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Comparison of BER and SNR by using Different Modulation and STBC Code for MIMO

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Abstract

The paper presents the comparison of various modulation technique victimization BER and SNR and coordinate system Block Codes (STBC) for Multiple-Input Multiple-Output (MIMO) systems to assure transmit diversity. The receive diversity is resolved with a most magnitude relation combining technique. For the various variety of transmit antennas, the performances of various STBC codes are analyzed in terms of Bit Error Rate (BER) and SNR for a quasi-static physicist flat weakening channel. Finally, it is shown that by increasing the quantity of transmit receive antennas, the system performances increase, and conjointly error performance analysis of multiple rate space-time-block code (STBC) for MIMO wireless network. This necessitates that the MIMO system should be capable to beat rate limitation and there should have choices open for future improvement. Error performance and spectral potency will any be improved by incorporating STBC with MIMO system. Recently several researchers are functioning on MIMO systems with STBC to boost the performance of system while not further information measure or transmit power necessities. We have got thought-about simulation results to match the performances of SNRVs BER exploitation completely different modulation and with and while not STBC and accumulated MIMO system to ascertain the performance of BER.

Keywords: *BER, SNR, STBC, MIMO, technique*

INTRODUCTION

In trendy wireless communication systems like 3G,4G, wireless local area network and Wi-MAX, the multipath propagation channels shapely as a Multiple-Input Multiple-Output (MIMO) system. So, as to combat the consequences of multipath attenuation and to extend the capability and reliableness of the wireless channel, a sensible answer is that the spatial diversity, victimisation multiple antennas at one or each side of the link. For MIMO systems, the information of channel State info (CSI) at the transmitter (CSIT) and at the receiver (CSIR) is the early criterion for selecting a diversity technique [1, 2]. At the receiver, if the channel is unknown it is calculable mistreatment completely different techniques sowed suppose that we tend to continuously have CSIR. At the transmitter, if the channel acknowledged is thought (with CSIT) then beam forming techniques square measure accustomed assure each the range gain and, therefore, the array gain; if the channel is not known (without CSIT) then reference system (ST) codes square measure accustomed assure solely the range gain. The ST codes square measure a additional general category of error correcting codes, with a spatial-temporal structure, the management symbols being inserted in each special and Foschini introduces the multi-layered reference system design, referred to as Bell Labs superimposed reference system (BLAST). Later, in square measure projected the reference system Trellis Codes (STTrC) which give the simplest exchange between constellation size, data rate, diversity gain and trellis complexness, however, with a bigger coding complexness [3–6].

Addressing the last issue, Alamouti introduced in an easy diversity theme for two transmit antennas, that provides a most diversity gain and no cryptography gain for a minimum secret writing quality [7–10]. Later, the Alamouti code was generalized for an absolute range of transmit antennas by Tarokh *et al.* as the Space-Time Block Code (STBC) [7].

Communication technologies became a really vital a part of human life. Wireless communication systems have opened new dimensions in communications. Folks will be reached at any time and at anyplace. Over 700 million folks round the world purchase existing second and third generation cellular systems supporting information rates of nine, half dozen kbps to 2Mbps. a lot of recently, IEEE 802.11 wireless computer network networks change communication at rates of around 54Mbps and have attracted quite one, half dozen billion USD in instrumentality sales. Over successive 10 years, the capabilities of those technologies square measure expected to maneuver towards the 100 Mbps - 1 Gbps vary and to subscriber numbers of over 2 billion. At the current time, the wireless communication analysis community and trade discuss standardizations for the fourth mobile generation (4G). The analysis community has generated variety of promising solutions for vital enhancements in system performance. One in every of the foremost promising future technologies in mobile radio communications is multi antenna parts at the transmitter and at the receiver.

MIMO stands for multiple-input multiple-output and suggests that multiple antennas at each antenna ends of a communication system, i.e., at the transmitter and at the receiver aspect. The multiple-antennas at the transmitter and/or at the receiver in an exceedingly wireless communication link open a replacement dimension in reliable communication, which may improve the system performance considerably. The concept behind MIMO is that the transmit antennas at one finish and also the receive antennas at the opposite finish are “connected and combined” in such the simplest way that the standard (the bit error rate (BER), or the information rate) for every user is improved. The core idea in MIMO transmission is space-time signal processing in which signal processing in time is complemented by signal processing in the spatial dimension by using multiple, spatially distributed antennas at both link ends.

Because of the big capability increase MIMO systems provide, such systems gained a great deal of interest in mobile communication analysis [5, 7]. One essential drawback of the wireless channel is attenuation, that happens because the signal follows multiple ways between the transmitter and also the receive antennas. Below sure, not uncommon conditions, the arrival signals can add up destructively, reducing the received power to zero (or terribly just about zero). During this case no reliable communication is feasible. Fading are often satisfied by diversity, which implies that the data is transmitted not one time, however, many times, hoping that a minimum of one amongst the replicas would not bear severe attenuation. Diversity makes use of a very important property of wireless MIMO channels, totally different signal methods typically often sculptured as variety of separate, freelance attenuation channels. These channels are often distinct in frequency domain or in time domain [11].

Several transmission schemes are projected that utilize the MIMO channel in numerous ways in which, e.g., spatial multiplexing, reference frame committal to writing or beam forming. Reference frame committal to writing (STC), introduced initial by Tarokh *et al.* could be a promising methodology wherever the quantity of the transmitted code symbols per slot are adequate the quantity of transmit antennas [6]. These code symbols are generated by the reference frame encoder in such some way that diversity gain, committal to writing gain, similarly as high spectral potency are achieved. Reference frame committal to writing finds its application in cellular communications similarly as in wireless native space networks. There are various coding methods as space-time trellis codes (STTC), space time block codes (STBC), space-time turbo trellis codes and layered space-time (LST) codes. A main issue in all these schemes is the exploitation of redundancy to achieve high reliability, high spectral efficiency and high performance gain. The design of STC amounts to find code matrices that satisfy certain optimality criteria [12, 13]. In particular, STC schemes optimize a trade-off between the three conflicting goals of maintaining a simple decoding algorithm, obtaining low error probability, and maximizing the information rate. In the previous couple of years the analysis community has created a colossal effort to grasp coordinate system codes, their performance and their limits. The aim of this work is to elucidate the conception of coordinate system block secret writing in an exceedingly systematic method. This thesis provides an outline of STBC style principles performance. The most focus is devoted the comparisons of BER Vs SNR for QPSK and QAM-16. Our goal is to supply a unified theory of STBCs completely different transmit antennas and different receive antenna and to investigate their performance on different MIMO channels, mistreatment multiple channels, i.e., AWGN and John William Strutt flat attenuation channels.

OBJECTIVE

Finding BER for STBC system for different Modulations, different channels and for number of transceivers.

- BER for QPSK and QAM-16.
- SNR Vs BER for AWGN and Rayleigh flat fading channel.
- SNR Vs BER for different number of transmitter and receivers.

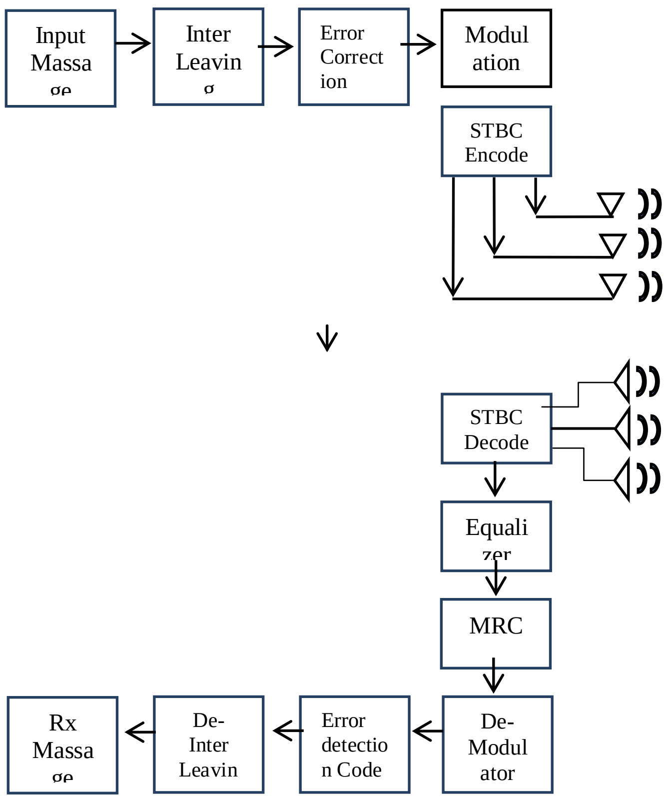

Fig. 1: *Block Diagram.*

Transmitter

Inter-Leaving

Inter-leavers are designed and utilized in the context of characteristics of the errors that may occur once the message bits are transmitted through a loud channel. To know the functions of AN inter-leaver understanding of error characteristics is important. Two sorts are errors concern communication system style engineer. They are burst error and random error. Interleaving could be a technique for creating forward error correction a lot of sturdy with reference to burst errors. An interleaver permutes symbols according to a mapping. Interleaving can be useful for reducing errors caused by burst errors in a communication system.

Random Errors

Error locations square measure freelance of every different. Error on one location would not have an effect on the errors on different locations.

Channels that introduce these varieties of errors square measure known as channels while not memory (since the channel has no information of error locations since the error on location does not have an effect on the error on another location).

Burst Errors

Errors are trusted one another to illustrate, in channels with deep weakening characteristics, errors typically occur in bursts (affecting consecutive bits). That is, error in one location incorporates a contagious result on different bits. In general, these errors are thought of to be dependent and such channels are thought of to be channels with memory. One in every of the foremost common ways that to correct burst errors is to require a code that works well on random errors and interleave the bursts to “spread out” the errors so they seem random to the decoder. There are two sorts of interleavers unremarkably in use these days, block interleavers and convolution interleavers.

The block interleaver is loaded row by row with L code words, each of length n bits. These L codeword’s are then transmitted column by column until the interleaver is emptied. Then the interleaver is loaded again and the cycle repeats. At the receiver, the code words are deinterleaved before they are decoded. A burst of length L bits or less can cause no over one bit error in anyone codeword. The random error decoder is far a lot of doubtless to correct this single error than the whole burst. The parameter L is termed the interleavers degree, or interleavers depth. The interleavers depth is chosen supported worst case channel conditions. It should be massive enough so the interleaved code will handle the longest error bursts expected on the channel. The main drawback of block interleavers is the delay introduced with each row-by-row fill of the interleavers.

In observe, interleaving is one in all the simplest burst-error correcting techniques. In theory, it is the worst thanks to handle burst errors. Why? From a strict probabilistic sense, we tend to are changing “good” errors into “bad” errors. Burst errors have structure which structure is often exploited. Interleavers “randomize” the errors and destroy the structure. Theory differs from reality, however. Interleaving could also be the sole technique on the market to handle burst errors with success. To Illustrate, Viterbi showed that, for a channel impaired by a pulse transmitter, exploiting the burst structure is not enough. Interleaving remains needed. This does not mean that we must always be careless concerning our selection of code and take up the slack with long interleavers. Codes designed to correct burst errors are able to do an equivalent performance with a lot of shorter interleavers. Till the committal to writing theorists discover a higher means, interleaving are a necessary error management committal to writing technique for bursty channels.

Error Correcting Codes

An error-correcting code is associate in nursing algorithmic program for expressing a sequence of numbers such any errors that square measure introduced will be detected and corrected (within sure limitations) supported the remaining numbers. The study of error-correcting codes and also the associated arithmetic is thought as committal to writing theory.

Error discoverion is way less complicated than error correction and one or a lot of "check" digits area unit unremarkably embedded in mastercard numbers so as to detect mistakes. Early house probes like seafarer used a kind of error-correcting code referred to as a block code, and newer house probes use convolution codes. Error-correcting codes are utilized in CD players, high speed modems, and cellular phones.

Modems use error detection after they reason checksums, that area unit sums of the digits in an exceedingly given transmission modulo some range. The ISBN accustomed determines books conjointly incorporate a check digit.

Modulation

Modulation is a process of mixing a signal with a sinusoid to produce a new signal. This new signal, conceivably, will have certain benefits over an un-modulated signal.

$$f(t) = A\sin(\omega t + \varphi)$$

We can see that this sinusoid has 3 parameters that can be altered, to affect the shape of the graph. The first term, A, is called the magnitude, or amplitude of the sinusoid. The next term, ω is known as the frequency, and the last term, ϕ is known as the phase angle. All 3 parameters can be altered to transmit data. The sinusoidal signal that is used in the modulation is known as the carrier signal, or simply "the carrier". The signal that is used in modulating the carrier signal (or sinusoidal signal) is known as the "data signal" or the "message signal". It is important to notice that a simple sinusoidal carrier contains no information of its own. In other words we can say that modulation is used because some data signals are not always suitable for direct transmission, but the modulated signal may be more suitable.

QPSK Modulation

Quadrature Phase Shift Keying (QPSK) may be a kind of section Shift Keying within which 2 bits are modulated promptly, choosing one in every of four doable carrier section shifts (0, 90, 180, or 270 degrees). QPSK permits the signal to hold double the maximum amount as info compare to normal PSK for an equivalent information measure

QAM-16

Quadrature Amplitude Modulation (QAM) is both an analog and a digital modulation scheme. It conveys two analog message signals, or two digital bit streams, by dynamic (modulating) the amplitudes of two carrier waves, victimisation the amplitude-shift keying (ASK) digital modulation theme or AM (AM) analog modulation theme. The two carrier waves of identical frequency, sometimes sinusoids, square measure out of part with one another by 90° and square measure, therefore, referred to as construction carriers or construction elements, hence the name of the theme. The modulated waves square measure summed, and also the final wave form could be a combination of each phase-shift keying (PSK) and amplitude-shift keying (ASK), or, within the analog case, of PM (PM) and AM. In the digital QAM case, a finite number of at least two phases and at least two amplitudes are used. PSK modulators are often designed using the QAM principle, but are not considered as QAM since the amplitude of the modulated carrier signal is constant.QAM is used extensively as a modulation scheme for digital telecommunication systems.

Arbitrarily high spectral efficiencies can be achieved with QAM by setting a suitable constellation size, limited only by the noise level and linearity of the communications channel.

Space–Time Block Coding (STBC)

Space–time block writing may be a technique employed in wireless communications to transmit multiple copies of an information stream across variety of antennas and to take advantage of the various received versions of the info to enhance the dependability of data-transfer. The very fact that the transmitted signal should traverse a doubtless tough setting with scattering, reflection, refraction then on and will then be any corrupted by thermal noise within the receiver means a number of the received copies of the info are 'better' than others. This redundancy leads to the next probability of having the ability to use one or additional of the received copies to properly decipher the received signal. In fact, space–time writing combines all the copies of the received signal in a best thanks to extract the maximum amount info from every of them as attainable.

Space-time block codes (STBC) area unit a generalized version of Alamouti theme, however, has constant key options. These codes area unit orthogonal and may reach full transmit diversity such that by the amount of transmit antennas. In different words, reference system block codes area unit a fancy version of Alamouti's reference system code, wherever the secret writing and decryption schemes area unit constant as there within the Alamouti reference system code on each the transmitter and receiver sides. The information area unit created as a matrix that has its columns up to the amount of the transmit antennas and its rows up to the amount of the time slots needed to transmit the information. At the receiver facet, the signals received area unit initial combined victimization most magnitude relation combiner and also the send to MMSE and also the reception of QPSK and QAM-16. Space-time block codes were designed to attain the most diversity order for the given range of transmit and receive antennas subject to the constraint of getting an easy linear decryption algorithmic program. This has created reference system block codes a awfully standard and most generally used theme. Training-based strategies appear to offer superb results on the performance of channel estimation at the receiver [4]. The comparison are spoken SNR is high than the BER and result's terribly clearly obtaining. Pure training-based schemes will be thought of as a bonus once associate degree correct and reliable MIMO channel has to be obtained. However, this might even be a drawback once information measure potency is needed. This is often as a result of pure coaching-based schemes cut back the information measure potency significantly because of the utilization of an extended training sequence that is essentially required so as to get a reliable MIMO channel estimate. As a result of the computation complexness of blind and semi-blind strategies, several wireless communication systems still use pilot sequences to estimate the channel parameters at the receiver aspect.

We consider a general MIMO system with *NT* transmits antennas and *NR* receives antennas, employing a space-time encoder, a MIMO channel with *NT* inputs and *NR* outputs and a space-time decoder with MRC technique and MMSE.

The Space-Time Encoder

The simplest transmit diversity scheme for two transmit antennas is the Alamouti code, described by the transmission matrix:

$$G=\begin{bmatrix} x_1 & x_2 \\ -x_2^* & x_1^* \end{bmatrix}$$

To transmit m bits/channel use we use a modulation that maps every m bits to one symbol from a real or complex constellation with M = 2m symbols, for example PSK or QAM. The transmitter picks two symbols from the constellation, for example, x1 and x2. In the first time slot t1, the first antenna transmits the symbol x1 and the second antenna the symbol x2. Then, in the second time slot t2, the symbols–x2* and x1* are transmitted simultaneously from the two antennas. Both symbols x1 and x2 are spread over two transmit antennas and over two time slots. At the transmitter, we do not know the channel (without CSIT), so we suppose an equal transmit power for each antenna and a unitary total transmit power.

The Space-Time Coded MIMO Channel

The transmitted symbols over the MIMO channel are affected by severe magnitude fluctuations and phase rotations.

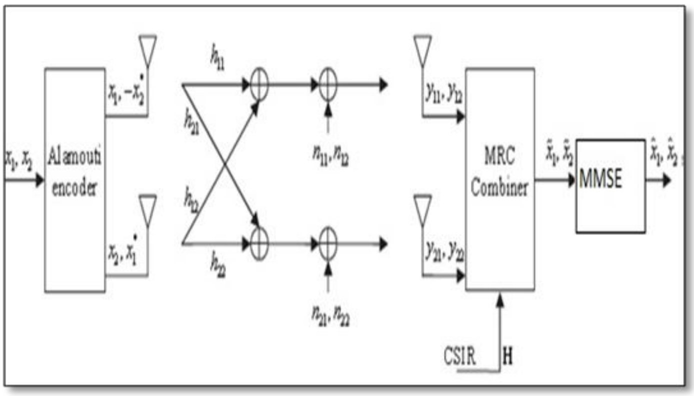

Fig. 2: *A Particular MIMO 2x2 System with Alamouti Coding and MRC and MMSE.*

$$\begin{aligned} y_{11} &= h_{11}x_1 + h_{12}x_2 + n_{11}, \\ y_{12} &= -h_{11}x_2^* + h_{12}x_1^* + n_{12}, \\ y_{21} &= h_{21}x_1 + h_{22}x_2 + n_{21}, \\ y_{22} &= -h_{21}x_2^* + h_{21}x_2^* + n_{22}, \end{aligned}$$

Where, h_{ij} is the path gain between the j^{th} transmit antenna and the i^{th} receive antenna. The term n_{ij} is the additive noise for the i^{th} receive antenna at the j^{th} time slot, modeled as independent complex Gaussian random variables with zero-mean and variance 1/(2*SNR*) per complex dimension, where *SNR* is the signal to noise ratio of the channel.

Channel

Rayleigh Fading Channel

The delays connected with totally different signal methods during a multipath weakening channel modification in an unplanned manner and may solely be characterized statistically. Once there are an outsized range of methods, the central limit theorem is often applied to model the time-variant impulse response of the channel as a complex-valued mathematician random method. Once the impulse response is sculptured as a zero mean complex-valued mathematician method, the channel is claimed to be a John William Strutt weakening channel. The article gives a quick overview of a simple statistical multipath channel model called Rayleigh fading channel model.

We assume a quasi-static flat weakening John William Strutt channel, with coherence time Tc. For a flat weakening channel, the weakening coefficients hij stay constant inside a frame of length Tc time slots and alter into new ones from frame to border. Also, we have a tendency to assume unrelated path gains (the distance between 2 antennas is over half the wavelength) that vary severally from one frame to a different. For a quasi-static channel, the trail gains area unit constant over a frame of length multiple of Tc. For a John William Strutt channel, the trail gains area unit freelance advanced mathematician random variables, with zero mean and variance 0.5 per real dimension.

Receiver

STBC Decoder

At the receiver, we suppose a perfect CSIR, so we use the Maximal Ratio Combining (MRC) technique, combining coefficients being optimally chosen equal with the complex conjugated equivalent channel matrix.

MMSE Equalization

In Minimum Mean Square Error solution, for each sample time k we would want to find a set of coefficients c[k] which minimizes the error between the desired signal y[k]and the equalized signal c[k]⊗y[k], i.e.,

$$E(e[k])^2 = E(s[k] - c[k] \otimes y[k])^2$$

$$= E(s[k] - c_y^T)(s[k] - c_y^T)T$$

$$= E(s[k])^2 - c_y^T) - E\left(c_y^T s[k]\right) - E(s[k] y_c^T) + E(c^T yyT_c)$$

$$= E(s[k])^2 - c^T Rys - Rsyc + c^T Ryyc$$

Where,

e[k] is the error at sample time k,

C is column vector of dimension k*1 storing the equalization coefficients,

K is column vector of dimension k*1 storing the received samples,

K is the number of taps in the equalizer,

R_{ys} = E(ys[l]) is the cross correlation between received sequence and input sequence ,

$R_{sy} = E(s[k]y^T)$ is the cross correlation between received sequence and input sequence and

$R_{yy} = E(yy^T)$ is the auto-correlation of the received sequence.

For solving the Minimum Mean Square Error (MMSE) criterion, we need to find a set of coefficients c which minimizes $E(e[k])^2$.

Differentiation with respect to c and equating to 0,

$$\frac{\partial}{\partial c}\left[E(s[k])^2 - c^T R_{ys} - R_{sy}c + c^T R_{yy}c\right] = 0$$
$$-R_{sy} + R_{yy}c = 0$$
$$c = R_{yy}^{-1} R_{sy}$$

Simplifying, $R_{sy} = E(s[k]y^T)$

$= E(s[k](hs[k] + n)^T$

$= h^T E(s^2[k]) + E(s[k]n)$

$= h,$

$R_{yy} = E(yy^T)$

$= E((hs[k] + n)(hs[k] + n)^T$

$= E(hh^T)E(s^2[k]) + hE(s[k]n) + E(n[k]s[k])h^T + E(n^2)$

$= E(hh^T) + E(n^2)$

Note:

a) $E(s^2[k]) = 1$ is the variance of the input signal

b) $E(s[k]n[k]) = 0$ (as there is no correlation between input signal and noise)

Maximum Ratio Combing (MRC)

Combining all the signals in an exceedingly co-phased and weighted manner, therefore, on have the very best doable SNR at the receiver in the least times. In MRC, all the branches are used at the same time. Every of the branch signals are weighted with a gain issue proportional to its own SNR.

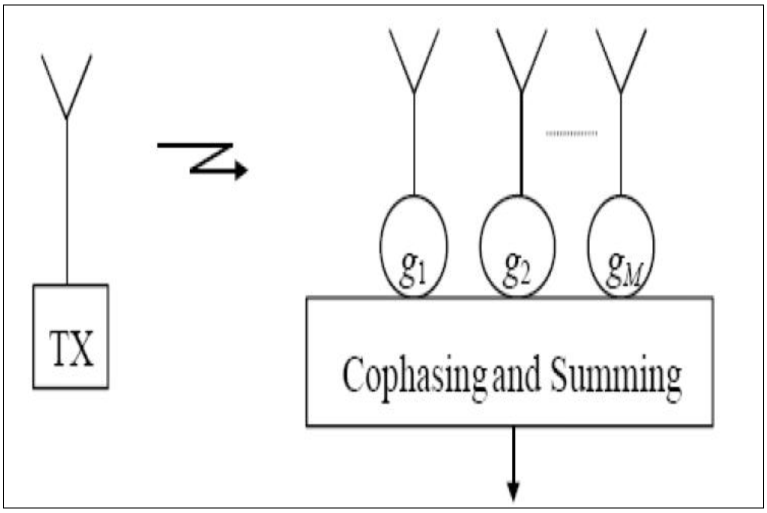

Fig. 3: *Maximum Ratio Combining.*

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Derivation of Maximum Ratio Combining Improvement

Co-phasing and summing is done for adding up the weighted branch signals in phase. The gain associated with the ith branch is decided by the SNR of the corresponding branch, i.e., $g_i=(S/N)_i$

The MRC scheme requires that the signals be added up after bringing them to the same phase, if a_i is the signal envelope, in each branch then the combined signal envelope is given as,

$$a = \sum_{i=1}^{M} a_i \; g_i$$

Assuming that the noise components in the channel are independent and identically distributed in each branch, total noise power is,

$$Nt = No \sum_{i=1}^{M} a_i \; g_i$$

The resulting SNR is thus given by

$\gamma = a^2 E_b /N_o = (E_b /N_o)($ $\Sigma_{g_i\, a_i)} 2 /(\Sigma_{g_i\,)} 2)2$The equality in this case is obtained when $g_i=k*a_i$, k being some constant. The maximum value of the output SNR after MRC is given by,

i.e.,

$\gamma = \Sigma(E_b /N_o)\ (a_i^{\,2})= \Sigma\, \gamma_i$

(All summations between i=1, 2 ...M). Thus, we notice that the sum of the SNRs of the individual branches yields the final SNR of the output. To obtain the distribution of the combined signal, observe that,

$\gamma_i = (E_b /N_o)a_i^2 = (E_b /N_o)*(X_i^2 + y_i^2)$

γ_i is χ2 distributed with degree 2 which is the same as an exponential distribution.

Let $\gamma = \Sigma\, \gamma_i$. Then we can see that γ is χ2 distributed with degree 2M. Then the PDF of γ is given by,

$\rho(\gamma) = 1/(M-1)! * \gamma\, \gamma^{M-1}/\gamma_0^{M*}\ \ \exp(-\gamma/\gamma_0)$

With $\gamma >= 0;$

γ_0 is the mean SNR in each branch and is given by 2σ2Eb/No. The CDF of γ is

$P(\gamma) = \int_0^{\gamma} \frac{1}{(M-1)!} \frac{x^{M-1}}{\gamma_0^M} \exp\left(-\frac{x}{\gamma_0}\right) dx$

$= 1 - exp\left(\frac{\gamma}{\gamma_0}\right) \sum_{i=0}^{M} \frac{1}{(i=1)!} \left(\frac{\gamma}{\gamma_0}\right)^{i-1}$

It can be noticed that as compared to selection combining, the fall of the probability is more rapid.

Example: at a level of 10dB below γ_0, M=1 Probability=0.1, M=2 Probability =0.005. The main challenge in MRC combining is the co-phasing of the incoming branches after weighting them. The expected value of the signal strength, E[Signal Strength]= E[Σγi] = Mγ0.

Demodulation

QPSK Demodulation

For QPSK detector, a coherent detector is taken as associate example. In coherent detection technique the data of the carrier frequency and section should be glorious to the receiver. This will be achieved by employing a PLL (phase lock loop) at the receiver.

QAM-16

In this experiment, solely the principle of severally sick either message A or message B from the QAM is incontestible. Therefore, just one 1/2 the rectifier want be made. By acceptable adjustment of the part either message A or message B will be recovered.

Error Detection Code

An error-correcting code is an algorithmic program for expressing a sequence of numbers such any errors that square measure introduced is detected and corrected (within bound limitations) supported the remaining numbers. The study of error-correcting codes and also the associated arithmetic is understood as secret writing theory. Error sightion is way less complicated than error correction and one or additional "check" digits square measure unremarkably embedded in mastercard numbers so as to detect mistakes. Early house probes like Jack used a sort of error-correcting code known as a block code, and newer house probes use convolution codes. Error-correcting codes are also used in CD players, high speed modems, and cellular phones. Modems use error detection when they compute checksums, which are sums of the digits in a given transmission modulo some number.

De-Interleaving

A corresponding deinterleaver uses the inverse mapping to revive the first sequence of symbols. It is often helpful for reducing errors caused by burst errors in a very communication system. Output is given to receiver message and obtaining the noise free receiver message, that why we tend to calculate the BER for various transreceiver.

MIMO FOR WIRELESS NETWORKS

Digital communication victimization multiple-input–multiple output (MIMO) additionally known as as “volume-to-volume” wireless link and has emerged in concert of the foremost important technical breakthroughs in trendy communications. The technology figures conspicuously on the list of recent technical advances with an opportunity of breakdown the bottleneck of traffic capability in future

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Internet-intensive wireless networks. Even perhaps additional shocking is that simply a couple of years when its invention, the technology appears poised to penetrate large-scale standards-driven business wireless merchandise and networks corresponding to broadband wireless access systems, wireless native space networks (WLAN), third-generation (3G) networks and on the far side.

MIMO systems are often outlined as: Given associate degree discretionary wireless communication system, we have a tendency to think about a link during which the transmittal finishes further because the receiving end is provided with multiple antenna components. the thought behind MIMO is that the signals on the transmitter (TX) antennas at one finish and, therefore, the receiver (RX) antennas at the opposite finish square measure "combined" in such the way that the standard (bit-error rate or BER) or the info rate (bits/sec) of the communication for every MIMO user are going to be improved. Such a bonus is often wont to increase each the network's quality of service and, therefore, the operator's revenues considerably.

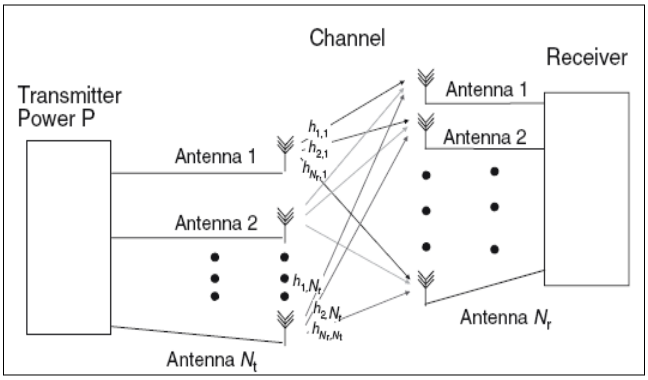

Fig. 4: *Multiple Input Multiple Output System.*

A core idea in MIMO systems are space–time signal processing in which time (the natural dimension of digital communication data) is complemented with the spatial dimension inherent in the use of multiple spatially distributed antennas. As such MIMO systems can be viewed as an extension of the so-called smart antennas, a popular technology using antenna arrays for improving wireless transmission dating back several decades. It is important to note that each antenna element on a MIMO system operates on the same frequency and, therefore, does not require extra bandwidth. Also, for fair comparison, the total power through all antenna elements is less than or equal to that of a single antenna system, i.e,

$$\sum_{K}^{N} = 1P_k \quad \leq P \qquad (1)$$

Where, N is the total number of antenna elements, p^k is the power allocated through the k^{th} antenna element, and P is the power if the system had a single antenna element. Effectively, the equation (1) ensures that a MIMO system consumes no extra power due to its multiple antenna elements.

We consider a general MIMO system with *NT* transmit antennas and *NR* receive antennas, employing a space-time encoder, a MIMO channel with *NT* inputs and *NR* outputs and a space-time decoder with MRC technique and Maximum Likelihood (ML) decoding.

APPLICATION AND ADVANTAGES

Advantages

1. Makes efficient use of the spectrum by allowing overlap.
2. Eliminates ISI and IFI through use of a cyclic code.
3. Using adequate channel coding and interleaving one can recover symbols lost due to the frequency selectivity of the channel.
4. Channel equalization becomes simpler than by using adaptive equalization techniques with single carrier systems.
5. Is less sensitive to sample timing offsets than single carrier systems are.
6. Provides good protection against co-channel interference and impulsive parasitic noise.

Applications

1. Wireless Local Area Networks (LANs).
2. Digital Televisions Transmission (European and Australian standards).
3. ADSL (asymmetric digital subscriber loop), for high speed data transmission along existing telephone lines.
4. May be used in future Mobile communication.

RESULTS

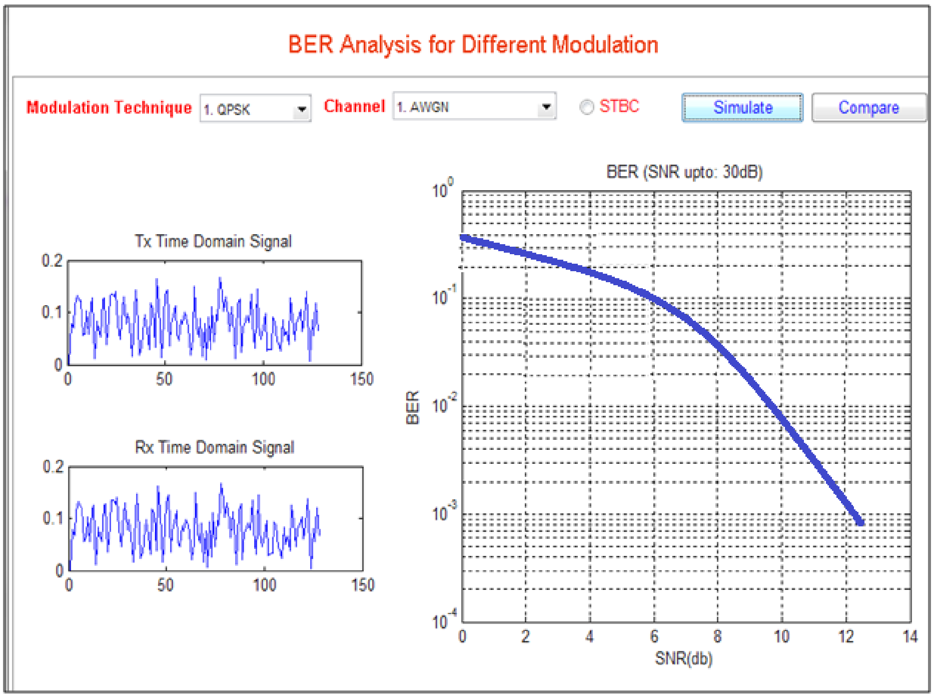

Fig. 5: *Output for QPSK using AWGN.*

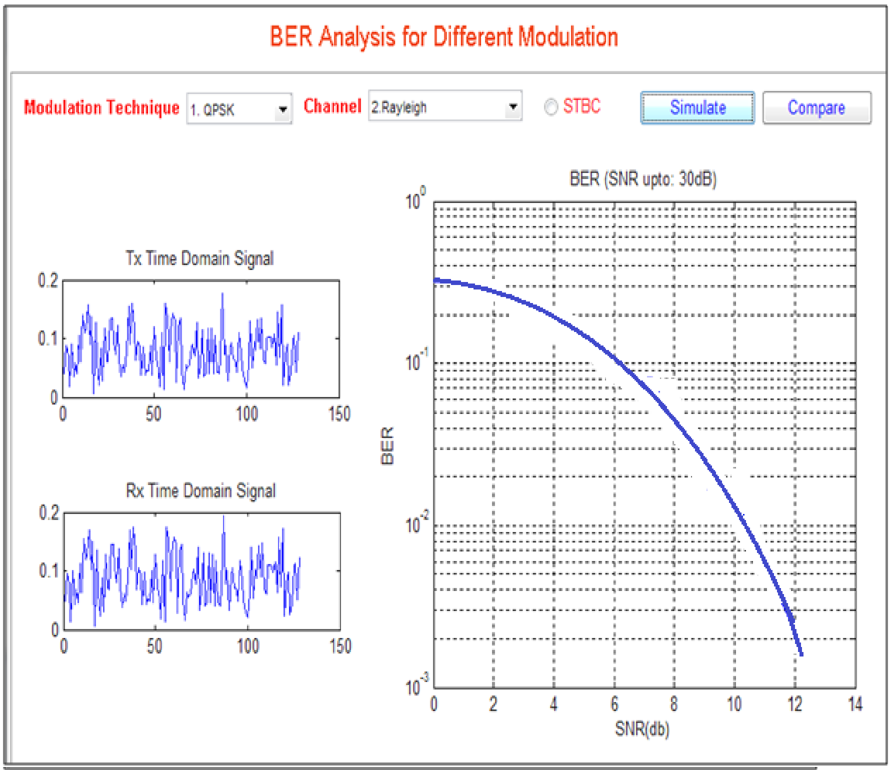

Fig. 6: *Output for QPSK using Rayleigh Fading Channel.*

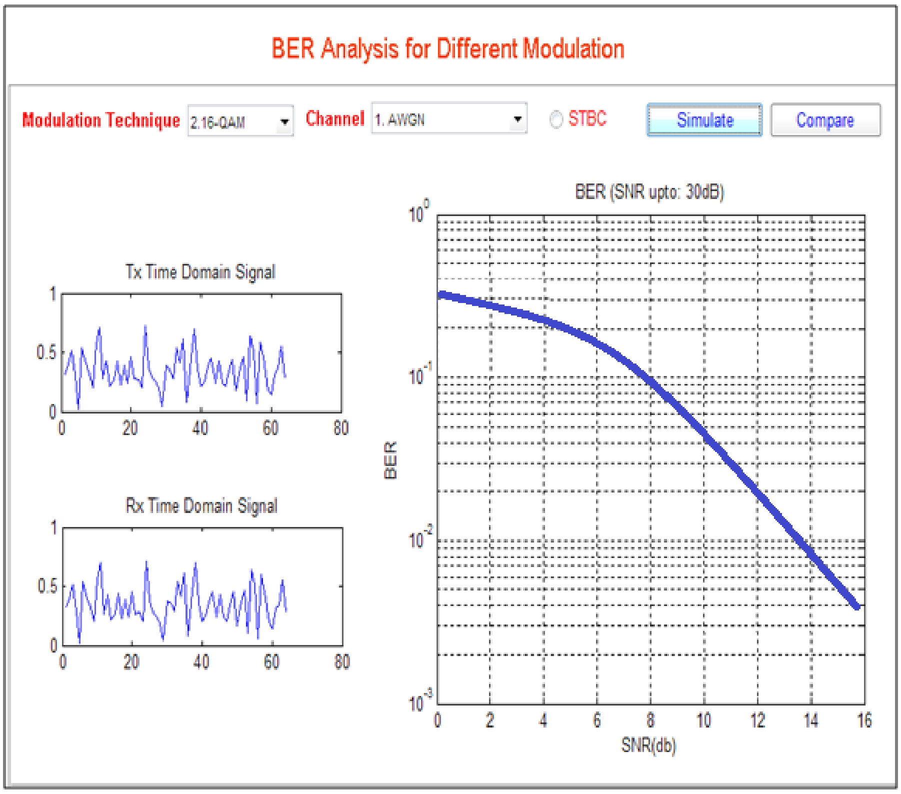

Fig. 7: *Output for 16 QAM using AWGN.*

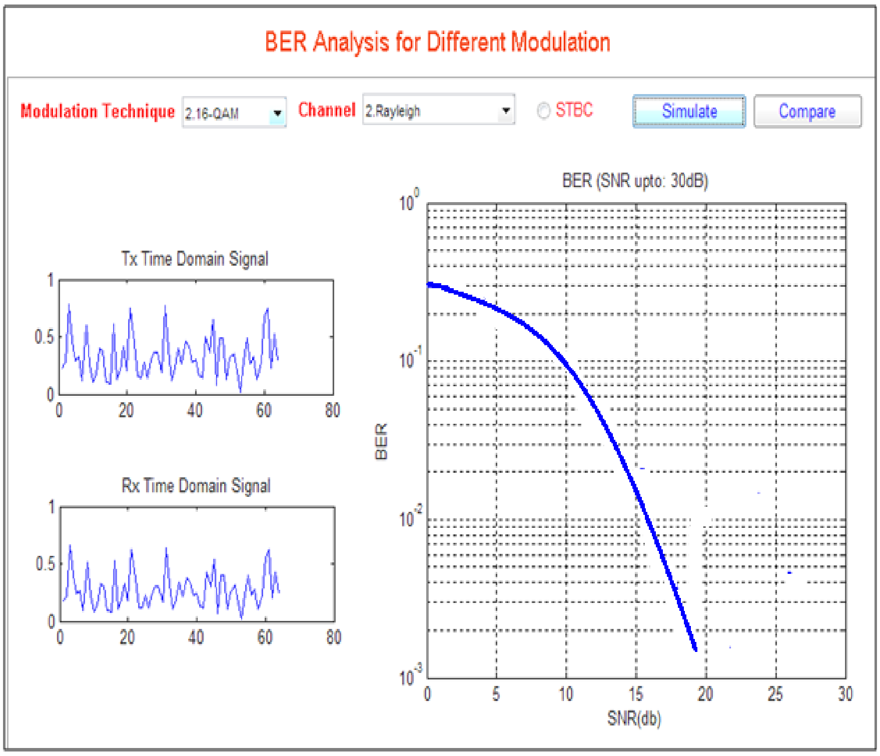

Fig. 8: *Output for 16 QAM using Rayleigh Fading Channel.*

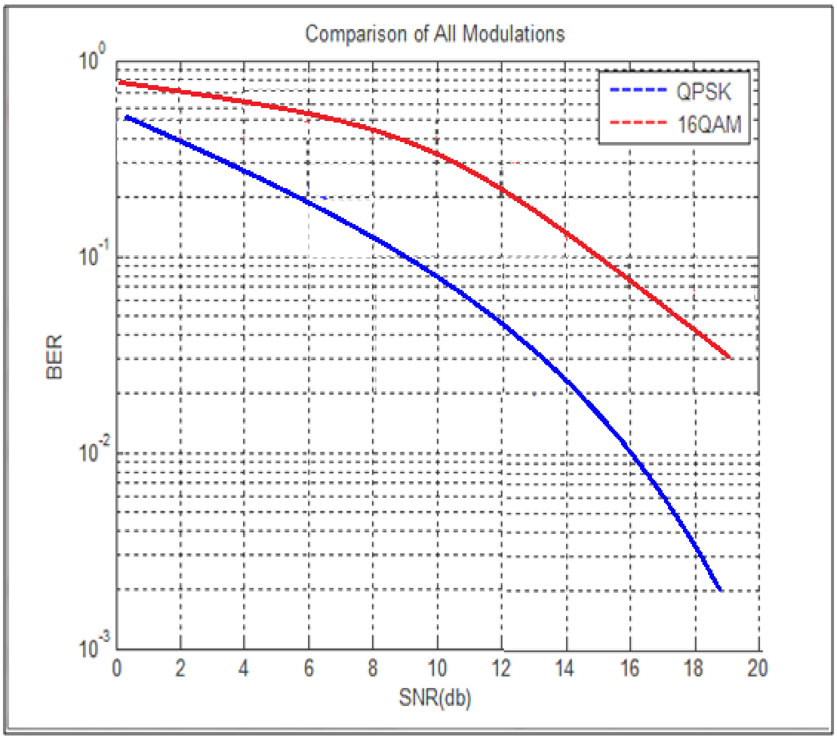

Fig. 9: *Comparisons of QPSK and 16 QAM Modulation.*

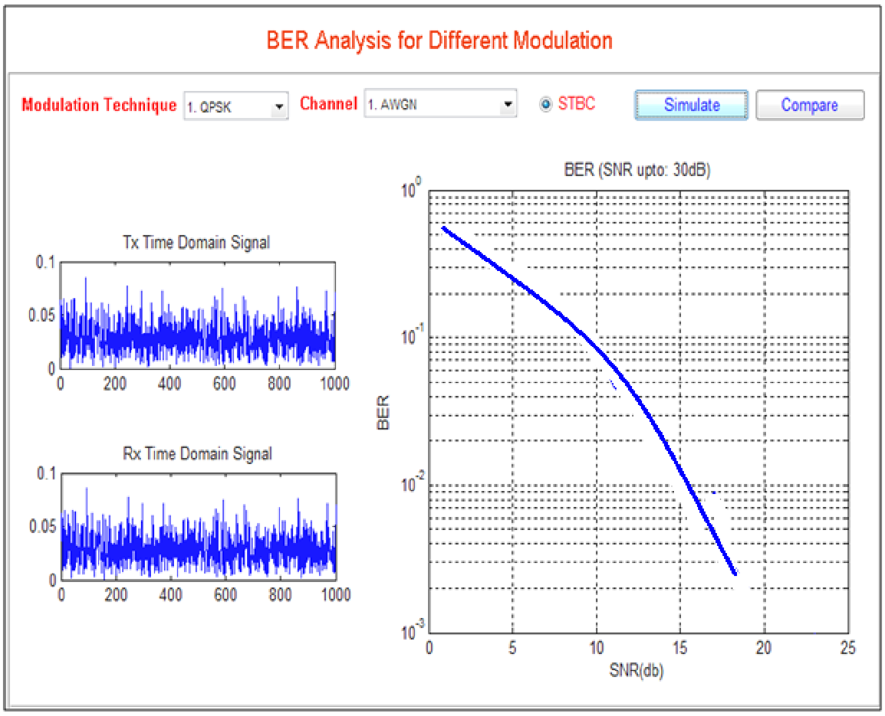

Fig. 10: *Output for QPSK using Channel AWGN with STBC.*

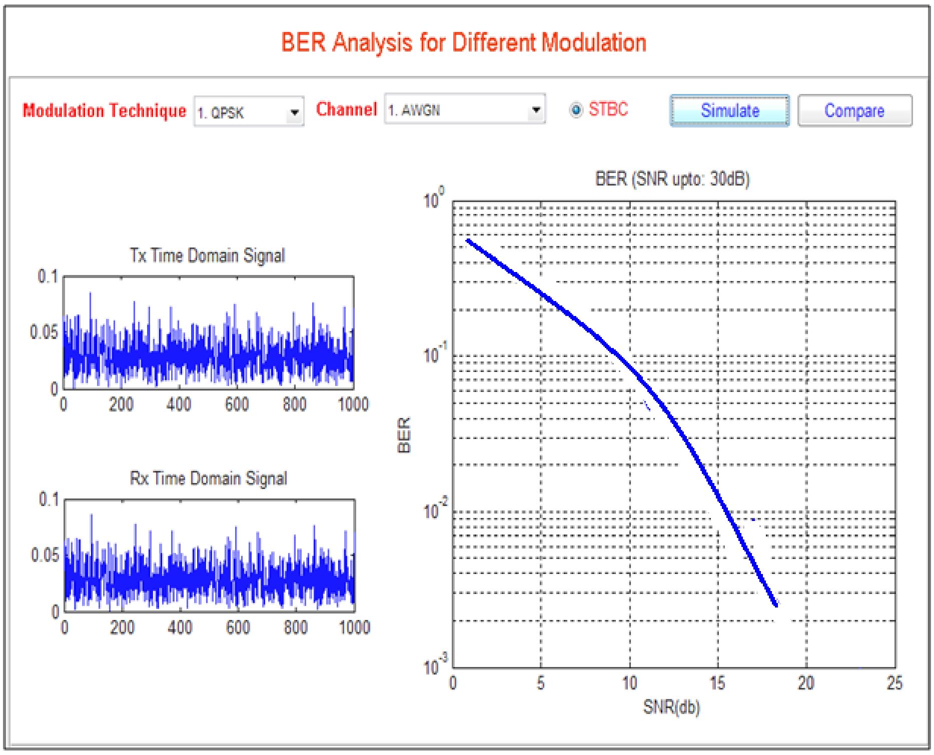

Fig. 11: *Output for QPSK using Channel AWGN with STBC.*

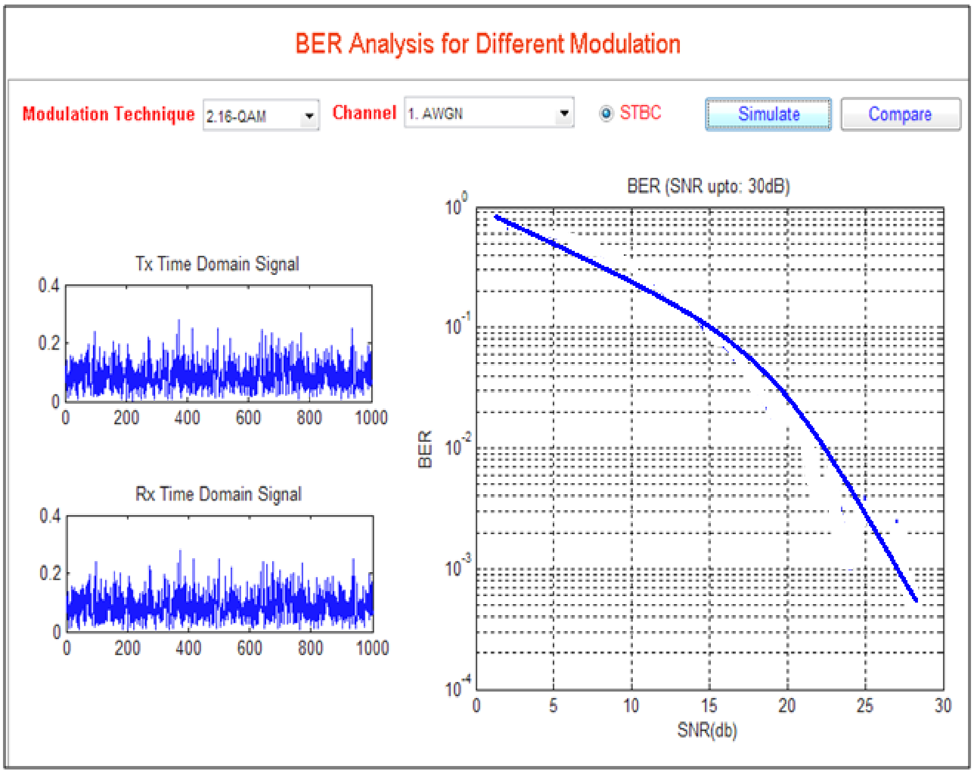

Fig. 12: *Output for 16 QAM using Channel AWGN with STBC.*

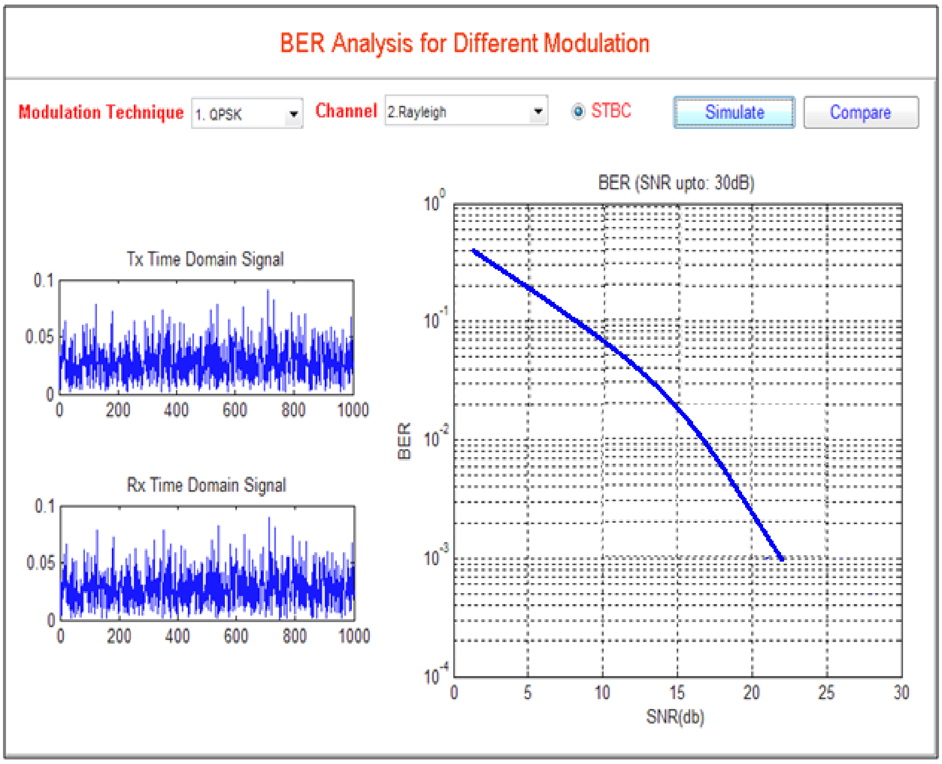

Fig. 13: *Output for QPSK using Channel Rayleigh Fading Channel with STBC.*

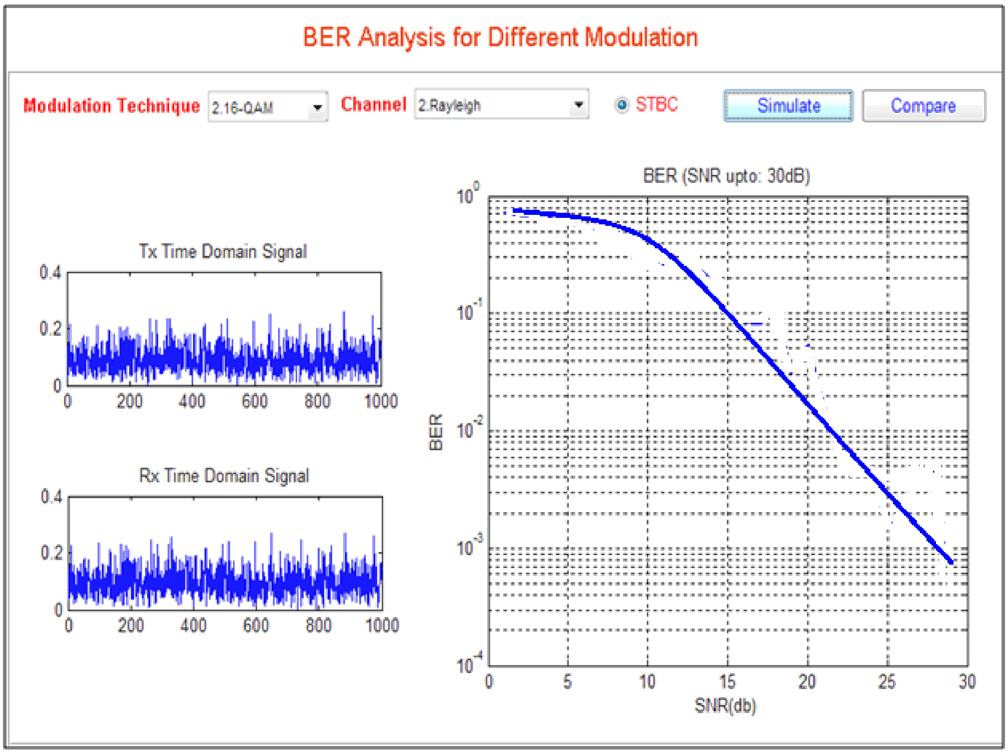

Fig. 14: *Output for 16 QAM using Channel Rayleigh with STBC.*

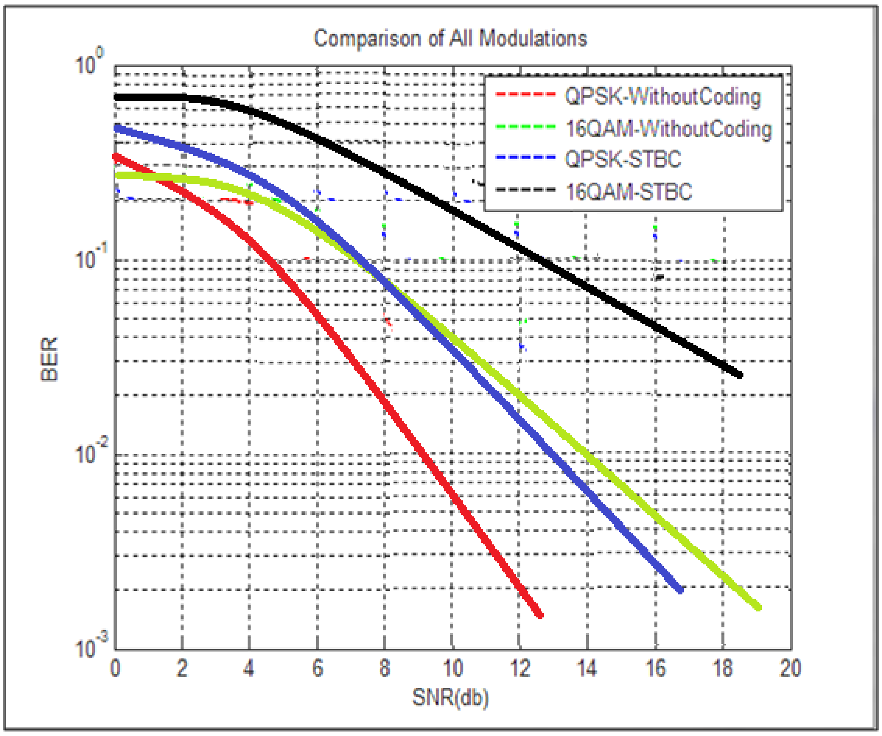

Fig. 15: *Comparison of QPSK and QAM-16 Modulation using STBC and without STBC.*

CONCLUSION

In this paper, we have process for the comparison of QPSK and QAM-16.For different STBC codes from the literature; we have specified the transmission matrix and the code parameters. Then, we have provided simulation results to compare the performances of different STBC codes chosen for a different number of transmit antennas, specifying the best code that assures a maximum diversity gain and a minimum BER. However, the concatenation of STBC codes with classical channel codes like convolution or turbo codes, can offer optimal diversity and coding gain, with the expense of a decreased bit rate and an increased complexity.

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