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A SURVEY ON METAMATERIAL USED FOR COMPACT MICROSTRIP ANTENNAS & APPLICATIONS

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ABSTRACT

Over other antennas, a patch or microstrip antenna has a low profile antenna with number of advantages. Metamaterial used in Microstrip antenna is latest design technique to introduce compact and good band width antennas. In this paper, a survey is done for the research for further. The artificial materials which generally not found in nature but can be engineered the characterized by parameters are known as Metamaterial. The properties of these material having negative permeability as well as permittivity make them differ from other materials. In Metamaterial structure, Split Ring Resonators (SRRs) used to produce negative permeability and thin wire elements used to generate negative permittivity. With the use of such metamaterial in patch antennas it increase the performance parameters especially bandwidth, which are usually considered as narrowband antennas. Metamaterial are also used for miniaturization of microwave antennas.

Keywords: Metamaterial, Thin Wire Element, Microstrip antenna, Split Ring Resonator (SRRs), Complementary Split Ring Resonators (CSRRs).

1. INTRODUCTION

In the history of over 89 years it still remains as stated in [1] "a vibrant field which is bursting with activity, and is likely to remain so in the foreseeable future." This statement is applicable even now. With the scope of antenna design moves into new and innovating range of technology. The essential component in a wireless system is an antenna. The different types of antenna used and they all have their own uses. By embedding the system, demands for compact and efficient is fulfilled as according to the requirement. For compact size Microstrip patch antenna is very popular.

For advanced technologies, an antenna needs to be more reduced in order to use it for compact size. In this survey, to increase the gain and bandwidth of microstrip antenna deals with the actual methods. The main interest behind using metamaterial substrate is to improve the performance parameters of a microstrip antenna using metamaterial and comparison of a metamaterial based patch antenna with a conventional patch antenna. An antenna uses a patch with feed is responsible for radiation and ground fabricated on the insulated di-electric substrate by placing it with metallic sheet.

Many techniques used to improve the bandwidth of a microstrip are stated in [6] as :

a) Reducing the Q factor of the microstrip by increasing the substrate lowering and height the dielectric constant.

b) Use of multiple resonators in single plane.

c) Use of multilayer configurations with multiple resonators.

d) Use of impedance matching networks.

2. CLASSIFICATION OF METAMATERIALS

Metamaterials are unnatural materials constructive to have properties which may not be found in nature [7]. The discovery of metamaterial started in the late 1960s. In 1967, Scientist named Victor Georgievich Veselago found in this studied that electrodynamics of substances with together negative values of dielectric magnetic permeability (μ) and permittivity (ε) [8].

Electromagnetic field resolved by the properties of the materials used. These properties define the macroscopic parameters permittivity ε and permeability μ of materials [8-9]. Permeability μ and Permittivity ε based metamaterials are classified in given below four groups:

a. DPS (Double Positive) Material

Properties with both permittivity & permeability greater than zero ($\varepsilon > 0$, $\mu > 0$) in the material are called as DPS (Double Positive) materials. Under this classification most occurring media (for example dielectrics) fall.

b. ENG (Epsilon Negative) Material

Properties with permittivity less than zero and permeability greater than zero ($\varepsilon < 0$, $\mu > 0$) in the material is called as epsilon negative (ENG) material. In assured frequency system, various plasmas display these characteristics.

c. MNG (Mu Negative)Material

Properties with permittivity greater than zero & permeability less than zero ($\varepsilon > 0$, $\mu < 0$) in the material is called as MNG (mu negative) material. In assured frequency system, some gyro tropic material displays these characteristics.

d. DNG (Double Negative) Material

Properties with permeability & permittivity less than zero ($\varepsilon < 0$, $\mu < 0$) in the material is called as DNG double negative) material. This type of materials can only been produced unnaturally.

3. METAMATERIAL APPLICATIONS

Metamaterials applications are found in various fields including public safety, sensor detection, high frequency battle field communication, improving ultrasonic sensors, solar power management, for high gain antennas and remote aerospace applications [9-10].

a. WMD Detectors

Army and air Force researcher use metamaterials to detect the presence of chemical explosives, biological agents, and contamination. The same structure and science is used for cargo and screening passenger.

b. Invisible Subs

The metamaterials easily manipulate the wavelength of sound that is much larger than light. To make the submarine invisible to enemy sonar, it bends sound around it and this program is funding by Naval Research. Civilian spinoffs also use the metamaterials to produce sound proofing rooms with perfect acoustics.

c. Revolutionary Electronics

Army engineers use the metamaterials as a switching device for building fast and small photonic equipment because in future circuits makes with the use of light rather than electricity. To trap light can be turned on and off a semiconductor combines with the metamaterials in the device. These photonic chips are 10 times faster than the current chips.

d. Light and sound filtering

To control light or sound signals that improve ultrasound resolution and change a material's color, nano scale wrinkles of metamaterials are used. These materials can be made with a multi-layer deposition process and high-precision. B**y** using afraction of a wavelength each of the layer‟s thickness can be control. The precise wrinkles spacing scatters the selected frequencies which created by compressing the materials [11-12]. These are used in sound suppression, medical diagnostics and non-destructive and material testing.

e. Biosensor

Biosensors are very important tools in many areas, like environmental monitoring, food safety and disease diagnostics in the investigation of biological phenomena‟s [13-14]. In past the fluorescence-based methods were used to prove it but recently metamaterials been used by researchers in bio sensing technologies because of its detection of label-free bio molecules and efficient cost [15-16].

f. Metamaterials Absorber

A metamaterial absorber efficiently absorbs electromagnetic radiation. Metamaterials absorbers offer benefits over conventional absorbers such as supplementary miniaturization, wider adaptability, and increased effectiveness [17]. To create a high ratio of electromagnetic radiation absorption, it requires effective medium design, permittivity and magnetic permeability.

g. Metamaterial Antennas

Metamaterials are used in antennas to increase performance of miniaturized antenna systems [18-19]. The metamaterials antennas are used to increase the gain of an antenna because it has a unique band gap features and periodic structures [20]. In small conventional antennas the most of the wavelength reflects the signal back to the source. But the metamaterials antenna has structure that stores and re-radiates energy which makes its size small and behaves as larger antenna.

The use of artificial materials and surfaces, properly engineered to expand some prescribed antenna features impedance matching, gain bandwidth, efficiency, front-to-back ratio, etc [21-22].

4. METAMATERIAL ADVANTAGES

Metamaterial provides many advantages over other methods used for the better performance of in the future miniature antennas and many more applications. These are given below:

a. Directivity Enhancement

Metamaterials has inherent property that controls the direction of electromagnetic radiation in order to collect the originating energy in a small angular domain around the normal to the surface [23]. A DNG material enhances the directive properties of an antenna.

b. Bandwidth Enhancement

Metamaterials antenna increase achieved bandwidth as compared to the conventional patch antenna [24]. This is achieved by use of substrate of metamaterial over conventional antenna or by loading of LHM.

c. Radiated Power Enhancement

A small antenna can increase the radiated power through the application of DNG metamaterials [25]. A small dipole antenna enclosed with DNG metamaterials is use to increase the radiated power much more as compared to the conventional antenna.

d. Beam width and side lobes

The metamaterials antennas decrease the beam width and side lobe ratio [26] and thus enhance the directivity and reduce the return loss of antenna.

5. CONCLUSION

In the new field of research area Metamaterials is the latest and impactful technique without any doubt. The researchers from different disciplines are attracted towards microstrip patch antenna using metamaterials because of its different electromagnetic chacterstics. A brief review is given in this paper as per the discussion done on metamaterial of their some of salient features, history, applications, various types, and advantages. The metamaterials have improved performance results in the field of electromagnetic response functions which may offer exciting opportunities of future design of electrical & electronic devices, components and salient properties of metamaterials.

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