Analysis of Metamaterial Based Microstrip Array Antenna

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ABSTRACT
Metamaterials have been intensively researched due to their peculiar features such as negative permittivity and/or permeability and ultra-refraction phenomenon. To satisfy the demand of commonly used wireless communication systems, an antenna which can operate at higher frequencies and enhanced characteristics are desirable. The arrangement of all elements is done that they provide an improvement in bandwidth, directivity return loss etc. The frequency response of a metamaterial can be tailored by varying its characteristics. A new metamaterial structure using square and ring split ring resonator is proposed. Using this metamaterial structure, a microstrip patch antenna is designed with enhanced characteristics such as reduction in return lossfrom-20dB to -36dB with tunability is achieved.
Keywords: *Double negative materials, directivity, return loss, bandwidth enhancement.*

I. INTRODUCTION

A microstrip patch antenna consists of a radiating patch on one side of a substrate and a ground plane on the other side of the substrate. The advantages of a patch antenna are: light weight and low volume, low fabrication cost , compatible with MIC technology and so on. Even though it has the above mentioned advantages, it has some disadvantages like low bandwidth, surface waves present in the substrate. Metamaterials are being used extensively to remove the problem of low bandwidth of antenna. Metamaterials are periodic structures consisting of sub wavelength metalo-dielectric scatterers having aperiodicity that is much smaller than the impinging and guided wavelengths. These constituent scatterers or"inclusions" behave like "artificial molecules" that scatter an incident electromagnetic wave giving rise to macroscopic effective material parameters such as a permittivity, a permeability, and a refractive index.In the recent years electromagnetic metamaterials (MTMs)are widely used for antenna applications. These specifically designed composite structures have some special properties which cannot be found in natural materials. Metamaterials are also known as Double negative (DNG) materials, Left handedmaterials (LHM) etc. In 1968, the concept of metamaterials was first published by the Russian physicist Victor Veselago. Thirty years later,Sir John Pendry proposed conductor geometries to form a composite medium which exhibits effective values of negative permittivity and negative permeability. Based on the unique properties of Metamaterials, many novel antenna applications of these materials have been developed. The use of metamaterials could enhance the radiated power of an antenna. Negative permittivity and permeability of these engineered structures can be utilized for making electrically small antenna, highly directive, and reconfigurable antennas.

These, metamaterial based antennas have also demonstrated the improved efficiency & bandwidth performance. Metamaterials have also been utilized to increase the beam scanning range of antenna arrays. They antennas also find applications to support surveillance sensors, communication links, navigation systems, and command and control systems. In this paper we have limited our discussion to antenna.

II. METAMATERIAL AS ANTENNA

Metamaterial coatings have been used to enhance the radiation and matching properties of electrically small electric and magnetic dipole antennas. Metamaterial step up the radiated power. The newest Metamaterial antenna radiate 95% of input radio signal at 350 MHz Experimental metamaterial antenna are as small as one fifth of a wavelength. Patch antenna with metamaterial cover have increased directivity. Flat horn antenna with flat aperture constructed of zero index metamaterial has advantage of improved directivity. Zero-index metamaterials can be used to achieve high directivity antennas. Because a signal Propagating in a zero-index metamaterial will stimulate a spatially static field structure that varies in time; the phase at any in a zero-index metamaterial will have the same constant value once steady state is reached. Metamaterial can enhance the gain and reduce the return loss of antenna.

Theory & Discussion: The metamaterial is composed of copper grids with a square lattice. When electromagnetic wave propagates in free space, the electric field is enhanced by using metamaterial structure. The gain of antenna with metamaterial structure increases nearly 100%.The gain of the circular waveguide aperture antenna with metamaterial structure is already very close to the theoretical maximum value of antenna with the same size and operating frequency. The array structure combining with metamaterial-mantled technology is a more effective method to improve gain. The simulation results, which validate the theoretical analysis, show an about 7 dB addition in the antenna array gain in comparison with the conventional antenna array, so the radiation characteristics of antenna array with metamaterial structure are remarkably improved. Metamaterials are used for further miniaturization of microstrip patch antennas. Patch antennas using metamaterials can be used for C band applications. The size of such an antenna reduces by a factor of 2.45 and the gain directivity increases from 4.18 dBi in conventional design approach to 5.67 dBi in metamaterial design. Several shapes can be considered to make the metamaterial substrate in order to operate in different frequencies. Square rings, different C patterns, square and circular patterns, etc are considered to make metamaterial antenna substrate. All these shapes are designed with the intention to enhance the bandwidth and to reduce return loss along with size reduction. There are several methods to find out the permeability and permittivity of an antenna. They are Wave perturbation method, Nicolson Ross Wier method, NIST iterative technique, new non- iterative technique and short circuit technique. Complex permittivity and permeability of the proposed structures in most investigations has been extracted by Nicolson-Ross-Weir (NRW) approach. SRR is not the main component in a making a left handed medium. Sometimes its complementary structure takes the role.Based on the Babinet principle and the duality concept, the CSRR is the negative images of SRR. It is shown that addition of the CSRRs has shifted resonant frequency 5 GHz of typical patch array antenna to 3.8 GHz without changing the size of radiating patch. Also a size reduction of approximately 50% is observed with the new structure. A circuit design which has a broader range of material parameters resulting in negative refractive index has resulted in antennas that are innovative. Combining a left-handed transmission line segment with a conventional (righthanded) transmission line results in novel configurations with advantages over conventional antenna designs. The left handed transmission lines are essentially a high-pass filter with phase advance. Conversely, the right-handed transmission lines are a low-pass filter with phase lag. This configuration is designated composite right/left-handed (CRLH) metamaterial. Broad band antenna design is one of the major applications of metamaterials. Composite Right/Left Handed Transmission Line approach is used with metamaterial antenna design to enhance the antenna performance. A size reduction of nearly 60% can be achieved with a Mushroom Structured Composite Right/Left Handed transmission line (CRLH - TL) metamaterial. In addition, a wideband also can be obtained by reducing the ground plane of the antenna. A compact ultra Wide Band (UWB) antenna can be designed using metamaterial structure. The antenna exhibits a wide bandwidth of about 190%. The bandwidth of a single patch antenna can be raised by placing a number of metamaterial unit cells.

III. CONCLUSION

Metamaterial are expected to have an impact across the entire range of technologies where electromagnetic radiation are used and will provide a flexible platform for technological advancement. Among metamaterials, negative refractive index materials or left-handed materials have drawn special attention in microwaves. Metamaterial properties, which allows for the reduction in size as compared to other materials for the multiband operation and reconfigurability of microwave devices and antennas. The most interesting application is as an absorber and also as sensors for humidity, soil moisture measurement etc. It is also true that no progress in metamaterials research will be possible without further developments in fabrication, however, From the progress and interest in this field it is clear that the future of metamaterials lies in the field of optics and medical. This is closely linked to advancements in nanotechnology.

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