fig.2Almouti 2x1 MIMO structure

Encoding is done in the following manner:

	Transmitter 1	**Transmitter 2**
Time t	x_1	x_2
Time t + T	$-x_2^*$	x_1^*

where x_1, x_2 are the modulated symbols.

The received vectors are

$y_1 = h_1(x_1) + h_2(x_2) + n_1$ (first time slot)

$y_2 = h_1(-x_2^*) + h\ (x_1^*) + n_2$ (second time slot)

where n_1, n_2 denote AWGN noise and y_1, y_2 denote the received vectors.

These equations can be written in matrix equation form as

$$\begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \begin{bmatrix} h_1 & h_2 \\ h_2^* & -h_1^* \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} n_1 \\ n_2 \end{bmatrix}$$

$H = \begin{bmatrix} h_1 & h_2 \\ h_2^* & -h_1^* \end{bmatrix}$ is an 2X2 Channel matrix where a* represents the Complex Conjugate of a.

$$Y = HX + N \qquad \text{Note: H is an Orthogonal Matrix}$$

It is promptly clear this is a rate-1 code. It requires two investment spaces to transmit two images. The bit error rate (BER) of this STBC is comparable to 2nR-branch maximal proportion consolidating (MPC). This is an aftereffect of the ideal orthogonality between the images after get handling. There are two duplicates of every image transmitted and nR duplicates got. This is an exceptionally unique STBC. It is the main orthogonal STBC that accomplishes rate-1.That is to state that it is the main STBC that can accomplish its full differing qualities pick up without expecting to yield its information rate. Entirely, this is valid for complex regulation images. Since all group of stars charts depend on complex numbers be that as it may, this property for the most part gives Alamouti's code a huge preferred standpoint over the higher-arrange STBCs despite the fact that they accomplish a superior error-rate execution. Figure appears, a common Alamouti STBC-MIMO correspondence framework comprises of transmitter, channel and collector. Space Time coding includes utilization of multiple transmit and get reception apparatuses. Figure1 demonstrates the handset of MIMO in space time code. Bits entering to the information source framework are mapped into the image mapper (regulation) utilizing diverse adjustment techniques like BPSK, QPSK and 16-QAM. Bits entering the Alamouti space time block encoder serially are circulated to parallel sub streams. Inside every sub stream, bits are mapped to flag waveforms, which are then transmitted from the reception apparatus relating to that sub stream. Signals transmitted all the while over every receiving wire meddle with each different as they spread through the remote channel. The collector gathers the flag at the yield of recipient reception apparatus component and turns around the transmitter operation keeping in mind the end goal to unravel the information with Alamouti space time block decoder.

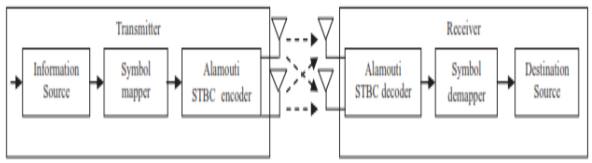

Fig.3 Alamouti STBC-MIMO Communication System

2) Alamouti 2x2

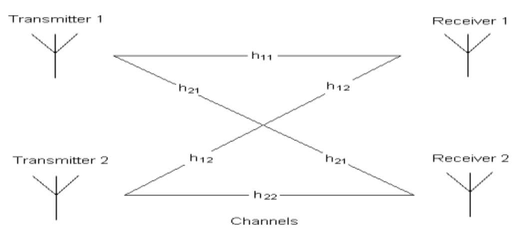

Fig.4 Alamouti 2x2 MIMO structure

We assume that the channel parameters remain constant during the two time slots. Encoding is done in the same manner as discussed in Alamouti 2X1 code.

	Transmitter 1	**Transmitter 2**
Time t	x_1	x_2
Time t + T	$-x_2^*$	x_1^*

3) ML Decoding

The best performance is given by the brute force ML decoder which searches for the matrix X which minimizes the overall noise power. i.e.,

An ML decoder computes an estimate of the transmitted matrix as

$$\hat{X} = \arg\min_{X} \|Y-HX\|^2$$

IV. DENT CHANNEL MODEL

A Rayleigh fading channel constitutes Doppler's spectrum is produced by synthesizing the complex sinusoids. The complex output of the jakes model, is given as,

$$h(t) = \frac{E_0}{\sqrt{2N_0+1}} h_I(t) + jh_Q(t)$$

$$h(t) = 2\sum_{n=1}^{N_0}(\cos\varphi_n \cos w_n t) + \sqrt{2}\cos\varphi_n \cos w_d\, t$$

$$h_Q(t) = 2\sum_{n=1}^{N_0}(\sin\varphi_n \cos w_n t) + \sqrt{2}\sin\varphi_N \cos w_d\, t$$

The undesirable connection of Jake's model is expelled in a change by Dent demonstrate. The undesirable connection can be revised by utilizing orthogonal capacities generated by Walsh Hadamard code word to measure the oscillator values before summing so that every wave has level with power. The weighting is accomplished by altering the Jake's model so that the approaching waves have somewhat extraordinary entry edges. The adjusted Jakes model is given by,

$$T(t) = \sqrt{2/N_0}\sum_{n=1}^{N_0}[\cos\beta_n + i\sin\beta_n]\cos(w_n t + \theta_n)$$

Where, the normalization factor $\sqrt{(2/N_0)}$gives rise to$E\{T(t)T^*(t)\} = 1$,$N_0 = {}^{N}/_{4}$,$i = \sqrt{-1}$,$\beta_n = \prod * n/N_0$is phase, $\theta$is initial phase that can be randomized to provide different waveform realizations and$w_n = w_M\cos(\alpha_n)$is the Doppler shift. Dent's model successfully generates uncorrelated fading waveforms thereby simulating a Rayleigh multi-path air channel.

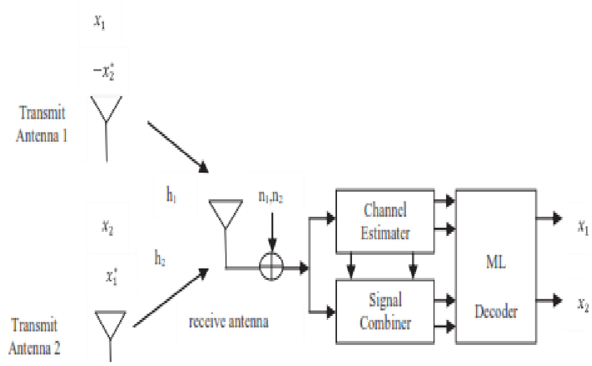

Fig.5 Alamouti two antenna transmit diversity

A. Maximum Likelihood Decoding

We now assume that the channel coefficients $h_1$and $h_2$can be recovered perfectly at the receiver. We use these coefficients as the CSI. The combiner combines the received signal as follows

$$x_1' = h_1^* r_1 + h_2 r_2^* = (\alpha_1^2 + \alpha_2^2)x_1 + h_1^* n_1 + h_2 n_2^*$$

$$x_2' = h_2^* r_1^* - h_1 r_2^* = (\alpha_1^2 + \alpha_2^2)x_2 + h_2^* n_1 - h_1 n_2^*$$

and sends them to the maximum likelihood detector, which minimizes the following decision metric,

$$\left|r_1 - h_1 x_1 - h_2 x_2\right|^2 + \left|r_2 + h_1 s_2^* - h_2 s_1^*\right|^2$$

expanding the above equation and deleting terms that are independent of the code words, the above minimization reduces to separately minimizing

$$\left| r_1 h_2^* - r_2^* h_1 - x_2 \right|^2 + (\alpha_1^2 + \alpha_2^2 - 1) \left| x_1 \right|^2$$

for detecting x_1,

$$\left| r_1 h_2^* - r_2^* h_1 - x_2 \right|^2 + (\alpha_1^2 + \alpha_2^2 - 1) \left| x_2 \right|^2$$

for decoding x_2.

The transmissions in the Alamouti scheme are orthogonal. This implies that the receiver antenna ''sees'' two completely orthogonal streams. Hence, we obtain a transmit diversity of two. Consider two distinct code sequences (x, x') and $S^{\wedge}$generated by the inputs (x_1, x_2) and (x'_1, x'_2) respectively, where $(x_1, x_2) \neq (x'_1, x'_2)$

The code word difference matrix is given by

$$G(x\, x') = \begin{bmatrix} x_1 - -x_1' & -x_2^* - x_2'^* \\ x_2 - x_2' & x_1^* - x_1'^* \end{bmatrix}$$

Since, the rows of the code matrix are orthogonal, the rows of the code word difference matrix are orthogonal as well. The code word distance matrix is given by,

$$\mathrm{A}(\mathrm{x}, \mathrm{x}') = \mathrm{B}(\mathrm{x}, \mathrm{x}')\mathrm{B}^{\mathrm{H}}(\mathrm{x}, \mathrm{x}') = \begin{bmatrix} |\mathrm{x}_1 - \mathrm{x}'_1|^2 + |\mathrm{x}_2 - \mathrm{x}'_2|^2 & 0 \\ 0 & |\mathrm{x}_1 - \mathrm{x}'_1|^2 + |\mathrm{x}_2 - \mathrm{x}'_2| \end{bmatrix}$$

Since,$(\mathrm{x}_1, \mathrm{x}_2) \neq (\mathrm{x}'_1, \mathrm{x}'_2)$, the distance matrixes of any two distinct code words have a full rank of two. Alamouti scheme gives diversity two. The determinant of matrix is given by

$$\det\left(\mathrm{A}(\mathrm{x}, \mathrm{x}')\right) = (|\mathrm{s}_1 - \mathrm{s}'_1|^2 + |\mathrm{s}_2 - \mathrm{s}'_2|^2)^2$$

The code word distance matrix at above equation has two identical eigenvalues. The minimum Eigen value is equal to the minimum squared Euclidian distance in the signal constellation. Hence, the minimum distance between any two transmitted code sequences remains the same as in the un-coded system, this implies that the coding gain is one.

V. EXPERIMENTAL RESULTS

MATLAB has been used as a Simulation tool for the proposed 2x2 MIMO system with Alamouti and Silver STBC's. We had considered various modulation techniques to compare the alamouti STBC for 2x2 MIMO systems.

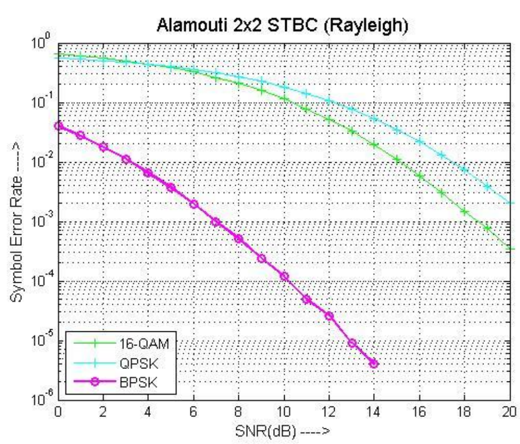

Fig.6 Comparison of various modulation schemes with Alamouti 2x2 STBC under Rayleigh distribution

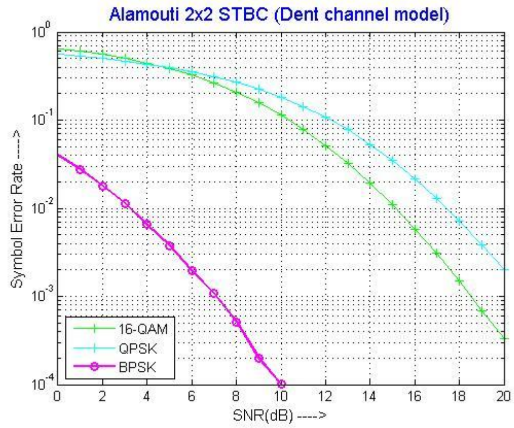

Fig.7 Comparison of various modulation schemes with Alamouti 2x2 STBC under Dent channel model

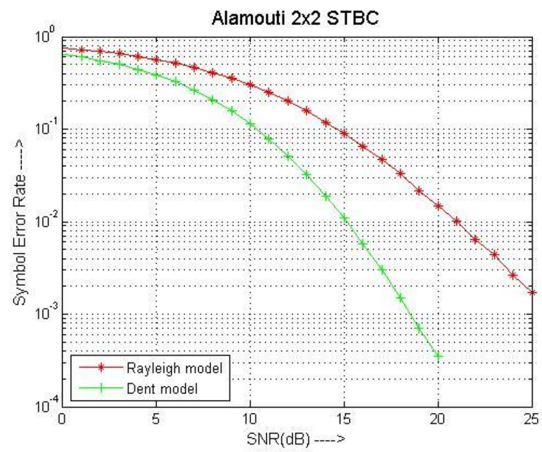

Fig.8 Comparison of Alamouti 2x2 STBC under Rayleigh and Dent channel model

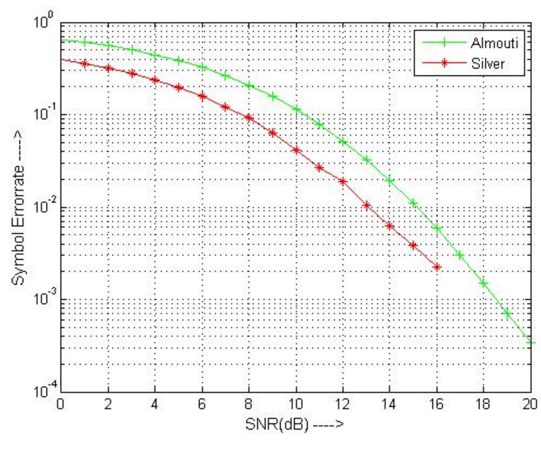

Fig.9 Comparison of Dent Channel with Alamouti and Silver STBC

Figure 6 shows that the comparison of Alamouti STBC for 2x2 MIMO with Rayleigh distribution. The graph shows that the relation between symbol error rate (SER) and signal-to-noise ratio (SNR). Comparison of various modulation techniques with Alamouti 2x2

STBC under dent channel model has been demonstrated in figure 7. Figure 8 displayed that the comparison of Alamouti 2x2 STBC with Rayleigh and Dent channel models with respect to SER and SNR. Comparison of Alamouti and silver codes STBC under the dent channel model has figured out in figure 9. By observing the figure 9 we can conclude that the Silver coded STBC under dent channel model has got superior performance over the Alamouti coded STBC.

VI. CONCLUSIONS

In this paper, we studied Alamouti and Silver STBC-MIMO system performance under different mobile radio channel (dent channel model & Rayleigh channel model). System performance is compared with three different modulation techniques and system with BPSK modulation gives better result. Furthermore, Alamouti STBC provide code rate of 1 and provide full rate and full diversity system with simple decoding technique. Maximum likelihood (ML) decoding reduces the decoding complexity of the system and enhances the system performance. By employing dent model at the channel simulation speed is increased as compared to the Rayleigh channel model. This increases the data speed. It is clearly observed by the simulation result that the system performance enhances using dent channel model. Furthermore enhancement has been done by using Silver STBC with dent channel model. It has compared with Alamouti dent and proven that the Silver STBC has got superior performance over Alamouti STBC.

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