RECONFIGURABLE ANTENNA FOR MIMO SYSTEM

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***Abstract*— MIMO system is an attractive technology for wireless systems. Now Reconfigurable Antenna for MIMO systems improves link capacity which is an additional feature of this system. In this paper we are going to see Reconfigurable Antennas for MIMO Systems based on Array system. In Array based Reconfigurable Antennas for MIMO Systems, an array of two printed dipoles separated by a distance of quarter wavelength are used and each of them are reconfigured in length using pin diode switches. The switch configuration can be modified in a manner adaptive to changes in the environment. The configuration of the switches effect the mutual-coupling between the array elements and subsequently the radiation pattern of each antenna, leading to different degree of pattern diversity which can be used to improve link capacity. A new definition of spatial correlation is studied to include the effects of antenna mismatch and radiation efficiency when quantifying the benefits of pattern diversity.**

Keywords— MIMO systems, Reconfigurable Antenna, Spatial Correlation.

Literature Survey:

There are many excellent publications in the current literature on MIMO systems, and the associated transmission algorithms such as space-time codes (STCs) and spatial multiplexing (SM). The common goal of these research efforts is to make the best use of limited and costly wireless bandwidths by exploiting high spectral efficiencies offered by multiple antenna systems.

Many innovative Reconfigurable Antennas have been proposed in recent years such as composite right/left-handed leaky-wave antenna, electronically steerable parasitic array radiator, switchable MEMS Antennas such as PIXEL Antenna [1], Octagonal Reconfigurable Isolated Orthogonal element (ORIOL) Antenna [2]. Reconfigurable antennas have been used to yield diversity gain in SISO systems [3], [4] and also have been suggested for MIMO systems [5,6,7].

An excellent discussion on adaptive MIMO systems is given in [8]. In this reference, the adjustable system parameters are identified as the modulation level, coding rate, and transmission signaling schemes such as spatial multiplexing, space-time coding, and beam forming. The adaptation algorithm must be able to select the best combination of the system parameters with respect to the properties of instantaneous or averaged space-time channel matrix in a continuous way.

Problem Definition and Motivation for Research:

Today we are facing the increased data-rate requirements brought about by the arrival of new services such as internet services and the transmission of images via wireless communication systems, as well as the saturation of resources in the transmission channel, in particular in the mobile telephony band.

The emergence of MIMO systems have been motivated by all the above factors. MIMO systems consist of using several antennas for transmission and reception. Several space time processing techniques are studied and by taking advantage of the associated space time processing, MIMO systems have shown a considerable increase in spectral efficiency i.e. proportional to the number of antennas used.

Introduction:

MIMO wireless systems have demonstrated the potential to increase communication spectral efficiency in a rich multi-path environment. Recent works in this field have focused on measuring and characterizing the real MIMO propagation channel and novel antenna solution in order to improve MIMO links. With the integration of the internet and new multimedia applications into wireless communication systems, the demand in terms of data rate is continuously increasing. Several techniques have been developed in order to respond to this need. The implementation of MIMO signal demodulation algorithms is a topic currently under discussion for the above demand.

It has been shown that signal correlation and mutual coupling effects between the MIMO array elements has a significant effect on MIMO capacity [9], [10]. Recently, it has been shown that pattern diversity, which results from mutual coupling, can potentially lead to inter-element received signal correlation and thus higher MIMO channel capacity [10], [11].

In this paper we present a novel reconfigurable MIMO antenna array system which will demonstrate how the ability to select between different pattern diversity configurations can improve MIMO system link capacity. The switch based parasitic antenna[12] has also been proposed to improve the MIMO system link capacity through pattern diversity.

In this paper the antenna system under study consists of two reconfigurable micro strip dipoles.

The two active elements of the array can be reconfigured in length using pin diode switches. The setting of different switches result in different geometric positions of the antenna and as a result different level of inter-element mutual coupling and array far field radiation patterns. The goal of such a system is to choose the reconfiguration of switches in an environmental /channel adaptive fashion to decrease MIMO spatial channel correlation and subsequently maximize link capacity.

In order to be able to manage the multiplicity of communication standards, the MIMO system has to be capable of supporting various types of modulation and propagation. These are the reasons why a reconfigurable architecture is of considerable interest in MIMO systems.

I. MIMO SYSTEM:

From our study, we can see that the capacity of the Multi-Antennas systems increase linearly with the number of antennas. These discoveries lie at the origin of MIMO systems, primarily aimed at resolving the problems of congestion and the capacity limitation of broadband wireless networks. The basic idea in MIMO system is space-time processing, where time (a natural dimension) is complemented by a spatial dimension inherent in the use of several antennas. Such a system may be regarded as the extension of intelligent antennas. The key property of the MIMO system is its capacity to turn multi-path propagation (traditionally a drawback) into an advantage – in other words, MIMO systems exploit multi-paths instead of suppressing them.

Conventional techniques used on reception to cancel out the distortion introduced by the MIMO channel often necessitate either knowledge of the channel or the use of a known symbol sequence at the receiver end. In practice, the channel is unknown and hence an estimation of it is needed. Often the estimation of the channel is based on the use of training sequences multiplexed with the useful data, which quite clearly reduces the useful data rate. For channels that do not change over time, the loss is not significant, as only a single learning cycle is needed. Figure 1 shows shape principle of 2x2 MIMO System and Figure 2 shows shape principle of NxN MIMO System.

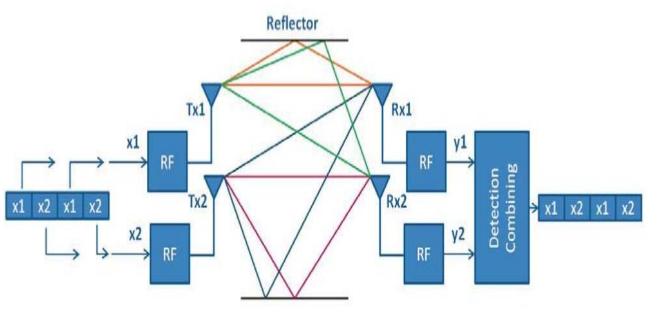


Figure 1: 2 x 2 MIMO Systems

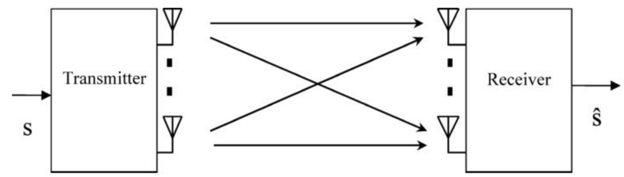


Figure 2: NxN MIMO System

MIMO Systems can be distinguished into two types: the first based on space-time codes, the other on spatial multiplexing.

II. MIMO System based on space-time codes:

In order to improve transmission quality, researchers have designed systems based essentially on diversity, proposing linked coding and labeling. This space-time coding allows more reliable communications. It consists of adding redundancy to the transmitted binary data in order to increase the diversity and avoid the drop outs characteristic of the MIMO channel.

III. MIMO System based on spatial multiplexing:

The transmission antennas each transmit a different symbol, independent of the other antenna but using the same modulation and same carrier frequency. The bandwidth used remains identical to that of the classical system, but as several symbols are transmitted, the spectral efficiency increases.

For a system with m Transmission antennas and n Reception antennas, the received antenna r may be written as

$$r = Hs + v,$$

Here:
s is a vector of transmitted symbols (n*1),
H is the channel matrix (m*n),
v is a complex additive white Gaussian noise vector (m*1),
r is a vector of received symbols (m*1).

In the equation, the elements of H have a uniformly distributed phase and amplitude that follows the Rayleigh law. This model is typical of an environment with numerous echoes and sufficient separation between the antennas. We are also assuming the channel remains constant during the transmission of a block of n data vector s and that the receiver has full knowledge of the H matrix. This knowledge may be obtained by training symbols or by blind estimation of channel.

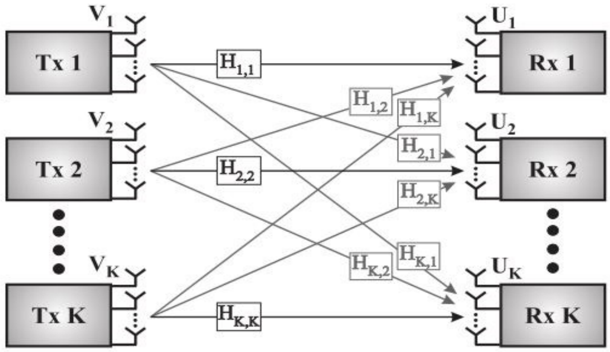


Figure 3: K user MIMO System

A K user MIMO system looks as in Figure 3.

IV. *RECONFIGURABLE MIMO SYSTEM*:

MIMO communication systems can significantly improve the wireless communication performance in rich scattering environments. However in practice, placing multiple antennas in handset or portable wireless devices may not be possible due to space and cost constraints. To overcome this limitation, Reconfigurable antennas can be a promising solution to improve the performance of MIMO communication system, especially in environments where it is difficult to obtain enough signal de-correlation with conventional means i.e spatial separation of antennas, polarization, etc. Unlike conventional antenna elements, in MIMO systems which have a fixed radiation characteristics, Reconfigurable antenna element in MIMO systems has the capability of changing its characteristics such as operating frequency, polarization and radiation patterns. Therefore, using this type of antenna in wireless communication system can enhance their performance by adding an additional degree of freedom which can be obtained by changing the characteristics of the wireless propagation channels. Generally Reconfigurable antennas are divided into three categories including frequency, polarization and radiation pattern reconfigurable antennas.

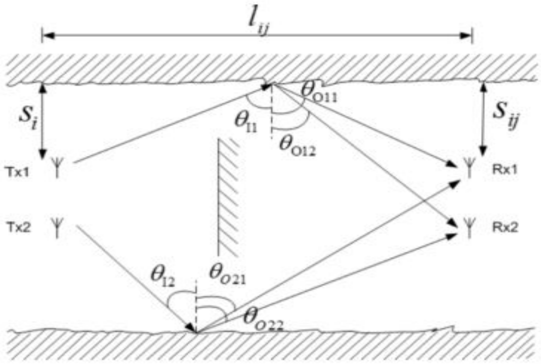


Figure 4: A MIMO model based on nano-patch antenna array

In Figure 4 s_i is the distance between the i th transmit antenna and its reflecting object, s_{ij} is the distance between the j th receive antenna and i th transmit antenna's reflecting object, and I_{ij} is the horizontal distance between the i th transmit antenna and j th receive antenna.

V. *Antenna design:*

Diagram can also be inserted of shape of antenna fig 2,3

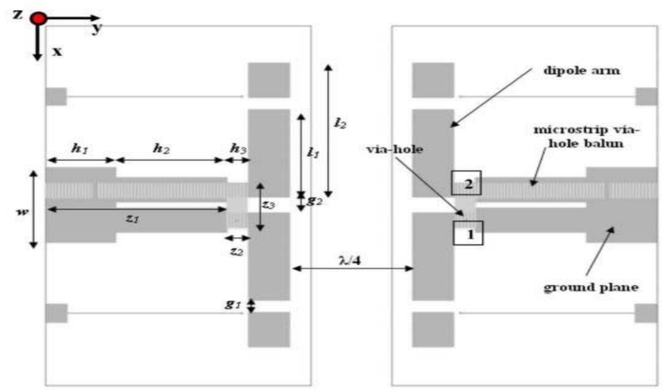
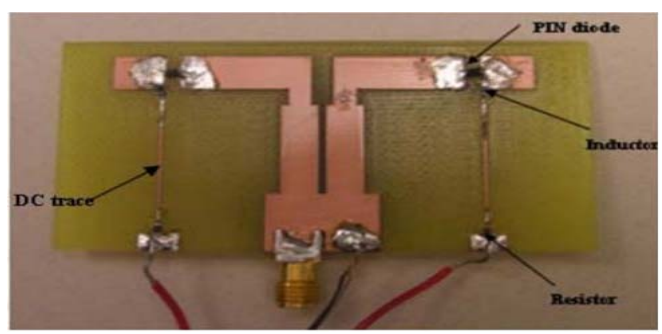
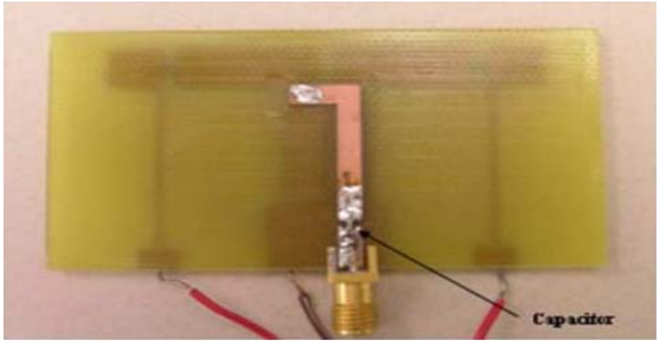


Figure 4: Dipole Antenna Design

The antenna design using an array of two micro strip dipoles, the geometry of which is shown in the Figure 4. A quarter-wavelength micro strip balun acts as an unbalanced to balanced transformer from the feed coaxial line to the printed dipole strips[13]. The ground plane of the micro strip line and the dipole strips are in the same plane. The presence of via hole permits the feed point 2 of a printed dipole strip to be shifted in phase by 180 degree with respect to the feed point 1 of the other printed dipole strip. This occurs due to 180 degree phase difference between the top strip and the ground plane of the micro strip line.



The lengths of the dipole-arm strip, and there after the geometry of the antenna, can be changed using 2 pin diode switches. In this way it is possible to define 2 configurations of the antenna, one when both of the switches are turned on(long configuration) and another when they are turned off(short configuration).



A surface mounted capacitor is placed on the balun to block the dc current from flowing back to the RF input, an inductor is used to block the RF from lowing in the dc supply trace and a resistor is used to limit the voltage across the dipole.

The close proximity of the two printed dipole is selected such that there is a strong mutual coupling between the dipoles. This coupling is effectively used to have different radiation patterns for each array's geometry. In particular the vicinity of the two reconfigurable dipoles, varying the length of one of the dipole, effect's the input impedance and current distribution of the other dipole, changing thereafter the radiation properties[13].

The four different configurations are both short, both long, first antenna short and second long, first antenna long and the other short. The differences in input impedances are due to the different lengths of the dipole and the different levels of the mutual coupling of the two configurations. A difference in input impedance is in fact obtained not only when the active dipole length is changed but also when the parasitic dipole length is changed leaving the active dipole length unchanged.

VI. *Spatial Correlation:*

Spatial Correlation is a measure of similarity between the signals received by two spatially separated antennas. In this section, we propose a new definition of spatial correlation to quantify only the pattern diversity while including the effects of antenna input impedance and radiation efficiency. Using this definition, the proposed reconfigurable antenna array for MIMO systems is motivated through spatial correlation and ergodic capacity performance analysis in clustered channels.

The spatial correlation between the l^{th} and m^{th} elements of MIMO arrays, previously used to quantify pattern diversity is given by [14]

$$r_{l,m} = \frac{\int_{4\pi} P(\Omega)\underline{E}_l(\Omega)\underline{E}_m^*(\Omega)d\Omega}{\int_{4\pi} P(\Omega)\left|\underline{E}_{iso}(\Omega)\right|^2 d\Omega}$$

Formula 1

Where

Ω is the solid angle,

$P(\Omega)$ is the pas of the scattered field

$\underline{E}_l(\Omega)$ is the far-field radiation pattern of the l^{th} antenna of the reconfigurable antenna array and $\underline{E}_{iso}(\Omega)$ is the far-field radiation pattern of ideal isotropic radiators

More over it is assumed that

$$\int_{4\pi} P(\Omega)d\Omega = \int_{4\pi} \left|\underline{E}_l(\Omega)\right|^2 d\Omega = \int_{4\pi} \left|\underline{E}_{iso}(\Omega)\right|^2 d\Omega = 1$$

Formula 2

Where the first term of the quantity is the condition for the $p(\Omega)$ to be a PDF,probability density function.

Since the spatial correlation is normalized with respect to the antenna gain of ideal isotropic radiators, the envelope of the Formula 2 is not guaranteed to be lower than one, as provided by the conventional definition of correlation [15] [16]. This guarantee cannot be satisfied because in Formula 1 the power radiated by the isotropic radiator and the l^{th} and m^{th} elements of the MIMO arrays are assumed to be equal. For the case of proposed reconfigurable antenna however, the above assumptions may not hold because each antenna configuration has different level of radiated power given equal input power.

Conclusion:

A MIMO system using a reconfigurable antenna was studied in terms of capacity. The variation in the antenna geometry and in the mutual coupling effect between the radiating elements were studied which generate different radiation patterns. This pattern diversity were studied on a channel by channel basis to identify the antenna configuration which provided the greatest level of channel capacity.

The benefits deriving from using a reconfigurable MIMO antenna system was first motivated through a spatial correlation coefficient analysis in a clustered MIMO channel model. We learnt the advantage of switching between the different antenna configurations based on the spatial characteristics of the MIMO model.

The reconfigurable antenna for MIMO system is an attractive solution for hand held devices (where space is an important constraint) to maintain good communication link capacity. The studied antenna is an initial type of reconfigurable MIMO system with only two switches per antenna array element. The future may be still brighter with higher thoughts

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