Performance Analysis of Various Receivers under Non Data Aided Technique using HSPA+ Technology

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Abstract: *To offer the promising communication beyond 3G and between 4G wireless communication, IDMA receiver combined with multiple Antennas namely MIMO system . Traditional MIMO system provides benefit of spatial diversity. In addition, the usage of multiple transmitter and receiver antennas can significantly improve the wireless communication performance is compared with the QR-OSIC (Order successive interference cancellation) receiver design for the transmitter-side power allocated Multi-Input Multi-Output (MIMO) system. In this paper, comprehensive review of the MIMO - IDMA receiver with MIMO –QR-OSIC receiver performed based non data aided technique is presented.*

Keywords: *Multiple Input Multiple Output (MIMO), Interleave Division Multiple Access (IDMA),QR-OSIC receiver, HSPA+.*

I. INTRODUCTION

WCDMA stands for Wideband Code Division Multiple Access, a mobile technology that improves upon the capabilities of current GSM networks that are deployed around the world. . HSDPA (High Speed Downlink Packet Access) is what is commonly known as 3.5G, as it offers no substantial upgrade to the feature set of WCDMA, but improves the speed of data transmission to enhance those services.

Prior to the introduction of HSDPA, WCDMA networks were only capable of reaching speeds of 384kbps. Although this might be sufficient for most services, people always want faster speeds, especially when browsing the internet or downloading files. HSDPA allowed speeds above 384kbps, the most notable of which is 3.6Mbps and 7.2Mbps, which a lot of telecommunications companies often advertise. In truth, HSDPA is capable of reaching much higher speeds depending on the type of modulation that is being used. HSDPA speeds can even reach a theoretical maximum of 84Mbps.

In order to exploit the full potential of WCDMA 5 MHz operation, the performance of HSPA-based radio networks has been further enhanced in terms of spectrum efficiency, peak data rate and latency. HSPA+ as specified in 3GPP Release 7 includes downlink MIMO operation, higher-order modulation (downlink 64QAM, uplink 16QAM) and protocol improvements that specifically allow a high number of "always on" users to be supported in the network. Peak data rates reach 28 Mbit/s in the downlink and 11.5 Mbit/s in the uplink with round-trip times below 50 ms.

In higher modulations MIMO systems provide a number of advantages over single antenna-to-single-antenna communication. Sensitivity to fading is reduced by the spatial diversity provided by multiple spatial paths. Under certain environmental conditions, the power requirements associated with high spectral-efficiency communication can be significantly reduced by avoiding the compressive region of the information-theoretic capacity bound. Here, spectral efficiency is defined as the total number of information bits per second per Hertz transmitted from one array to the other. After an introductory section, the next section describes the concept of MIMO information-theoretic capacity bounds, the phenomenology of the channel with reference to its capacity associated with parameterization techniques, Capacity. Channel estimation is done by two techniques namely data aided and non data aided.

While Data Aided (DA) algorithms achieve good performance, transmission of training sequences contributes to overheads and reduces overall data rate. Further, the receiver needs to know the starting point of the training sequences and hence frame synchronization is required even before symbol timing can be estimated, thus further complicating the receiver. Non Data Aided (NDA) algorithms work by extracting the timing estimate from the received signal without using any training sequence.

Since NDA methods usually make use of second order statistics, they require longer observation lengths and are computationally intensive. However they provide several benefits as the data rate is not compromised and the need for frame synchronization at the physical layer is obviated. Further, if the receiver is resourceful (e.g. a base station), NDA methods allow us to trade-off receiver complexity with the performance of estimator simply by changing the observation length and without compromising data rate, unlike DA estimators. In section II describes IDMA receiver Performance in comparison with QR-OSIC receiver implementing with 2*2 MIMO system. Whereas section III describes the simulation results.

II. SYSTEM MODEL

A. MIMO IDMA RECEIVER STRUCTRURE

MIMO technology is implemented by IDMA process in which transmitter and (iterative) receiver structures are shown in below figure Since interleaving is the only mechanism for user separation here, it is referred to as interleave-division multiple-access (IDMA)]. The upper part of Fig.1 shows the transmitter structure of an IDMA system with K simultaneous users.

The input data sequence d*k* of user-k is encoded based on a low-rate code C. The coded sequence is then interleaved by a chip-level interleaver _ k, producing *xk _[xk(1), …, xk(j), …, xk(J)]T*. The key principle of IDMA is that the interleavers { _k} should be different for different users. It is assumed that the interleavers are generated independently and randomly. These interleavers disperse the coded sequences so that the adjacent chips are approximately uncorrelated, which facilitates the simple chip-by-chip detection scheme. Assume quasi-static single-path channels.

After chip matched filtering, the received signal from K users can be written as where hk is the channel coefficient for user-k and {n(j)} are samples of an AWGN with variance _2 = N0/2. Here the channel coefficients {hk} are known a priori at the receiver side.

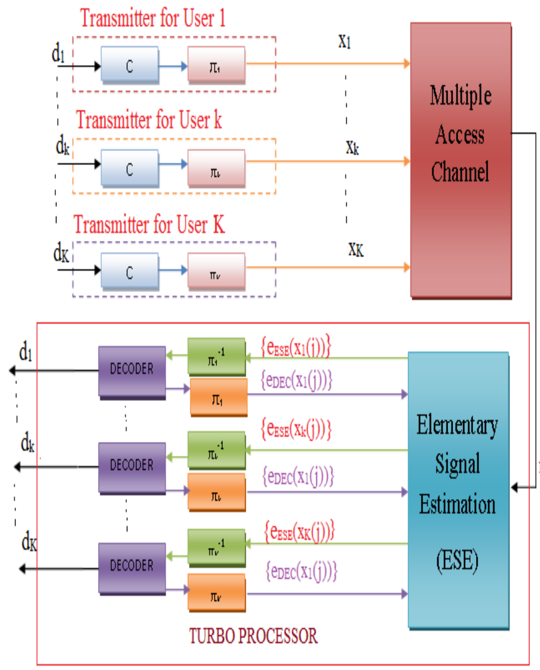

Fig1: System Model MIMO IDMA Receiver structure

Receiver Structure*:* The receiver operation is still based on two constraints: (i) the constraint of the FEC code *C* and (ii) the constraint due to the superposition of the transmitted chips. The adopted sub-optimal receiver structure, as illustrated in Fig.2. Without signature sequences, he processing related to the second constraint becomes very simple. The chip-level interleavers {_ *k*} allow us to adopt a chip-by-chip estimation technique, as detailed below. The receiver in Fig.2 consists of an elementary signal estimator (ESE) and *K* single-user *a posteriori* probability (APP) decoders (DECs). For simplicity, we first consider higher modulation signaling,, and real channel coefficients. ESE is used (after de-interleaving) as the *a priori* information in the DECs, and vice versa.

Denote by *e*(*x* (*j*)) *k* the extrinsic information about *xk*(*j*) [. It is further distinguished by subscripts, i.e., *eESE*(*xk* (*j*)) and *eDEC*(*xk* (*j*)) , depending on whether it is generated by the ESE or DECs. During the turbo-type iterative process, the extrinsic information generated by the ESE is used (after de-interleaving) as the *a priori* information in the DECs, and vice versa.In the simulation result for two transmitters and receivers BER is converged at SNR value of 7db and BER is 10^{-3}.

B. MIMO QR-OSIC RECEIVER

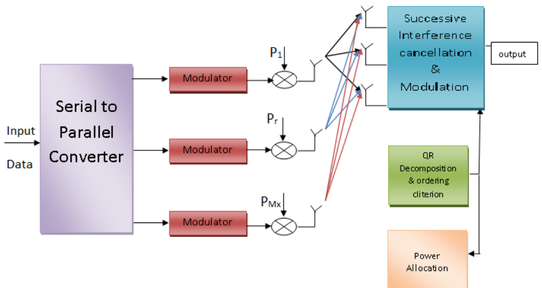

Fig 2MIMO Transmission with QR-OSIC

In MIMO system with M_t transmit antennas and N_r receive antennas with existing channel condition based on fading. MIMO channel with flat folding can be expanded by $M_t x N_r$ matrix H with h_{ji} which indicates channel gain of transmit antenna and receive antennas for i & j variables. If received signal vector represented by $Z=[z_1,z_2.....z_{Mr}]^T$ of $M_r x1$ is shown as $Z = \sqrt{\frac{B_s}{M_t}}\, HKW + r$ detector For transmitted antenna signal vector is $W=[w_1,w_2.....w_{Mt}]^T$ which shows $M_t x1$ dimensional vector for signal. For M_r dimensional noise vector with element is $V=[v_1,v_2.....v_{Mr}]^T$ consists of elements with variance of σ_x^2 having complex zero mean Gaussian distribution. The total transmitted signal energy is represented as B_s for transmit antenna M_t and $K=\sqrt{M_t}$ diag(k1,k2.....k_{Mt}) denotes precoding matrix of individual power allocation powers of k1,k2..... For MMSE QR detector signal model can be expressed as $(M_t+M_r)xM_t$ augmented channel matrix Ĥ and $(M_t+M_r)x1$ extended receive vector **Z.** and for zero matrix o_{nt},1 is shown as $M_t x1$ can be written as

$$\tilde{H} = \begin{bmatrix} H \\ \sigma_n I_{Mt} \end{bmatrix} \text{ Q'R' and } \tilde{Z} = \begin{bmatrix} z \\ o_{nt}, 1 \end{bmatrix}$$

SNR can be determined by upper triangular matrix T' which is shown differently and represented by detecting order.

For k^{th} data stream post detector SNR is

$$p_j = \frac{B_s}{\sigma_r^2} k_j^2 \overline{T_{j,j-1}}^{2} \qquad k = 1,2 \ldots \ldots Mt$$

BER minimized allocation of power transmitter can be performed using Q_R decomposition based on OSIC detection by the given architecture.

The transmission power K_j is allotted to each data stream based on feedback in transmitter of diagonal elements $\overline{T_{jj}}$ by using diagonal power allocation matrix independently encoded symbols are precoded and passed from M_t data stream. The operation of QR-OSIC recover in which transmit symbols are detected sequentially by following designated direction order.

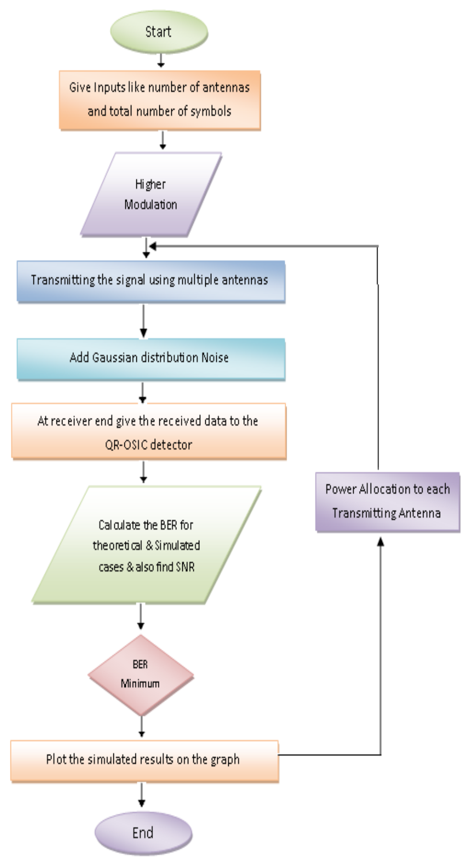

Fig 3 Flow Chart

MMSE Detector

The MMSE detector minimizes the mean squared error (MSE) between the actually transmitted symbols and the output of the linear detector and leads to the filter matrix

$$G_{MMSE} = (H^H H + \sigma_n^2 I_{N_t})^{-1} H^H$$

The resulting filter output is given by

$$\tilde{S}_{MMSE} = G_{MMSE}\, y = \left(H^H H - \sigma_n^2 I_{N_t}\right)^{-1} H^H y$$

The estimation errors of the different layers correspond to the main diagonal elements of the error covariance matrix

$$\phi_{MMSE} = E\left\{\left(\tilde{s}_{MMSE} - s\right)\left(\tilde{s}_{MMSE} - s\right)^H\right\}$$

$$= \sigma_n^2 (H^H H + \sigma_n^2 I_{N_t})^{-1}$$

With the definition of a an (N_r +N_t) XN_t augmented channel matrix , an (N_r + N_t) X 1 extended receive vector $\bar{y}$ and an N_t X 1 zero matrix $0_{N_t,1}$ can be written as

$$\bar{H} = \begin{bmatrix} H \\ \sigma_n I_{N_t} \end{bmatrix} \rightarrow ordering\ \bar{Q}\bar{R}\ and\ \bar{y} = \begin{bmatrix} y \\ 0_{Nt,1} \end{bmatrix}$$

the output of the MMSE filter now can be rewritten as

$$\tilde{S}_{MMSE} = (H^H H)^{-1} \bar{H}^H \bar{y} = \bar{H}^+ \bar{y}$$

Furthermore, the error covariance matrix becomes

$$\phi_{MMSE} = \sigma_n^2 (\bar{H}^H \bar{H})^{-1} = \sigma_n^2 \bar{H}^+ \bar{H}^{+^H}$$

Comparing last two equations to the corresponding expression for linear zero-forcing detector in previous topic, the only difference is that the channel matrix **H** has been replaced by $\bar{H}$. This observation is extremely important for incorporating the MMSE criterion into the SQRD based detection algorithm.

Precoding For Ordinary Detector

MMSE QR DETECTION

By seeing the equation of post detection SNR channel gains are effected by error rate and power allocation of transmitter. The ordering strategy is derived based on the

properties of Q-function and ordering results. The precoding based on QR-OSIC receiver are explained in the next section.

In order to extend the QR based detection with respect to the MMSE criterion, we can apply the similarity of ZF and MMSE detection noted in previous Section. We introduce the QR decomposition of the extended channel matrix

$$\bar{H} = \begin{bmatrix} H \\ \sigma_n I_{N_t} \end{bmatrix} = \bar{Q}\bar{R} = \begin{bmatrix} Q_1 \\ Q_2 \end{bmatrix} \bar{R} = \begin{bmatrix} Q_1 \bar{R} \\ Q_2 \bar{R} \end{bmatrix}$$

where the (N_r + N_t) XN_t matrix $\bar{Q}$ with orthogonal columns was partitioned into the an N_r XN_t matrix Q_1 and the N_t XN_t matrix . Q_2 Obviously,

$$\bar{Q}^H \bar{H} = Q_1^H + \sigma_n^2 Q_2^H = \bar{R}$$

holds and from the relation $\sigma_n I_{N_t} = Q_2 \bar{R}$ it follows that

$$\bar{R}^{-1} = \frac{1}{\sigma_n} Q_2$$

i.e. the inverse $\bar{R}^{-1}$ is a by-product of the QR decomposition and Q_2 is an upper triangular matrix. This relation will be useful for the post-sorting algorithm Using above equations, the filtered receive vector becomes

$$\tilde{S} = \bar{Q}^H \bar{y} = Q_1^H y = \bar{R} S - \sigma_n Q_2^H S + Q_1^H$$

The second term on the right hand side of above equation including the lower triangular matrix Q_2^H constitutes the remaining interference that cannot be removed by the successive interference cancellation procedure. This points out the trade-off between noise amplification and interference suppression.

The optimum detection sequence now maximizes the signal-to-interference-and-noise ratio (SINR) for each layer, leading to minimal estimation error for the corresponding detection step. The estimation errors of the different layers in the first detection step correspond to the diagonal elements of the error covariance matrix

$$\phi = \sigma_n^2 (\bar{H}^H \bar{H})^{-1} = \sigma_n^2 \bar{R}^{-1} \bar{R}^{-H}$$

The estimation error after perfect interference cancellation is given by $\sigma_X^2 / |\overline{r_{k,k}}|^2$. Thus, it is again optimal to choose the *MMSE-BLAST algorithm.*

Explanation of BER Performance:

The average BER minimization for a power allocation scheme under a channel matrix related to QR decomposition. In data stream no error propagation, successive cancellation is proposed. In higher modulation allocation of power is expressed in terms as

$$\text{Minimize } \frac{1}{M_t} \sum_{j=1}^{M_t} R\left(\sqrt{2r_t} k_j \text{Tij'}\right)$$

$$\approx \frac{1}{M_t} \sum_{k=1}^{M_t} R\left(\sqrt{2\rho_k}\right)$$

$$s.t = \sum_{j=1}^{M} k_j^2 = 1$$

$$\overline{T_{jj}} \geq 0 \qquad j \in (1,2 \ldots \ldots M_t)$$

$$\text{Where } R(w) = \frac{1}{\sqrt{2\pi}} \int_w^\infty e^{-t^2} dt \text{ and } r_t = \sqrt{\frac{B_s}{\sigma_r^2}}$$

If $\overline{T_{ij}} \geq 0$ it is obtained from the j[th] column of the channel matrix which is any meam**.** By taking specific constant with cancellation the average BER of idle power allocation can be estimated. By taking the channel gain $\overline{T_{ij}}$ and allocating power K_j post detector SNR P_k and BER is derived from eq4. The BER minimized br QROSIC receiver due to convexity property of Q function. By detection ordering of the QR-OSIC all diagonal elements of the matrix T' are equal to their average

$$\mu = \sqrt[M_t]{\det(\bar{T})} = \sqrt[M_t]{\prod_{j=1}^{M_k} \overline{T_{jj}}}$$

When K_j and T_{ij}' variables makes product at the transmitter for them power allocation is same for all data stream. By several spatial temporal properties the real MIMO channel is characterized with respect to following conditions. By optimality condition it is not practical. If different detecting order is taken into consideration that reflects to T_{ij}' due to its T<j will be differently **any**. The improved BER is obtained by proposed algorithm determines an optimized detection sequence with a single sorted QR performance can be accurate depending on PA scheme with estimation detection order strategy.

When two variables k_j and T_{ij}' produced is maximized by simplifying due to that average BER is minimized.

$$k_j \overline{T_{11}}$$

$$k_1 \overline{T_{11}} = k_2 \overline{T_{22}} = k_{Mt} \overline{T_{Mt\ Mt}}$$

$$\sum_{j=1}^{Mt} k_j^2 = 1 \qquad 0 < k_j < 1$$

From the properties taking into consideration

$$K_1 \overline{T_{1,1}} = K_2 \overline{T_{2,2}} = \sqrt{1 - k_1^2} \det\left(\frac{\bar{T}}{\overline{T_{11}}}\right)$$

$$k_1^2 = det^2\left(\frac{\bar{T}}{\overline{T_{11}^4}}\right) + det^2(\bar{T}) \text{ and}$$

$$\text{Max } K_1 \overline{T_{1,1}} = \text{max } K_1^2 \overline{T_{1,1}}^2.$$

The two transmit antennas problem can be written as

$$\text{Maximize } \frac{\overline{T_{1,1}}^2 . det^2(\bar{T})}{\overline{T_{1,1}}^4 . det^2(\bar{T})} = \Phi(\overline{T_{1,1}}) \text{ Such that } K_1 \overline{T_{1,1}} = K_2 \overline{T_{2,2}}, R_1^2 + k_2^2.$$

If differential calculus is applied to $\Phi(\overline{T_{1,1}})$

$$2\overline{T_{11}}\left(\overline{T_{11}}^4 - \det(\bar{T})\right) = 0$$

$$\overline{T_{11}} = \sqrt{\det(\bar{P})} = \mu$$

If K^2 T_{ij}' α ρ_j then T_{ij}' approaches to μ is in increasing.

Higher post detection SNR can be accurate when $\overline{T_{ij}}$ converge to μ delivers the ordering strategy. Let us extend the system with M_t antennas. A fixed ordering algorithm has been trying to establish to satisfy the desired strategy. The channel gain can be minimized by $|\overline{T_{qq}} - \mu|$ for all j.

$$j_p = \arg \min_q |\overline{T_{qq}} - \mu|$$

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$$Q \epsilon \{j_1, \ldots j_{p-1}\} = \mu = \sqrt[M_t]{\det(\overline{T})}$$

Transmit elements are rearranged as its subscript implies the reverse order in which the elements are to be detected. Then permutated sequence of them is given by order $\{j_1, \ldots j_{mt}\}$. The robust convergence can be achieved by employing adaptive criterion for modified algorithm. If m_t=3 system by taking into consideration of selecting an element -1 as j_1.the result will be different in $\overline{T_{11}}$ if element 2 & 3 are selected. When value of j2, j3 are decided it effects the remaining sets. Channel gains are calculated as

$$\mu = \sqrt[M_r]{\prod_{j_p=1}^{M_t} \overline{T_{pl-pl}}}$$

From the previously determined channel gains adaptive ordering design is proposed by which controlling of the weights are done by renewing the thresholds. In fixed method different variables threshold are substituted then it is defined as

$$j_1 = \arg \min_q |\overline{T_{qq}} - \mu_p|$$

$$\mu_p = \mu = \mu_{p+1} = \frac{M_t - p + 1}{M_t - p} \sqrt{\frac{\mu_p}{\overline{T_{pp}}} \frac{N}{FP} + 1}$$

From above equations μ_p denote the threshold for j_p.

The decided gains which are already decided are extracted by reducing size of fixed ordering process. By this adaptive ordering algorithm can be considered.

The channel gain is enabled by adaptive ordering algorithm which is adjusted by μ_p+1 on the opposite sides if T_{jj}'-μ is distributes to one side serially.

Due to converge of μ is done for more channel gains.

The efficiency of QR-OSIC receiver is complexity of **computations** will be reduced.

Total number of assition and multiplications in B-OSIC detector are $(43/1)M_t^4 + (22/3)M_t^3 + O(M_t^2)$ and $(43/12)M_t^4 + (20/3)M_t^3 + O(M_t)^2$.

By using QR factorization is OSIC receiver total number of additions and multiplications.

$(2/3)M_t^3 + 7M_t^2 M_r + 2\, M_r^2 M_t + O(M_t)^2$ when $M_t = M_r$ the number of multiplications and additions are given with the complex floating point operations

$(43/6)M_t^4 + 14M_t^3 + O(M_t)^2$ for B-OSIC and

$(29/3)M_t^3 + O(M_t)^2$ for QR-OSIC.

III. SIMULATION RESULTS

We consider a MIMO system with, 2X2 transmit/receive antenna configurations and higher modulation. The effects of error propagation are not ignored, and simulations are used to obtain the actual performance. For each of the MIMO systems and for a specific value of SNR, a quasi-static channel is assumed for the performance evaluation, for which the channel gain is constant over a frame and changed independently from frame to frame. To concentrate our point on comparing ordering algorithms, we postulate the perfect channel estimation at the receiver and error-free PA information at the transmitter.

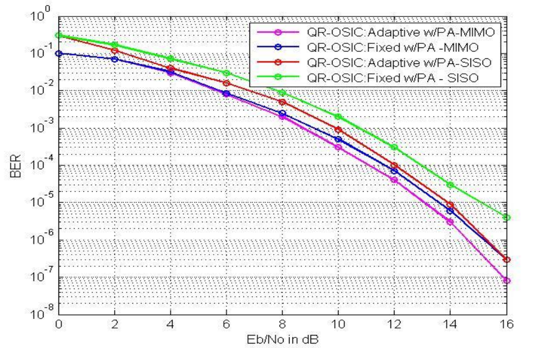

Fig4. Comparison of BER performance of MIMO systems with two transmit/receive antennas and SISO system

how the average BER performance comparison for MIMO systems with two transmit/receive antennas and SISO system with single transmit and receive antenna Now with fixed power allocation and adaptive power allocation .We compare MIMO – QROSIC receiver with MIMO-IDMA receiver.

The following parameters used in the simulation of MIMO-IDMA systems

Parameters Specifications

- i. No. of users 5
- ii. Data length 1024 bits/frame
- iii. Higher Modulation 64QAM
- iv. Interleaver Random Interleaver
- v. Tx.Antennas 2
- vi. Rx.Antennas 2

The MIMO-IDMA system with multiple antennas at transmitter and receiver provides better BER performance
when compared to Single Input and Single Output system is shown in figure.

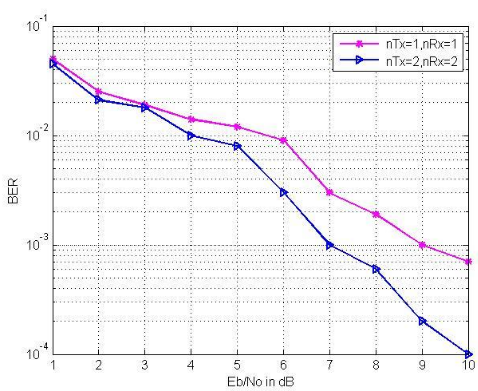

Fig5 Comparison of BER performance of MIMO systems with two transmit/receive antennas and SISO system

CONCULSION

Comparing simulation results of IDMA receiver and QR-OSIC receiver using MIMO technology with 2*2 implementing with HSPA+ technology under non data aided technique .in IDMA receiver BER is less than 10-3 for SNR value of 8db where QR OSIC-receiver BER is 10-2 to 10-3 for SNR value of 8db by analyzing these power optimization is more in IDMA receiver in comparison with QR-OSIC receiver.

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