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Metamaterial Based Body Wearable Antennas and Applications- A Review

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Abstract— In this paper application of metamaterial has been discussed. Metamaterial is an artificial material which exhibits unique properties which cannot be achieved from the conventional materials. Metamaterial can be used as antenna substrate, feed networks, phased array antenna and antenna ground planes. Metamaterial can be used to increase the gain directivity and bandwidth of antenna. In body wearable antennas specific absorption rate (SAR) also can be reduce.

Keywords— Metamaterial, SAR, wearable antenna, feed networks, phased array.

I. INTRODUCTION

Recently the metamaterial become the hot topic for engineering research. Metamaterial is an artificial material which exhibits unique properties which cannot be achieved from the conventional materials. Metamaterial can be classified on the basis of operating frequency, spatial arrangement and material point of view. On the basis of operating frequency metamaterial can microwave metamaterial, terahertz metamaterial and photonic metamaterial [1]. 1D, 2D and 3D are spatial arrangement of metamaterial. Metallic and dielectric are the types of material metamaterial. In 2001Veselago media was the first type of metamaterial used in microwave frequency range. Basis on the real part of permeability and permittivity metamaterial can be classified as DPS (double positive), DNG (double negative). For the DPS both the permeability and permittivity are positive and behave as a normal material. But DNG where both the permeability and permittivity are negative and behaves differently. This type of material is called left handed metamaterial (LHM) or negative refractive index (NRI) media [2].

II. METAMATERIALS IN ANTENNA DESIGN

Antenna design is one of the most important applications of metamaterial. By using the unique property of metamaterial we can improve the performance characteristics of antenna which is impossible from the traditional material. In this section, several types of metamaterial loaded antennas are reviewed.

In this paper authors have proposed a fully textile antenna except connector. The antenna is designed on a felt substrate of 6 mm with dielectric constant and tangent loss of 1.3 and 0.004 respectively. ShieldIt Super of thickness 0.17 mm is used for ground plane and patch of this textile antenna. This dual band antenna is designed for WLAN application at 2.4/5.2 GHz frequency. By using the matamaterial loading of composite right/left-handed transmission line (CRLH-TL) the size of antenna is reduced upto much extend. Further authors have reduced the specific absorption rate (SAR). The designed antenna was simulated and fabricated and even tested in free space as well as on body in flat and bending conditions. The measured SAR of antenna is observed in safe level [3].

In another paper authors has used a new technique to direct the radiation in desired direction by using negative refractive index metamaterial (NRIM) loading. Here a double feed dielectric resonator antenna (DRA) is loaded with NRIM unit. This antenna comprises the fractal cross ring resonator structure which gives negative refractive index in desired frequency band. Direction of propagating electromagnetic wave is changed when these waves enters in a medium having negative refractive index. Using these technique SAR value also reduced into safe level. The structure of antenna is called as beam tilting antenna because by using NRIM property radiation beam has been tilted in desired direction [4].

In this paper researchers has placed a mushroom type metamaterial in front of substrate integrated waveguide (SIW) horn antenna. A backward endfire radiation pattern has been observed due to generated backward waves. A monopulse four element array and a shunt four element array is used to further enhance the radiation performance. A low profile, wide operating bandwidth and enhanced radiation pattern is achieved by using arrays [5].

Another type of metamaterial mu-negative (MNG) is loaded on a unidirection loop antenna. By loading this MNG, the electrical size of antenna is reduced by 80% than a similar loop antenna. In this paper without using the extra reflector a moderate front to back ratio is achieved due to capacitive loading. Due to capacitive loop antenna is acting as array of dipole that results unidirectional radiation pattern [6].

By stacking very closely SRR in parallel, the permeability of the substrate is increased which further reduces the size of antenna. One more important benefit due to this arrangement is that antenna does not scarify for impedance matching and radiation gain. The size of antenna is reduced by 48% of without loading [7].

Another type of metamaterial used to reduce size of antenna presented in this paper is Zero order resonator (ZOR) and complimentary split ring resonator (CSSR). Three frequency bands are observed by changing the geometrical parameters of structure. Due to monopole shape and pattern characteristics these structures are suitable for vehicular wireless applications [8].

In this paper author presented two designs. In first structure a monopole antenna is composed with electric element to tune in frequency bands 2.49-2.55, 3.0-3.68 and 5.03-6.04 GHz. In second structure antenna is loaded with EBG structure which gave good impedance matching at frequency bands 2.49-2.55 and 2.95-6.09 (ultra-wide band) GHz. Due to small size, simple fabrication, unidirectional radiation pattern and compactness these antenna are useful for wireless mobile communication systems [9].

Here a multiband characteristic is obtained by using negative refractive index transmission line metamaterial. Due to the series capacitive gap and shunt inductive strip metamaterial behaviour is achieved [10].

In this paper another type of metamaterials epsilon negative (ENG) and double negative (DNG) are used to tune the antenna in multiband of frequency. Two rake-shaped split ring resonator (SRR) are placed face to face. Depending on their symmetry and location loaded dipole radiates at two or three frequency bands. Resonance frequency is reduced when compared with conventional half wavelength antennas. a good impedance matching and gain is achieved in desired frequency bands [11].

In this article author have compared the characteristics of a horn antenna when a metallic cone sphere is inserted and a horn antenna having an integrated dielectric lens and metamaterial in Ku-band of frequency. From the results it was observed that a horn antenna with cone sphere perform in better way than that of metamaterial loaded. In addition this antenna having light weight and low cost as compared to other horn antennas under consideration. In this paper a circularly polarized antenna is presented. Here a single fed antenna is loaded with mushroom like composite right/left handed metamaterial and a reactive impedance surface (RIS) for reduction of antenna size. By this technique two orthogonally-polarized modes generated simultaneously and results the circularly polarized radiation [12].

In this paper a tri-band antenna is presented by using defected ground plane and reactive loading. Due to reactive loading two orthogonal modes are generated. The loaded antenna operates in two frequency bands, one 2.4-2.48 GHz and second 5.15-5.80 GHz lower and upper frequency bands used for WiFi applications. The frequency band is achieved by applying the defective ground plane. Using defective ground plane a third frequency band 3.30-3.8 GHz falls in WiMAX band of frequency. Presence of air between antenna and feed line maintain the balanced current in structure [13].

In this paper both the metamaterial i.e mu-negative (MNG) or double-negative (DNG) are used for partial loading. In metamaterial by properly selecting the designed parameter the electric field can out of phase at the edge of radiating patch which results broadside radiation pattern. Here by using the proper combination of MNG and DNG a coaxial fed single patch and single layer antenna is proposed, which give good resonance and radiation gain at the designed frequency [14]. In this paper a MNG metamaterial is loaded with a significantly smaller antenna than a operating wavelength. [15]

III. CONCLUSION

Various types of metamaterials are discussed in this paper. From above survey it is clear that metamaterial is a unique material which can improve the radiation pattern, bandwidth. By the various researchers this material is used to reduce the size of antenna with increasing the resonant frequency. In textile antenna also metamaterial play important role to reduce specific absorption rate (SAR) of antenna.

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