IJCRT.ORG ISSN : 2320-2882
INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)
An International Open Access, Peer-reviewed, Refereed Journal

COMPARATIVE ANALYSIS OF SISO, SINGLE USER MIMO AND MULTIUSERMIMO

[1]Subhrajit Dey
[1]deysubhrajit3@gmail.com
[1] Research scholar of ECE department, Techno India University, Kolkata

[2] Dr. Soumitra Bhowmick
[2]soumitra.b@technoindiaeducation.com
[2] Assistant Professor of ECE department, Techno India University, Kolkata

***Abstract*—**Wireless communication is very useful in our daily life. The basis need of this communication is improve efficiency and increase coverage area. Previously here used single input and single output antenna (SISO). Then upgrade it and move on multiple input and multiple output antenna (MIMO). In case of single input and single output there used only one transmitting antenna and one receiving antenna. Next multiple input and multiple output antenna used in the wireless communication. Here number of antenna is increased but only for single user. One user uses multiple antennas. After that multiuser MIMO takes place single user MIMO. Here number of the user is increased. Communication enhance by using multiuser MIMO. In this environment coverage area is increased followed by multiple user. From the base station (BS) signals can access by multiple numbers of mobile station (MS). Among of this three technologies multiuser MIMO is better than others. Actually aim is to get better quality signal and reduce noise. For getting good quality signal we need to improve the signal power and reduce the bit error rate (BER). By using deferment kinds of technique BER minimization possible in the multiuser environment. When number of antennas and number of users are increased automatically noise will also increase. Our target is to decrease the noise and boost the quality of signal.

Keywords— SISO, MIMO, Multi-user MIMO, Channel Inversion, Block Diagonalization, Dirty Paper Coding(DPC), Tomlinson-Harashima Precoding (THP).

I. INTRODUCTION

Multiuser MIMO is such kind of environment where multiple antennas and multiple users both are used. In single input single output system only one antenna is used in transmitter end and one antenna used in receiving end. In case of single user MIMO system multiple antennas used in transmitter side as well as receiver side. So MIMO is better than SISO. Here number of paths are enhanced. For multiuser MIMO member of users' increases and each user have multiple antennas. Multiple antennas are used for improving the communication performance.

II. SISO

A system where a single antenna use at transmitter and another single antenna use at receiver. In TV broadcast,radio, Wi-Fi and Bluetooth this technology is applicable.

Fig 1-Single Input Single Output

III. SINGLE USER MIMO

A system which contain multiple antennas at the transmitter and the receiver. In the MIMO system same numbers of antenna are used in transmitter and receiver like 4×4 MIMO system four antennas use in transmitter and four antennas use in receiver. Similarly 2×2 MIMO system two antennas use in transmitter and two antennas use in receiver. It establishes the point-to-point link. This system is applicable in 802.11n WiFi, WiMAX, LTE system.

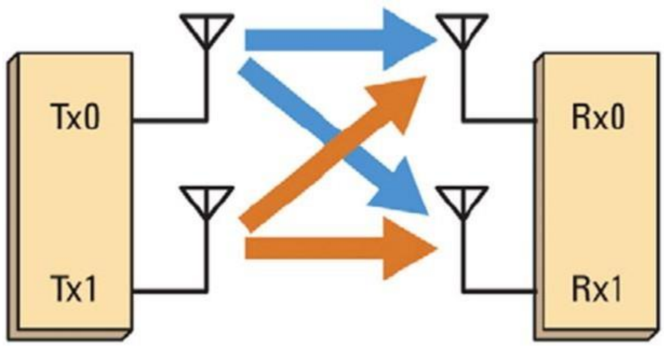

Fig 2 - 2×2 MIMO system

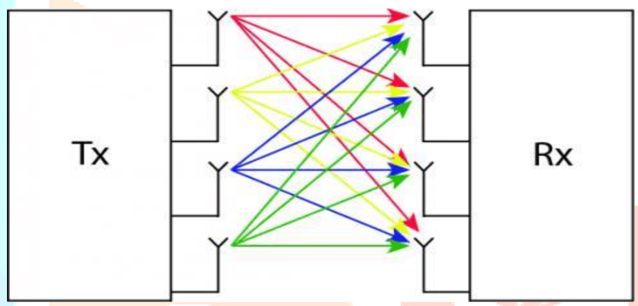

Fig 3 - 4×4 MIMO system

IV. MULTIUSER MIMO(MU-MIMO)

Here multiple antennas are used by generating multiple connections to the same system and same time. This MU- MIMO system uses in multiple users all access same wireless network at same time. It is used in routers and deal with smartphones. This technology helps to free from congestion of network and increase the efficiency of network. It decreases waiting time for each device. It also increase the capacity and efficiency of a user and also enhance the video playback streams and reduce buffering.

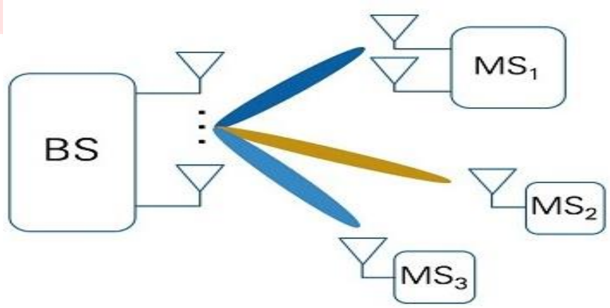

Fig 4 – Multiuser MIMO system

V. MATHEMATICAL MODEL FOR MULTI-USER MIMO SYSTEM

Let K independent users within the multi-user MIMO system [8] [9]. Let us consider that the Base Station and every Mobile Station are designed with N_B and N_M antennas, respectively. The uplink channel is explained as a multiple access channel (MAC) for K independent users.

$$y_{MAC} = H_1^{UL} x_1 + H_2^{UL} x_2 + \ldots\ldots + H_K^{UL} x_K + z = [H_1^{UL} \quad H_2^{UL} \ldots\ldots \quad H_K^{UL}] \begin{bmatrix} x_1 \\ x_2 \\ x_K \end{bmatrix} + z = H^{UL} \begin{bmatrix} x_1 \\ x_2 \\ x_K \end{bmatrix} + z \ldots\ldots\ldots 1$$

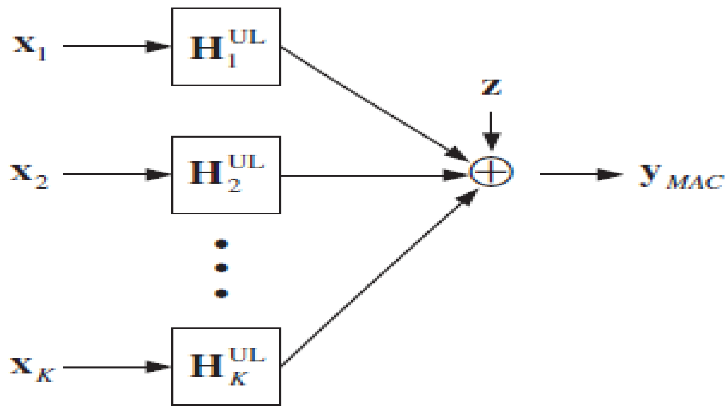

Fig. 5. Uplink channel model for multi-user MIMO system: multiple access channel (MAC)

In MAC, the received signal is

$$y_u = H_u^{DL} x + Z_u \ldots\ldots\ldots 2$$

$$\begin{bmatrix} y_1 \\ y_2 \\ y_K \end{bmatrix} = \begin{bmatrix} H_1^{DL} \\ H_2^{DL} \\ H_K^{DL} \end{bmatrix} x + \begin{bmatrix} Z_1 \\ Z_2 \\ Z_K \end{bmatrix} \ldots\ldots\ldots 3$$

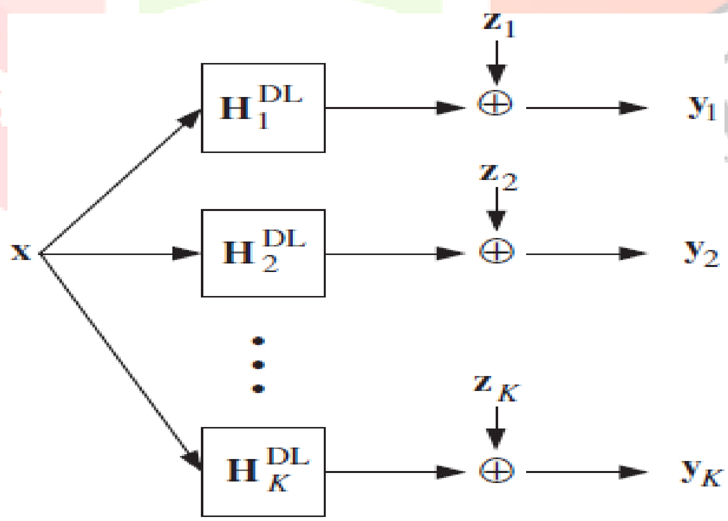

Fig. 6. Downlink channel model for multi-user MIMO system

VI. TRANSMISSION METHODS FOR BROADCAST CHANNEL

The main problem in data transmission in Broadcasting Channel is that the coordinated signal detection on the receiver side is not easy, and thus, interference cancellation at BS is needed. There are mainly four types of transmission methods: channel inversion, block Diagonalization [6] [7], dirty paper coding (DPC), and Tomlinson-Harashima precoding (THP).

A. Channel Inversion

Consider $N_M=1$ for all the users and $K=N_B$. Let $\tilde{x}_u$ denoted for u[th] user signal. The received signal of the u[th] user are

$$y_u = H_u^{DL}\tilde{x}_u + z_u \quad \text{Where } u=1, 2, 3\ldots\ldots K$$

The received signals of all users can be represented as

$$\underbrace{\begin{bmatrix} y_1 \\ \vdots \\ y_K \end{bmatrix}}_{y_{BC}} = \underbrace{\begin{bmatrix} H_1^{DL} \\ \vdots \\ H_K^{DL} \end{bmatrix}}_{H^{DL}} \underbrace{\begin{bmatrix} \tilde{x}_1 \\ \vdots \\ \tilde{x}_K \end{bmatrix}}_{x} + \underbrace{\begin{bmatrix} z_1 \\ \vdots \\ z_K \end{bmatrix}}_{z} \ldots\ldots\ldots\ldots\ldots\ldots\ldots 4$$

The regularized channel inversion is better than channel inversion method.

B. Block Diagonalization

In channel inversion method is use for multi user where each user have single receiving antenna. This method is not perfect for multiuser with each multiple antennas. If this is very important for this environment. Here the noise enhancement become more which is not good for target user. In this field block Diagonalization [2] [5] method is applicable.

Let $N_{M,u}$ denote the number of antennas for the u[th] user, u = 1, 2,............K. The received signal is

$$y_n = H_u^{DL}\sum_{k=1}^{k} W_k\tilde{x}_k + z_u \quad \ldots\ldots\ldots\ldots\ldots\ldots 5$$

$$y_n = H_u^{DL} W_u\tilde{x}_u + \sum_{k=1,\ k\neq u}^{k} H_u^{DL} W_k\tilde{x}_k + z_u \quad \ldots\ldots 6$$

Where H_u^{DL} the channel matrix between BS and the u[th] user, Wu is the pre coding matrix for the u[th] user, and z_u is the noise vector. Let the received signals for the three-user case (K = 3)

$$\begin{bmatrix} y_1 \\ y_2 \\ y_3 \end{bmatrix} = \begin{bmatrix} H_1^{DL} & H_1^{DL} & H_1^{DL} \\ H_2^{DL} & H_2^{DL} & H_2^{DL} \\ H_3^{DL} & H_3^{DL} & H_3^{DL} \end{bmatrix} \begin{bmatrix} W_1\tilde{x}_1 \\ W_2\tilde{x}_2 \\ W_3\tilde{x}_3 \end{bmatrix} + \begin{bmatrix} z_1 \\ z_2 \\ z_3 \end{bmatrix} \ldots\ldots 7$$

$$= \begin{bmatrix} H_1^{DL}W_1 & H_1^{DL}W_2 & H_1^{DL}W_3 \\ H_2^{DL}W_1 & H_2^{DL}W_2 & H_2^{DL}W_3 \\ H_3^{DL}W_1 & H_3^{DL}W_2 & H_3^{DL}W_3 \end{bmatrix} \begin{bmatrix} \tilde{x}_1 \\ \tilde{x}_2 \\ \tilde{x}_3 \end{bmatrix} + \begin{bmatrix} z_1 \\ z_2 \\ z_3 \end{bmatrix} \ldots 8$$

$\{H_u^{DL}W_k\}_{u\neq k}$ draw the interference to the u th user unless $H_u^{DL}W_k = 0_{N_{M,u}\times N_{M,u}}, \forall\, u \neq k$

So for interference free transmission the condition is

$$H_u^{DL}W_k = 0_{N_{M,u}\times N_{M,u}}, \forall\, u \neq k \ldots\ldots\ldots\ldots\ldots 9$$

Now put the value of equation (9) in equation (6) the received signal will become

$$y_n = H_u^{DL} W_u\tilde{x}_u + z_u \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 10$$

C. Tomlinson-Harashima Precoding(THP)

This method is utilized for reducing the peak or average power in the decision feedback equalizer (DFE), which affects from error propagation. The first think of TH precoding [3] [10] in DFE is to minimize the post-cursor ISI in the transmitter, where the past transmit symbols are familiar without chance of errors. In fact, it requires a total knowledge of the channel impulse response, which is solely available by a feedback from the receiver for time-invariant or dimlytime varying channel.

$$c = x + 2Am \qquad \text{.........11}$$

Here A is an even integer, x is data symbol, m is an integer, and an enlarged symbol is c. so as to allay the peak oraverage power, m must be chosen to attenuate the magnitude of the swell symbol c in the transmitter.

D. Dirty Paper Coding (DPC)

Dirty paper coding (DPC) [2] may be a process of precoding the data such that the effect of the interference can bedropped text to some interference that is known to the transmitter. The received signal is given as

$$\begin{bmatrix} y_1 \\ y_2 \\ y_3 \end{bmatrix} = \begin{bmatrix} H_1^{DL} \\ H_2^{DL} \\ H_3^{DL} \end{bmatrix} \begin{bmatrix} \tilde{x}_1 \\ \tilde{x}_2 \\ \tilde{x}_3 \end{bmatrix} + \begin{bmatrix} z_1 \\ z_2 \\ z_3 \end{bmatrix} \qquad \text{.........12}$$

The channel matrix H^{DL} are frequently LQ-spoiled as

$$H^{DL} = \underbrace{\begin{bmatrix} l_{11} & 0 & 0 \\ l_{21} & l_{22} & 0 \\ l_{31} & l_{32} & l_{33} \end{bmatrix}}_{L} \underbrace{\begin{bmatrix} q_1 \\ q_2 \\ q_3 \end{bmatrix}}_{Q}$$

$$\begin{bmatrix} y_1 \\ y_2 \\ y_3 \end{bmatrix} = \begin{bmatrix} l_{11} & 0 & 0 \\ l_{21} & l_{22} & 0 \\ l_{31} & l_{32} & l_{33} \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} z_1 \\ z_2 \\ z_3 \end{bmatrix} \qquad \text{.........13}$$

So, the received signal of the initial user is given as

$$y_1 = l_{11}x_1 + z_1$$

From the first-user point, the main condition needs to be get for the interference-free data transmission

$$x_1 = \tilde{x}_1 \qquad \text{.........14}$$

Form the equation (13) and (14) the received signal of the second part is

$$y_2 = l_{21}x_1 + l_{22}x_2 + z_2 = l_{21}\tilde{x}_1 + l_{22}x_2 + z_2 \qquad \text{.........15}$$

From Equation (15), the following precoding cancels the interference component, $l_{21}x_1$ or $l_{21}\tilde{x}_1$ on the transmitter side

$$x_2 = \tilde{x}_2 - \frac{l_{21}}{l_{22}}x_1 = \tilde{x}_2 - \frac{l_{21}}{l_{22}}\tilde{x}_1 \qquad \text{.........16}$$

From Equation (16), the precoded signal x_2 is now collected of the user signals, $\tilde{x}_2$ and $\tilde{x}_1$, the received signal of the third user is

$$y_3 = l_{31}x_1 + l_{32}x_2 + l_{33}x_3 + z_3 \qquad \text{.........17}$$

Where the precoded signals, x_1 and x_2, are calmed of the known user signals, $\tilde{x}_1$ and $\tilde{x}_2$, given in Equations (14) and (16). From the side of the third user, the precoded signals, x_1 and x_2, are interference components in Equation (17),which may be reduced by the following precoding on the transmitter side is

$$x_3 = \tilde{x}_3 - \frac{l_{31}}{l_{33}}x_1 - \frac{l_{32}}{l_{33}}x_2 \qquad \text{.........18}$$

The precoded signals in Equations (14), (16), and (18) are usually be represented by a matrix which is

$$\begin{bmatrix} x_1 \\ \tilde{x}_2 \\ \tilde{x}_3 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \tilde{x}_1 \\ \tilde{x}_2 \\ \tilde{x}_3 \end{bmatrix} \qquad \text{.........19}$$

$$\begin{bmatrix} x_1 \\ x_2 \\ \tilde{x}_3 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ -\frac{l_{21}}{l_{22}} & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ \tilde{x}_2 \\ \tilde{x}_3 \end{bmatrix} \qquad \text{.........20}$$

$$\begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ -\frac{l_{31}}{l_{33}} & -\frac{l_{32}}{l_{33}} & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ \tilde{x}_3 \end{bmatrix} \qquad \text{.........21}$$

Combining the above three precoding matrices, it are frequently be demonstrated as the DPC in the following matrix form:

$$\begin{bmatrix} x_1\\ x_2\\ x_3\end{bmatrix} = \begin{bmatrix}1&0&0\\ 0&1&0\\ -\frac{l_{31}}{l_{33}}&-\frac{l_{32}}{l_{33}}&1\end{bmatrix}\begin{bmatrix}1&0&0\\ -\frac{l_{21}}{l_{22}}&1&0\\ 0&0&1\end{bmatrix}\begin{bmatrix}1&0&0\\ 0&1&0\\ 0&0&1\end{bmatrix}\begin{bmatrix}\tilde{x}_1\\ \tilde{x}_2\\ \tilde{x}_3\end{bmatrix}$$

$$\begin{bmatrix} x_1\\ x_2\\ x_3\end{bmatrix} = \begin{bmatrix}1&0&0\\ -\frac{l_{21}}{l_{22}}&1&0\\ -\frac{l_{21}}{l_{22}}+\frac{l_{32}l_{21}}{l_{33}l_{22}}&-\frac{l_{32}}{l_{33}}&1\end{bmatrix}\begin{bmatrix}\tilde{x}_1\\ \tilde{x}_2\\ \tilde{x}_3\end{bmatrix}\text{.........22}$$

From equation (13)

$$\begin{bmatrix} y_1\\ y_2\\ y_3\end{bmatrix} = \begin{bmatrix}l_{11}&0&0\\ l_{21}&l_{22}&0\\ l_{31}&l_{32}&l_{33}\end{bmatrix}\begin{bmatrix} x_1\\ x_2\\ x_3\end{bmatrix} + \begin{bmatrix} z_1\\ z_2\\ z_3\end{bmatrix}\text{.............23}$$

$$\begin{bmatrix} y_1\\ y_2\\ y_3\end{bmatrix} = \begin{bmatrix}l_{11}&0&0\\ l_{21}&l_{22}&0\\ l_{31}&l_{32}&l_{33}\end{bmatrix}\begin{bmatrix}1&0&0\\ -\frac{l_{21}}{l_{22}}&1&0\\ -\frac{l_{21}}{l_{22}}+\frac{l_{32}l_{21}}{l_{33}l_{22}}&-\frac{l_{32}}{l_{33}}&1\end{bmatrix}\begin{bmatrix}\tilde{x}_1\\ \tilde{x}_2\\ \tilde{x}_3\end{bmatrix} + \begin{bmatrix} z_1\\ z_2\\ z_3\end{bmatrix}$$

$$\begin{bmatrix} y_1\\ y_2\\ y_3\end{bmatrix} = \begin{bmatrix}l_{11}&0&0\\ 0&l_{22}&0\\ 0&0&l_{33}\end{bmatrix}\begin{bmatrix}\tilde{x}_1\\ \tilde{x}_2\\ \tilde{x}_3\end{bmatrix} + \begin{bmatrix} z_1\\ z_2\\ z_3\end{bmatrix}\text{..............24}$$

From Equation (24), it is observable that the interference-free detection can be constructed for each user.

VII. SIMULATION RESULT

The BER analysis of MIMO and MU-MIMO. It is simulated by MATLAB code. Here MIMO has multiple antennas in transmitter side and multiple antennas in receiver side with one user. MU-MIMO also contain multiple antennas in transmitter and receiver side but here number of user is more than one.

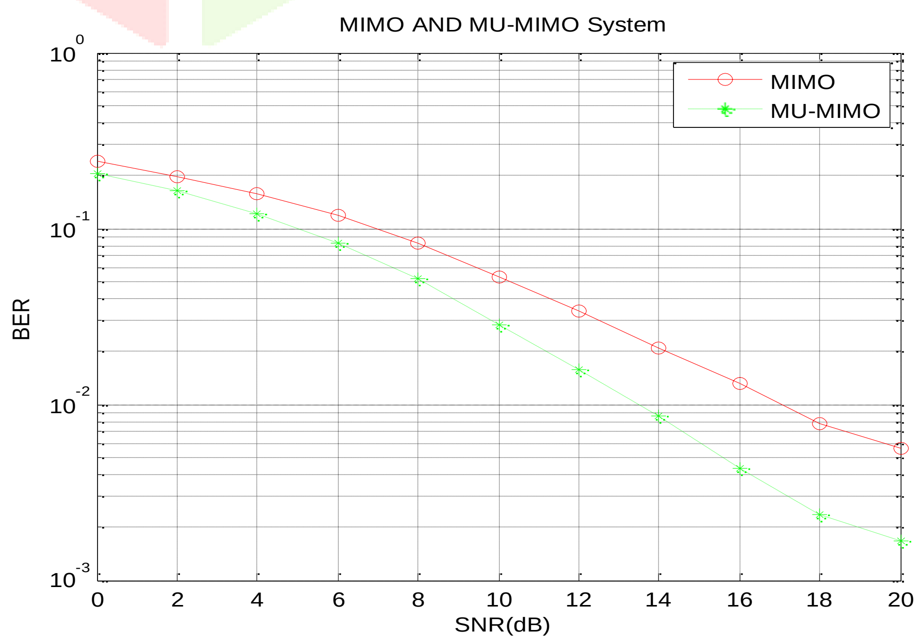

Fig 7- BER comparison for MIMO and MU-MIMO

The BER performance of channel inversion and regularized channel inversion is simulated for N_B =4 and N_M = 1, where four users with the highest channel norm values are used out of K = 20. The regularized channel inversion performance is more than channel inversion method.

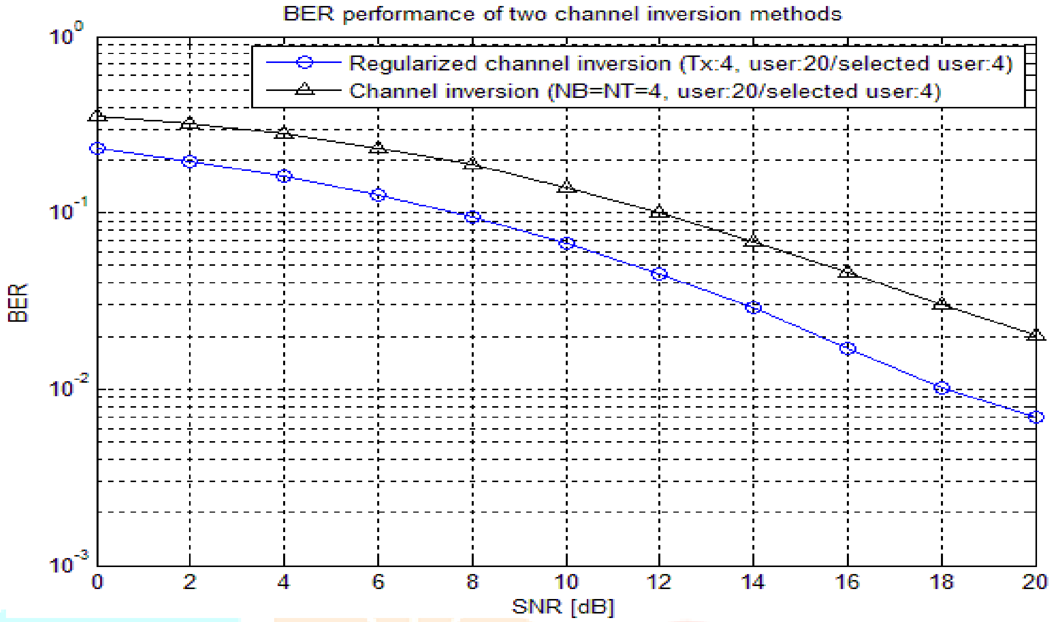

Fig. 8. BER comparison between channel inversion and regularized channel inversion

BER inspection for block diagonalization method for N_B =4, K = 2, and $N_{M,1}$ = $N_{M,2}$ = 2 set side by side with channel inversion and regularized channel inversion.

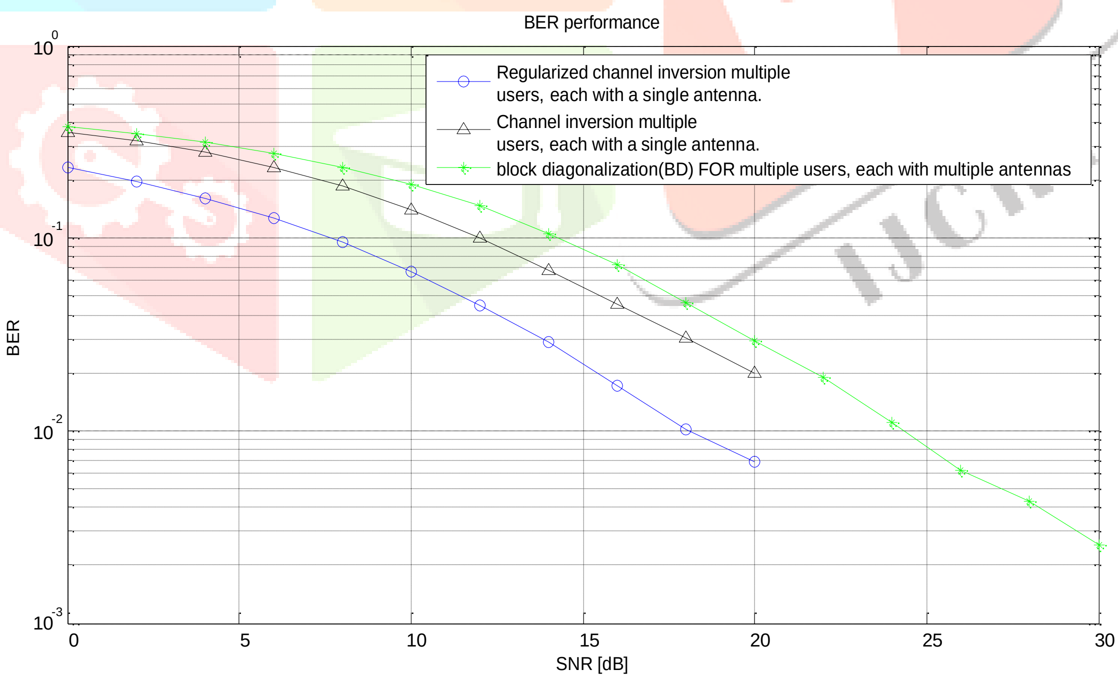

Fig. 9. BER performance of channel inversion and regularized channel inversion and block Diagonalization

The BER curve with DPC or TH precoding for $N_B = 4$ and K =10.The DPC is finest than THP in case of BER. Noise minimization is premier in case of DPC.

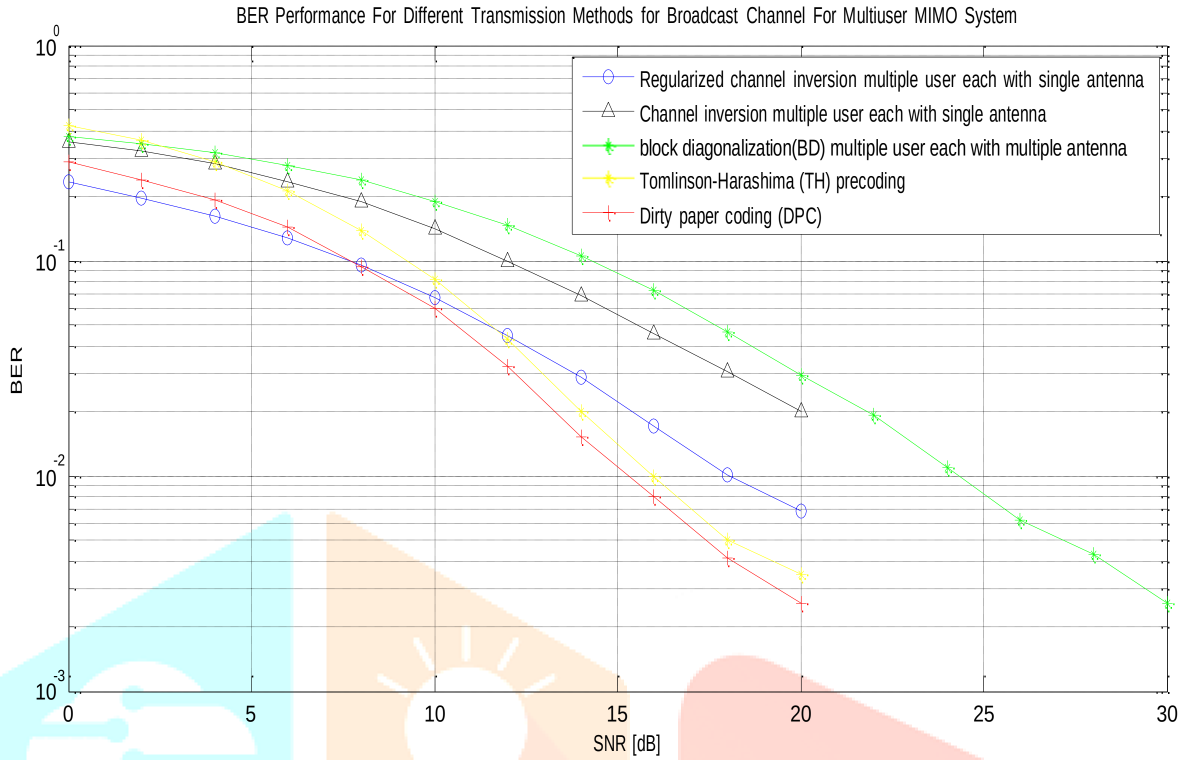

Fig. 10. BER Performance for various transmission methods for broadcast channel for multiuser MIMO system.

VIII. CONCLUSION

The multiple user MIMO is working for big converge field. For this domain the interference will become more than simple MIMO system. In simple MIMO hold more user but each of them carry single antenna. In multiuser environment number of users will be increased so noise will also increase. With the help of different transmission techniques the interference level can be suppressed. For stifle the noise four transmission broadcasting techniques are utilized. These techniques are Channel Inversion, Block Diagonalization, Dirty Paper Coding (DCP) and Tomlinson- Harashima Precoding (THP). DCP is proper for perfect channel state information (CSI). But for imperfect CSI, THPis very helpful.

REFERENCES:

[1] Greenstein, L.J. (1978) A multipath fading channel model for terrestrial digital radio systems. IEEE Trans. Commun., 26(8), 1247–1250.

[2] Du J, Li S L. “Tomlinson-Harashima precoding for multiuser MIMO downlink with imperfect channel state information” proceedings of ICMTMA ,2011, Jan 6-7, 2011, Shanghai, China. Piscataway, NJ, USA: IEEE, 2011:1027-1030.

[3]JaydipsinhJ.chavda,kalpeshR.chudasama,Ravi J.Bagatharia,prof.sunerakargathara,“performance analysis of Block diagonalization and Dirty paper coding precoding technique in multiuser MIMO system,”international journal of engineering research &technology (IJERT),ISSN:2278-0181,Vol.1 ISSUE10,December 2012.

[4] Pan, Y.-H., Letaief, K. B., & Cao, Z. (2004). “Dynamic spatial sub channel allocation with adaptive beamforming for MIMO/OFDM systems”, wireless Communications, IEEE Transactions on, 3(6), 2097–2107.

[5] F.Wang and M.E.Bialkowski, “Fast transmit antenna selection scheme employing Block diagonalization for multiuser MIMO system,” proceedings of asia-pacifia microwave conference, yohohama, 7-10 December 2010, and pp.1-5.

[6] F.Wang,X.Liu and M.E.Bialkowski, “Performance of Block diagonalization for multiuser MIMO system” 6th International Conference on wireless communication, networking and mobile computing, Chengdu,23-25, September 2010,pp.1-4

[7] F.Wang and M.E.Bialkowski, “performance of Block diagonalization broadcasting schemes for multi-user MIMO system operating in presence of spatial correlation and mutual coupling,” international journal of communications, network and system sciences, Vol.3,March,2010,pp.266272.doi:10.4236/ijcns.2010.3303

[8] Caire, G. and Shamai, S. (2003) on the achievable throughput of a multi-antenna Gaussian broadcast channel. IEEE Trans. Info. Theory, 43(7), 1691–1706.

[9] Yong feng, jichuanguo and ji-li, "A new interference alignment algorithms in the MIMO-OFDM system," information technology journal, 12: 935-942, 2013

[10] Saif khan Mohammed,Erik G.Larsson. "Per-antenna constant envelope pre-coding for large multi-user MIMO system" IEEE transactions on communications, 2012.