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Review of MIMO Zero-Order Resonant Antenna

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Abstract - ***MIMO is often traced back to 1970s research papers concerning multi-channel digital transmission systems and interference (crosstalk) between wire pairs in a cable bundle: A R Kaye and D A George (1970) [1], Branderburg and Wyner (1974) [2], and W. van Etten (1975, 1976) [3]. A multiple input multiple output (MIMO) technique has been considered one of the most developing techniques for various wireless applications to enhance the performance of wireless communication system. A MIMO system utilizing several antenna components is more advantageous than a single input single output (SISO) system in terms of increasing channel capacity and reducing transmitting power. When the transceiver uses more than one antenna, the antennas must be placed minimum at least half of the carrier wavelength apart, in order to transmit or receive an uncorrelated signals. Up to date, most MIMO antenna systems with more than two antennas are three-dimensional instead of planar. But the basic problem with the MIMO systems is the requirement of electrically small antennas which usually have several constraints. Since antenna integration and miniaturization are two major challenges in MIMO systems, the performance parameters of antenna are optimized to achieve an Omni directional radiation pattern with reasonably wide impedance bandwidth and high gain. In order to achieve the above challenges we can implement the MIMO antenna using zero-order resonant materials.***

Key Words: Metamaterials, MIMO, VSWR, Electrically Small Antenna etc…

1. INTRODUCTION

MIMO wireless system provides many advantages by using more than a single antenna. However, radio frequency (RF) transceiver design for MIMO wireless communications is a challenging task. MIMO has been the attracting research attention in both academic and industry. The concept of using multiple antennas at receiver was introduced in the early 1960 [4]. Once the signal is transmitted from the transmitter there will be a provision of multiple copies on the receiving side and there combination to obtain a signal with better performance, this technique is called space diversity technique. To realize receiver diversity technique, multiple antennas are employed on the receiver side. The antennas signal output then combined by applying different weighting co-efficient according to different diversity technique. The receiver diversity may be realized using three different methods- Selection method, Equal gain method and Maximal ratio combining. In the selection combining method, the receiver selects the strongest signal and is processed in the single receiver. Maximal ratio combining is realized by weighting both gain and phase of the received signal to maximize SNR. On the other hand in equal gain combining method, only the phases of the channel using weighting coefficients are cancelled. Among the three, Maximum ratio combiner diversity technique provides best performance. The designing of modern wireless transceivers has seen extensive progress and the design of these transceivers generally must follow three main factors. They should be high performance, low cost, and able to handle the complex objectives of advanced wireless communication systems. A multi-branch transceiver with *N* antennas at the transmitter and *N* antennas at the receiver is demonstrated in Fig. 1. In a fading environment, the performance of a wireless link can be greatly improved by using multiple antennas on both the transmitting and receiving sides. These benefits include increased reliability as well as high data rates. A MIMO wireless communication system can be designed to take advantage of reliability improvement or increasing the data rate. The first improvement is called a diversity order improvement, and the latter is called spatial multiplexing. However there is some fundamental trade-offs between obtaining efficient bandwidth, reduction in size and high gain [4-5].

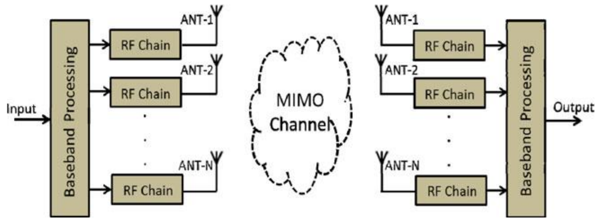

Fig-1 Multiantenna receiver

Antenna is one of the key component, provides interfacing between Radio hardware & air-interface for wireless communication. The major design parameters of wireless antennas are Bandwidth enhancement, multiband operation, high gain and size reduction. The performance of the antenna can be improved by using the various metamaterials. Metamaterials with their special features

like the negative permittivity (ε) and Negative permeability we can achieve the above parameters. Thus using metamaterials we can improve the performance of antennas such as size reduction, bandwidth enhancement, provides good coupling efficiency, improve radiation properties of the antennas [7-9]. Multiple Input Multiple Output technology uses multiple antennas to make use of reflected signals to provide gains in channel robustness and throughput.
MIMO is effectively a radio antenna technology as it uses multiple antennas at the transmitter and receiver to enable a variety of signal paths to carry the data, choosing separate paths for each antenna to enable multiple signal paths to be used.

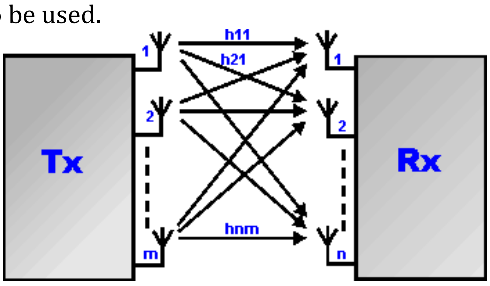

Fig-2 General outline of MIMO system antenna

The two main formats for MIMO are given below:

- ***Spatial diversity:*** Spatial diversity used in this narrower sense often refers to transmit and receive diversity. These two methodologies are used to provide improvements in the signal to noise ratio and they are characterized by improving the reliability of the system with respect to the various forms of fading.
- ***Spatial multiplexing:*** This form of MIMO is used to provide additional data capacity by utilising the different paths to carry additional traffic, i.e. increasing the data throughput capability.

MIMO wireless technology is able to considerably increase the capacity of a given channel, By increasing the number of receive and transmit antennas it is possible to linearly increase the throughput of the channel with every pair of antennas added to the system.

The word "meta", in Greek language, means beyond. It implies that the electromagnetic response of metamaterials (MTMs) is unachievable or unavailable in conventional materials. Many efforts have been done to search for an adequate definition for MTMs. In 2002, J. B. Pendry wrote in a conference paper: "meta-materials, materials whose permeability and permittivity derive from their structure". Later, in 2006, C. Caloz and T. Itoh wrote: "Electromagnetic metamaterials are broadly defined as artificial effectively homogeneous electromagnetic structures with unusual properties not readily available in nature" [22].

2. Literature survey

Multiple-input-multiple-output (MIMO) transmission is one of the promising antenna technologies used for wireless communications. MIMO achieves high capacities. The only limitation is that, the transmitting and receiving antennas should be placed at least half the wave length of the carrier signal in order to transmit or receive uncorrelated signals. In recent years there are lots of changes in wireless communication technologies such as increase in data rate, efficient bandwidth, high gain and at same time antenna size and weight is reduced. MIMO is often traced back to 1970s research papers concerning multi-channel digital transmission systems and interference (crosstalk) between wire pairs in a cable bundle: AR Kaye and DA George (1970) [1], Brander burg and Wyner (1974) [2], and W. van Etten (1975, 1976) [3]. In the mid-1980s Jack Salz at Bell Laboratories took this research a step further, investigating multi-user systems operating over "mutually cross-coupled linear networks with additive noise sources" such as time-division multiplexing and dually-polarized radio systems [10]. In the early 1990s the methods were developed to improve the performance of cellular radio n/w.

During this period the name of the scientist called Richard Roy and Bjorn Ottersten proposed an SDMA system in 1991. It stands for "space division multiple access" this uses directional or smart antennas to communicate on the same frequency with users in the different locations within range of the same base stations. It described a method for increasing capacity using "an array of antennas at the base stations" with "plurality of remote users [11]." Arogyaswami Paulraj and Thomas Kailath proposed an SDMA-based inverse multiplexing technique in 1993. Their US patent [12] described a method of broadcasting at high data rates by splitting a high-rate signal "into several low-rate signals" to be transmitted from "spatially separated transmitters" and recovered by the receive antenna array based on differences in "directions-of-arrival." In the early 1996, Greg Raleigh published a paper and a patent that described natural multipath propagation can be exploited to transmit multiple, independent information streams using co-located antennas and multi dimensional signal processing [13]. This paper also identified practical solutions for modulation (MIMO OFDM) coding, synchronization and channel estimation.

In the late 1996 Gerard J. Foschini submitted a paper that suggested it is possible to multiply the capacity of a wireless link using "layered space time architecture" [14]. Greg Raleigh, V K Jones and Michael Pollack founded clarity wireless in 1996, built and field tested a prototype MIMO System antenna for the first time [15]. In the early 1998 MIMO-OFDM products are developed. Later in January 1998 the papers by Gerard J. Foschini and Michael J. Gans and in 1999 Emre Telator has shown that the channel capacity for a MIMO system is increased as the number of antennas is increased. It is proportional to the number of transmit antennas to the receive antennas. This is known as multiplexing gain and this basic finding in information theory is what led to a spurt of research in MIMO area [16-18]. A novel multiport matching method is devised to directly maximize the mean capacity with rigorous consideration of the mutual coupling effects of the matching network [19]. The recent papers show that MIMO system can provide substantial improvement in system capacity compared with the traditional SISO communication systems. This paper presents a novel optimal multiport matching network for the maximum mean capacity of a 2-by-2 MIMO system. Microstrip patch antenna is very demanded and important discussion thread in the theory of antennas because of its several advantages over conventional antennas like low cost, light weight, easy to feed and their attractive radiation characteristics. Microstrip patch antenna is concerned about the miniaturization of antenna size in achieving high gain and bandwidth. Arrangement of arrays in antenna by various topologies, composite antenna, highly integration of antenna/array and feeding network, operating at relatively high frequencies, proposed for achieving improved performance of microstrip patch antennas [20]. A compact electrically small antenna (ESA) design and fabrication that is based on the meander antenna is presented. The antenna is intended for the use in the 2.4-2.7 GHz of the USB applications. Simulation and measurement results are compared. The practical challenge is achieving an efficient match over a desired operating bandwidth.

In some applications, particularly where the antenna is very small, it is acceptable and perhaps necessary to add loss to the antenna structure so as to increase the usable operating bandwidth. Based on the studies, the impedance bandwidth of the proposed design is above 100% in all the cases studied with good radiation characteristics. The antenna presented here proves to be electrically small and is the best candidate for MIMO applications. In the early 2014 according to one paper a very compact metamaterial MIMO antenna is proposed. This MIMO antenna consists of two antennas which are based on composite left/right handed (CLRH) transmission lines for reducing the antenna dimension. In this proposed configuration, a defected ground structure (DGS) is employed to increase the isolation between two antenna elements. Thus, a novel metamaterial MIMO antenna is proposed which has a high isolation with only 7.5mm distance between the antenna elements. Metamaterial antenna achieves 60% size reduction in comparison with the unloaded antenna. The defected ground structures are inserted to suppress the effect of surface current on the elements of the proposed antenna for reducing the mutual coupling [21]. The antenna offers the compact size with the diversity radiation patterns. This fabricated MIMO antenna shows isolation less than −35 dB over its operating frequency band spreading from 2.38 to 2.5GHz. Summing up the result, it can be concluded that the proposed antenna is a good candidate for WLAN applications. A metamaterial is a composite the properties of which depend rather on an artificial periodic structure made up of macroscopic elements with arbitrary sizes and shapes than on the properties of its constituents. In a very rough approximation, these macro elements can be viewed as very large atoms embedded in a host material. The artificial periodic structure modifies the permittivity and permeability of the matrix, so that designers of metamaterials can control a number of free parameters such as the size and shape of the structure and the constant and variable lattice parameters of the constituents. Metamaterials may have a negative refractivity, which shows up when both the permittivity and the permeability of the material are negative [23].

3. CONCLUSION

Considering the above aspects in the design of multiple inputs multiple outputs antenna in which there are many aspects which must be focused to design the MIMO. There are three major challenges in designing MIMO wireless antenna; they are miniaturization, efficient bandwidth and high again apart from VSWR, directivity etc. All these parameters have trade-off between each other. We need to design the efficient MIMO which can afford better bandwidth, high gain, VSWR<2, directivity and the reduction in size of the MIMO system antenna. It can also be concluded that in order to achieve miniaturization we can use the metamaterials which special features like DNG permittivity and permeability.

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