# PROTECTION OF MULTI INPUT MULTI OUTPUT MOBILE COMMUNICATION AGAINST MANMADE JAMMING AND INTERFERENCES

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**Abstract:** Recently, the use of mobile communications has become very popular but a huge problem of manmade and other kinds of interferences have been appeared and there are specific manners which many people used against this kind of communication although CDMA techniques has a good protection of these kinds of noise which don't mention it in this paper .Multiple Inputs Multiple outputs (MIMO) techniques has high capacity, increased diversity, and interference suppression. In this paper the model of receiver with MIMO techniques  has introduced by using MATLAB 2014b to show the scan of the beam of antenna and measure the received power to get the best situation to make the call by suppression the signal from the direction which is many more the specific threshold.

**Keywords**: *mobile communication, manmade jamming, interferences, MIMO (multi input multi output), Antenna, capacity.*

## حماية الأتصالات النقالة المتعددة المدخلات والمخرجات من التشويش الذي من صنع الأنسان والتداخلات

**الخلاصة :**مؤخرا أصبحنا لا نستطيع العيش من دون استخدام الاتصالات النقاله ولكنها تمتلك مشاكل ضخمه من صنع الإنسان وغيرها من أنواع التداخلات وهناك تقنيه الوصول المتعدد لتقسيم الشفره والتي كثير من الناس ضد  استخدام هذا النوع من الأتصالات على الرغم من أن هذا النوع يمتلك حماية جيدة من الضوضاء الذي لم يتم التطرق له في هذا البحث. أما تقنيه متعدده المدخلات والمخرجات تمتلك قدره عاليه وزياده التنوع وقمع التداخل .في هذا البحث نموذج المتلقي باستخدام تقنيه متعدده المدخلات والمخرجات سوف يتم عرضه بأستخدام برنامج الماتلاب 2014 لأظهار فحص شعاع الهوائي وقياس القدره المستقبليه للحصول على افضل وضع لأجراء المكالمه عن طريق قمع الاشاره من الاتجاهات متعدده مع عتبه محدده

## 1. Introduction

Multiple-input multiple-output (MIMO) communication has great characteristics for next-generation wireless systems because of their high capacity, very well diversity, and interference suppression. For applications such as wireless LANs and cellular telephony.

MIMO systems will likely be deployed in environments where a single base must communicate with many users simultaneously. As a result, the study of multi-user MIMO systems has emerged recently as important research topic.

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Such systems have the potential to combine the high capacity achievable with MIMO processing with the benefits of space-division multiple accesses [1].

Multiple-input multiple-output (MIMO) will use in future communication systems because of their spectrum efficiency. The capacity of a MIMO system is proportional to the number of antennas in the system [2].

This is valid assumption as long as the multipath of the channel are uncorrelated, i.e., the environment enables rich scattering with uncorrelated small scale fading between the antenna elements [3]. Therefore, with the above mentioned conditions, MIMO offers spatial microscopic diversity [1].In modern communication adaptive antennas have been used because of their advantages, which are, the required transmission power is reduced because the transmitting antenna focuses energy on the receiving antenna by beam forming, and the sensitivity to signals from a particular direction.

That makes the system capacity to increase because these antennas reduce interference and this allows frequency reuse at short distances [2].

The benefits of adaptive antennas can be summarized as follows:

- Increased range/coverage
- Increased number of users with the increase of signal to interference ratio
- Low power which is used and/or cost reduction
 -Improved link quality/reliability: Diversity gain is obtained by receiving independent replicas of the signal through independently fading signal components. Based on the fact that one or more of these signal components will not be in a deep fade, the availability of multiple independent dimensions reduces the effective fluctuations of the signal.

-Increased spectral efficiency: Spectral efficiency is a measure of the amount of information – billable services- that carried by the wireless system per unit of spectrum. It is measured in bits/second/Hertz/cell, thus it includes the effect of multiple access methods, modulation methods, channel organization and resource reuse (e.g., code, timeslot, carrier).

Spectral efficiency plays an important role since it directly affects the operator cost structure.

Moreover, for a given service and QOS, it determines the required amount of spectrum, the required number of base stations, the required number of sites and associated site maintenance-, and ultimately, consumer pricing and affordability. Equation (1) shows a simplified formula to estimate the required number of cells per square kilometer. (The offered load is in bits/seconds/km2) bile environments. The necessary element spacing is 0.4-0.5 wavelengths. This means that an eight-element antenna would be approximately 1.2 meters wide at 900 MHz and 60 cm at 2 GHz. The essence work of MIMO systems is space diversity  time signal processing. One useful and consistent can be that the difference a smart/adaptive antenna and the "dump"/fixed one is the property of having and adaptive and fixed lobe pattern, respectively. Figure 1 illustrates the concept of adaptive antenna [3].
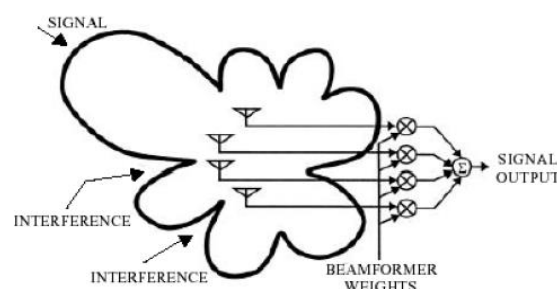


Figure 1. Adaptive antenna basic concept

The work of MIMO systems was explained by considering any wireless communication system having a RF link in which the transmitting side as well as the receiving end is equipped with multiple antenna elements. Such a setup is illustrated in Fig. 2.

The core thought which used in  MIMO systems is that the signals on the antennas on the transmitter Tx and the receive (RX) antennas at the other side are concerted in such a way that the quality (bit-error rate or BER) or the data rate (bits/sec) of the communication for each MIMO user will be improved. Such an advantage can be used to increase both the network's quality of service and the user's profit of digital communication data in the use of multiple spatially distributed antennas. As such MIMO systems can be observed as an expansion of the smart *antennas*, a popular technology using antenna arrays for improving wireless transmission.

A key feature of MIMO systems is the ability to turn multipath propagation, traditionally a pitfall of wireless transmission, into a benefit for the user. MIMO effectively takes advantage of random fading [1], [3] and when available, multipath delay spreads, for multiplying transfer rates. The prospect of many orders of magnitude improvement in wireless communication performance at no cost of extra spectrum (only hardware and complexity are added) is largely responsible for the success of MIMO as a topic for new research. This has prompted progress in areas as diverse as channel modeling, information theory and coding, signal processing, antenna design and multi antenna aware cellular design, fixed or mobile[4].
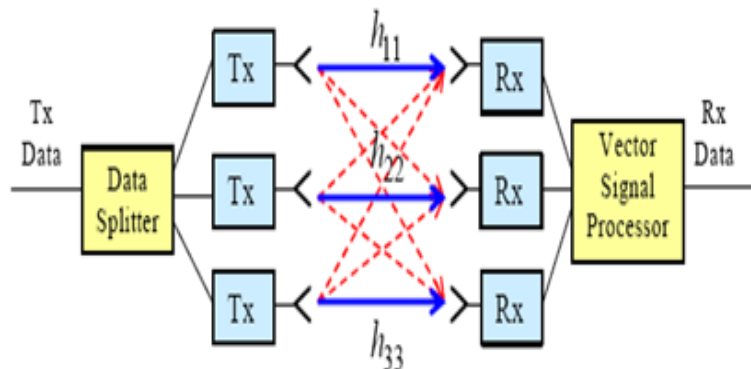


Figure 2.  Antenna design of MIMO System.

To develop the system mathematical model, consider in Fig 2. We can use the explanation which is shown in Fig.3.
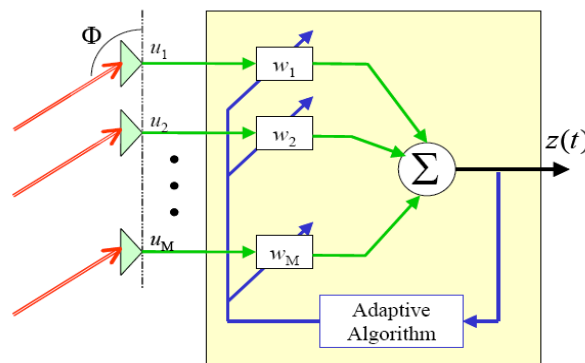


Figure 3. The system mathematical model.

The phase difference between the antenna element m and a reference element at origin is given by.

$$\Delta\Psi_m = \beta\ d_m \tag{1}$$

$$\Delta\Psi_m = \beta\ (x_m\cos(\varphi)\sin(\theta) + y_m\cos(\varphi)\sin(\theta) + z_m\cos(\varphi)\sin(\theta)) \tag{2}$$

Where $\Phi$, z and $\Theta$ are the elevation and azimuth angles respectively, $\beta$ is the phase propagation factor, and $x_m$, $y_m$ and $z_m$ are the Cartesian coordinates of the antenna element m with respect to a reference element at origin. The output signal can be expressed at the following:

$$Z(t) = \sum_{i=1}^{M} U_i\ (t)W_i \tag{3}$$

If the received signal at the reference antenna element is $u_1(t)$, the received signal at other elements will be phase-shifted replicas of $u_1(t)$. Hence, and for more than one user, we can expand (3) to: [3]

$$Z(t) = \sum_{i=1}^{M} u(t)e^{-i\beta(x_m\cos(\varphi)\sin(\theta) + y_m\cos(\varphi)\sin(\theta) + z_m\cos(\varphi)\sin(\theta)}w_i \tag{4}$$

## 2. Beam Forming of the Antennas

A linear antenna array can offer a more defendable communications link in the presence of reverse propagation conditions such as multipath fading and interference. A core idea in smart antennas is that of beam forming by which on one increases the average signal-to-noise ratio (SNR) through focusing energy into desired directions, in either transmit or receiver [2].

If the response of each antenna was assessed in the transmitter or receiver to a given desired signal, and may be to interference signal, it would have been favorably join the elements with weights selected as a function of each element response.

The features of MIMO are essential; to understand the implicit mathematical ease of MIMO, where data flow is transmitted over a *matrix* rather than a vector channel, give us new and excellent conditions beyond just the added diversity or array gain benefits.

Simple beam former, usually called as the delay-and-sum beam former, with all its weights of equal magnitudes. The phases are selected to steer the array in a particular direction, known as the look direction. With denoting the steering vector in the look direction, the array weights are given by (5).

$$w_c = \frac{1}{L}s_0 \tag{5}$$

The array of these antennas has vectors with unity response in forward direction, that is, the mean output power of the processor due to the source in the look direction is the same as the source power. This may be understood as follows. Assume that there is a source of power in the foreword direction, hereafter referred to as the signal source, with denoting its modulating function. The signal induced on the element due to this source only is given by (6).

$$x_s(t) = m_s(t)e^{i2\pi f(t+T.c(\theta+\Phi))} \tag{6}$$

Thus, in vector signaling, using a steering vector to indicate relevant phases, the array signal vector due to the look direction signal becomes (7) and the output of the array with weight vector becomes (8).

$$x_s(t) = m_s(t)e^{i2\pi ft}S_0 \tag{7}$$

$$y(t) = m_s(t)e^{i2\pi ft} \tag{8}$$

So the mean output power was received of the equation (9) Thus, the mean output power of the traditional beam former steered in the look direction is equal to the power of the source in the look direction.

$$P(w_c) = E[y(t)y^*(t)] = P_s \tag{9}$$

The output of equation (9) is similar to steering the array mechanically in the look direction except that it is done electronically by adjusting the phases. This is also referred to as electronic steering, and phase shifters are used to adjust the required phases. The idea of a delay-and-sum beam former can be understood with Fig. 4, which shows an array with two elements separated by distance. If we consider a plane wave arriving from direction induces voltage on first element.

As the wave arrives at the second element seconds later, with (9) the induced voltage on the second element equals .If the voltage induced at the first element is delayed by an amount equal to producing voltage, and no delay is provided at the second element, then both voltage waveforms appear in phase and the output of the beam former is produced by summing these waveforms. A scaling of each waveform by 0.5 provides the gain in direction equal to unity.
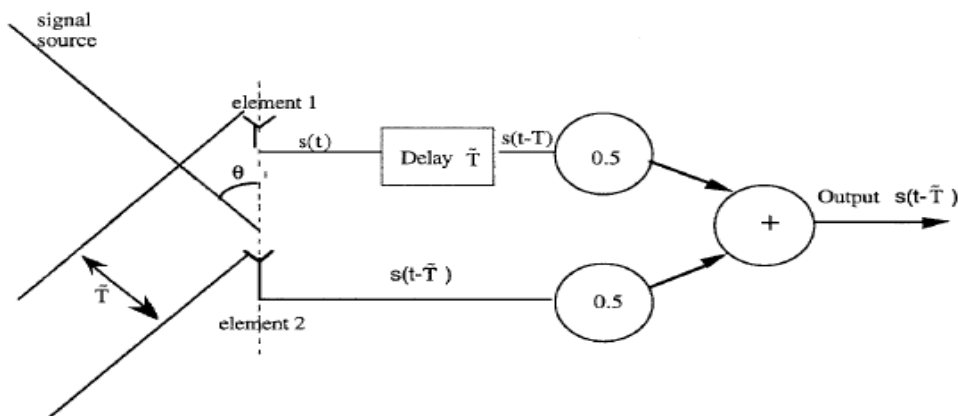


Figure 4. Array with two elements separated by distance.

The received signal at the base is due to reflections from all scattering structures in the propagation environment. Let $S_o(t)$ be the complex envelope of the transmitted baseband signal and $a_o$ be the corresponding channel vector. Assuming that the delay spread is much less than the inverse bandwidth of the signal, we can use (10) and write the received signal vector at the base station antenna array as

$$X(t)=s_o(t)a_o+i(t)+n(t) \tag{10}$$

where

$$i(t)=\sum_{i=1}^{N} s_i(t)\,a_i \tag{11}$$

Represents the composite of the *N* co-channel interferers is the additive noise vector, which is modeled as a complex Gaussian random vector with zero [3]. Adaptive Beam forming with Antenna Arrays 49 mean and disparity.

$$E\{n(t)n^*(t)\} = \rho_n^2 I \tag{12}$$

Where I is the $K \times K$ identity matrix and $\sigma^2_n$ is the antenna noise variance. Equation (13) implies that the noise is *spatially* white. The noise vectors n$^*$*(t)* and n$^s$*(t)* are both low pass white Gaussian random processes. In addition, the noise vector n*(t)* is assumed to be white,[4]

$$E\{n(t)n^*(t)\} = \rho_n^2 I £(t1\text{-}t2) \tag{13}$$

This modeling of the noise vector does not take into account. Let $w_o$ represent the desired weight vector for linearly combining the array outputs. From Figure (4), the output of the beam former *y(t)* is given by

$$Y(t)=W^*_o \; x(t) \tag{14}$$

Where W$^*_o$ is the Hermitian transpose.

## 2.1. Direction-Finding Based Beam forming

The direction-finding based beam forming techniques are based on the propositions that the angle spread *is* either zero or relatively small such that all the unresolvable paths that contribute to the received signal will essentially arrive from the same direction. In such case the channel vector as defined becomes

$$a_{i\approx} v(\theta_i) = (\sum_{t=1}^{L} Re^{-i\emptyset t})= \beta_i \,(t).v(\theta_i) \tag{15}$$

where $\theta i$ is the angular position of the *i*th source with respect the base station. In this case, we rewrite the received signal vector *x (t)* as

$$X(t)=\widetilde{s_o}(t)v(\theta_o)+ \sum_{t=1}^{N} \widetilde{s_i} \, v(\theta_i) + \; n(t) \tag{16}$$

Where ˜A reasonable proposition to make the signals $s_i(t), s_0(t)$, $n(t)$ are uncorrelated. All DF-based techniques use the array output x*(t)* and knowing the array divergent *A* to get an estimation of the directions of arrival (DOA) $\theta_o$, $\theta_1$, ,$\theta_n$ and the corresponding evaluates the array response vectors v(ˆ$\theta_o$), v(ˆ$\theta_1$), ···, v(ˆ$\theta_n$ ). A number of high-resolution techniques such as MUSIC, it is used to estimate the DOAs. A sensible design is to find the best weight vector to optimally combine the array outputs under some suitable criterion.

Minimization of mean squared error (MMSE), maximization of signal to interference-plus-noise ratio (SINR), and maximum likelihood (ML) have been widely used as optimization criteria, and in all these case the optimal weight vector turns out to be a function of signal strengths of the desired and undesired signals, their directions of arrival, Before we proceed to derive the optimal weight vector under any of those criteria, we first define some of the statistical quantities for the signal vector model in (16).

Let u$(t)$ = i$(t)$ + n$(t)$ be the total undesired signal vector. We define the array covariance R$xx$ and the undesired signal vector covariance

$$R_{xx} = E\{x(t)x^*(t)\} = \sum_{t=0}^{N} v(\theta_i)\, \rho_i^2 + \rho_i^2 I \qquad (17)$$

$$R_{xx} = E\{u(t)u^*(t)\} = \sum_{t=0}^{N} v(\theta_i)\, \rho_i^2 + \rho_i^2 I \qquad (18)$$

So the received signals in the array considering the phase difference and the angle of arriving will have the shape as in the Fig (5).
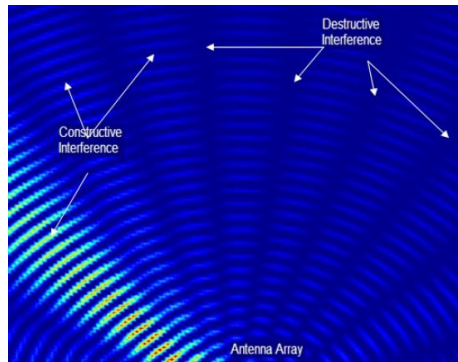


Figure 5. Received signals in the array.

## 2.2. Receiver Model Structure

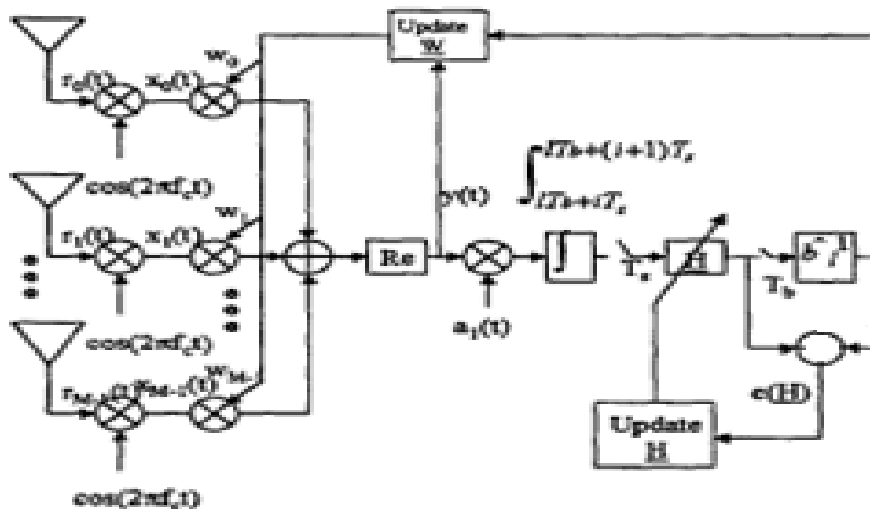In Fig (6) shown a proposed receiver model with multiple antennas



Figure 6. Receiver with an adaptive antenna array.

The transmitted signal from user k, using band pass notation, can be written as *P,* n, $f_o$, $a_K(T)$, and $b_K(T)$, are the transmitted power, phase, carrier frequency, PN sequence and information data bit sequence for user k,  The PN sequence can be written as

$$s_k(t) = \sqrt{2P}\, a_k(t)\, b_k \exp\{j(2\pi f t + \emptyset_k )\} \tag{20}$$

Where a; is the jth PN chip for the kth user and P& I is a unit rectangular pulse of duration chip time interval T, Similarly, the data bit sequence can be written as

$$a_k(t) = \sum_{j=0}^{n} \binom{k}{a} P_r(t\text{-}jTc) \tag{21}$$

Where a is the I-th data bit for user k and Pn(t) is a unit rectangular pulse of duration bit time interval Tb. Assuming that the channel response is ideal and a linear antenna array with M omnidirectional antenna elements is used at the receiver. The signal received at the n-th antenna element can be written as

$$r_m(t) = \sum_{i=1}^{k} \sqrt{2P}\, a_k(t\text{-}\tau)\exp j(2\pi f t + \varphi + \tfrac{2\pi lm}{\lambda}\sin\theta) + n(t) \tag{22}$$

n (t) is the complex AWGN process of the receiver at the mth antenna element, and r.. and ~ or the relative time and the phase difference between the desired user signal with q=O and p,=O and other user k signal, respectively. Each antenna element output m (Q after down converter is multiplied by a complex weighting factor and then summed to produce the antenna array output *y(t).*

$$W_{m=} \frac{1}{\sqrt{M}} e^{-\frac{j2\pi}{\lambda}\sin\theta}, m=0,\ldots\ldots,M\text{-}1 \tag{23}$$

$$y (t) = \text{Re}\{\textstyle\sum_{m=0}^{M-1} Wm\ Xn\} \tag{24}$$

Without loss of the generality, we suppose user 1 is the wanted user. We also suppose that the PN sequence at the receiver is synchronized with that of the desired user and coherent demodulation is employed. If a weighting vector is equal to the array response vector *a(θ),* which is defined as[5]

$$a (\theta 1) = \frac{1}{\sqrt{M}} \tag{25}$$

Antenna array will yield a beam pattern towards the desired signal and suppress interfering signals of different arrival angles. The demodulation input *can* be written as

$$y (t) = \sqrt{\frac{MP}{2}}\, a(t)b(t) + \zeta(t) + \varkappa(t) \tag{26}$$

The interfering signals due to other users and the thermal noise component, can be written as

$$\zeta(t) = \sqrt{\frac{1}{M}} \sum_{m=0}^{M-1} \left\{ \sum_{b=2}^{k} \sqrt{\frac{P}{2}} \; a_k(t-\tau)b_k(t-\tau)x\cos(\varphi + \sin\theta - \sin\theta i) \right\}$$
(27)

$$\Upsilon(t) = \sqrt{\frac{1}{M}} \sum_{k=0}^{M-1} \left\{ n(t)\cos(\frac{2\pi km}{\lambda} \; \sin\theta 1 + n(t)\sin(\frac{2\pi dm}{\lambda} \; \sin\theta) \right\}$$
(28)

From equation (28) we *can* see the receiver with antenna array will have an amplitude gain of the received signal power with M antenna elements will be M times stronger than that with single antenna receiver if the DOA of the desired user is obtained. The $f_i(t)$ is a Gaussian random.

## 3. Simulation

This paper proposed a receiver with multiple antennas of mobile communication system in BS using CDMA technique, 2.4 GHz bandwidth in the work .In the work was used the mathematical models of phase difference in the antennae array, electromagnetic waves captured by the array, radiation from an unwanted source and the signal processing to be done by the array in wireless network.

The low transmitting power of BS antennas makes these signals susceptible to jamming and interferences, and the received signal level in the handheld phone is a function of distance and jammer transmit power. Modern advanced signal processing techniques allow receiving signals with jamming to signal (j/s) ratio as 30- 35 db[5].

The most effective performance improvements against jammers are provided through the use of controlled radiation pattern antennas .These antennas increase the j/s margin to 70 db [6]. with advanced receiver design.

The basic design of simple beam steering or null-forming antenna array is shown in Fig 7 [6].
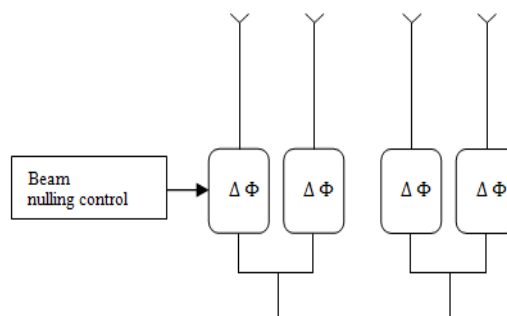


Figure 7. Antenna design for beam steering.

The array consists of 4 antennas with antenna weighting and phase shifter circuitry to adapt the array pattern. The system designed to detect multiple jammer signals and placed a null in the antenna pattern in the location of the jammer or interference source [7].

MATLAB 2014b used to simulate the work by applying   programmable weights to the signals received at each element and sweeping the space in hemispheric of the array which can be used in both handheld mobile station or Base station Transceivers as shown in Fig.8 to show how different amount of weighting allowed to change the antennae gain to get a protraction from interference and other unwanted signals from any direction of arrival to the antennas to get the best signal reception in the environment of noise manmade or from the natural causes the best mode to receive the signal shown in Fig.9 [8].
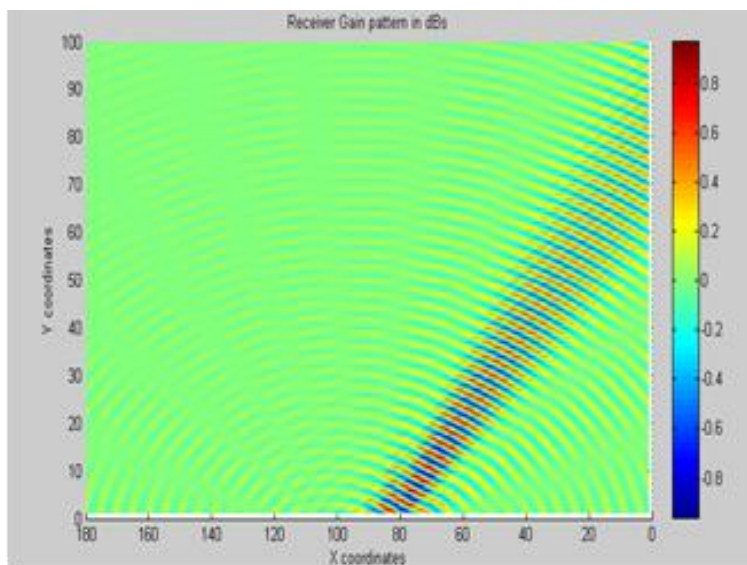
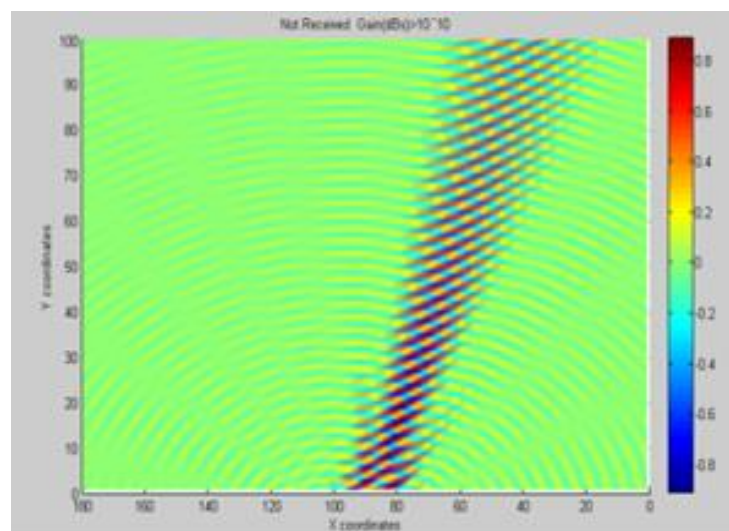

Figure 8. Antenna sweeps the radiation pattern.



Figure 9.Interference suppression receiver with an adaptive antenna array.

### *3.1. Ray Tracing program*

To make the ray tracing program more efficient and to create an overall MIMO simulator, further modifications were needed. To calculate the channel matrix, the ray tracing program applies an initial weighting to the transmitting antenna array. This weighting is simply a normalized weighting with a magnitude of one and no phase angle.

Once the antenna weightings are calculated from the MATLAB code, they need to be applied in the ray tracing program and plots obtained.
At this point the ray tracing program calculated the field points for a gain pattern of only the transmitter. If the gain pattern of the receiver antenna was plotted, swap around

The data files was needed relating to the receiver and transmitter. Essentially the receiver was plotted as a transmitter. For the final MIMO simulator this was unacceptable. The authors had been wanted the ray tracing program to calculate the gain patterns for both the transmitter and receiver simultaneously and also apply the appropriate weightings to each [9].

The ray tracing program uses a tab-delimited format specifying the real part and then the imaginary part of the complex number. Only one complex number is written to each line. Whereas MATLAB represents a complex number in the format 'real+ imaginary', also it MATLAB specifies more than one complex number per line. The following piece of code converts from the MATLAB format to the format needed to be compatible with the ray tracing program, and writes these values to the files [10].

The locations of the receiver base stations are stored in an array; this array is also used to store the locations of the transmitter locations. Additionally, the authors had been created two other functions to read in the antenna weightings which were calculated by MATLAB 2014b.

The system is located in the receiver equipped with many antennas in order to protect them from the interference intended against this device by conducting a survey of space and determine the direction that does not include high level of noise and zero-level direction towards the source of interference and thus the ratio of signal to noise S / N direction of reception is high.

These functions for the program to calculate two plots, it essentially iterates twice, once for the transmitter calculations and once for the receiver calculations. The only difference between the original contour fields plot and the two new functions are the locations of the data that is stored and read in, the functionality of both is the same.

## 4. Conclusions

In this paper the basic characteristics of MIMO system which is used in mobile communications was introduced and by using MATLAB 2014b simulation to show the scan of the beam of antenna and measure the received power to get the best situation to make the call by suppression the signal from the direction which is many more the specific threshold. In this research was shown the concepts of beam forming and has

provided details of various beam forming schemes which is used to receive the signal in the environment of noise.

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