Wearable Low-Profile Antenna having Artificial Magnetic Conductor for Body Analysis

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Abstract— In this project a design of low-profile wearable antenna is simulated on CST software. This proposed design is an analysis of CPW fed monopole with AMC (Artificial Magnetic Conductor) working as a ground. The design is made-up using different layers of Pellon Fabric mainly as textile material. This material is vastly used in different scientific, medical and industrial fields. In my proposed design of AMC antenna, it enhances the gain value up to little extent. The results from CST shows that the working of AMC antenna is good in all structural aspects like in the bending and crumping form. It also works efficiently if placed on any part of human body. Also, the numerical analysis shows that by adding AMC, the Specific Absorption Rate (SAR) values can be reduced in some conditions. For doing body analysis, three various models of body having different compositions & shapes were used.

***Index Terms*— Metamaterials, wearable antennas, textile antennas, Specific Absorption rate (SAR).**

I. INTRODUCTION

In Today's world, wearable electronic systems [1] are playing an important role. Their demand has been increased due to the potential of applications in the vast fields like health-care monitoring, medical care, patient & different animal tracing, and rescue & relief operations. The significant part of these wearable technology are antennas. These antennas play a vital part in the wireless communication. The main purpose of using wearable antennas is that they can work in the proximity of human body. The design procedure of flexible antenna (which can be built on the elastic surfaces) is relatively different compared to the design of outdated antennas [2, 3].

The electromagnetic coupling is also one of the important factors that must be examined because it can impact the antenna's performance like the frequency & radiation loss because of lossy material (i.e. in the case of human body). Also, electromagnetic radiation is not beneficial for the human body as the absorbed radiations may pose dangerous health risks. Especially for those circumstance in which these radiations are long term. So, in making wearable antennas, health and safety procedure comes at the first place. The radiations that emits from the antennas must have least absorbed power per mass unit which can be calculated by SAR. Furthermore, to make the antenna wearable and for improving the comfort factor, they should be elastic and conformal to human body. To build such kinds of antennas, Textile materials are now widely being used because of less weight and flexible in nature. One of the disadvantages of building antenna using textile material is that the fabrication tolerances are comparatively large as compared to such antennas which are built on PCB sheet etc. At last, the durability of the wearable antenna against several kinds of physical distortions such as bending, and wrinkling should be certain. Having all these issues in mind, it turns out to be hard task to make an efficient wearable antenna with good reliable performance.

In some journals, the authors have designed numerous kinds of elastic antennas that can be wearable. It was suggested by many of the researchers that electromagnetic band gap (EBG) and artificial magnetic conductor (AMC) antennas can help in lessening the electromagnetic radiations to absorb in human bodies. The suggested design of textile antenna covers major bandwidth due to which it is less subtle to the low frequency. Frequency detuning could take place as a result of abnormality in structures. Also, the proposed design of antenna composed of immensely little size which provides a good gain.

We have implemented a low-profile monopole antenna build on the textile structure attached with an AMC for providing the wearable properties. This antenna is designed for ISM band of 5.8 GHz. In this artical, only CST based simulations result are visualized. Measurements were carried out initially to predict the antenna's performance. Numerical analysis was performed using the CST software in which we have calculated results of single monopole & AMC components.

II. ANTENNA DESIGN

The proposed design of antenna contains coplanar waveguide (CPW) fed monopole antenna. The dimensions of designed monopole antenna are 27×34 mm^2. This monopole antenna is positioned above on the AMC layer having 4 x 6 units. The complete dimensions of AMC units are 102 x 68 mm^2. These two structures are designed on 1.8 mm substrate of Pellon Fabric having loss tangent and relative permittivity of 0.008 and 1.08 respectively.

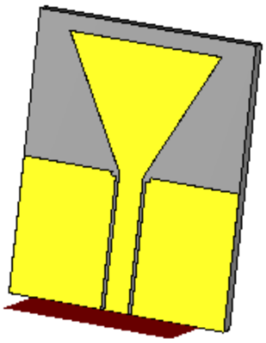

Figure 1: Coplanar Waveguide fed monopole

We have used a thick pure copper material from CST library having 0.08 mm thickness is used to create the conductive layers. The proposed conductivity of this material should be 2.5 x 10^5 S/m. Dimension of our antennas design is one single time until a high gain and good impedance matching can be attained in 5.8 GHz ISM frequency band.

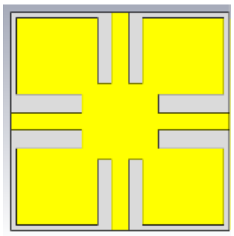

Figure 2: AMC Design

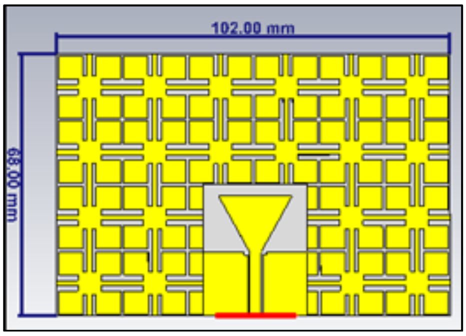

Figure 3: CPW fed Monopole with AMC arrays

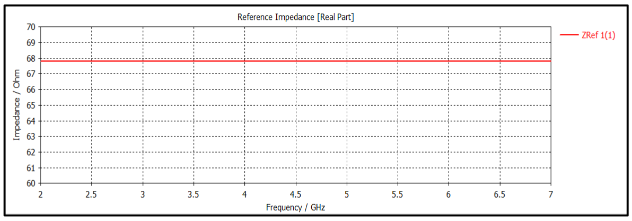

Figure 6: Ref. Impedance of Monopole antenna

Figure 7 VSWR of Monopole Antenna

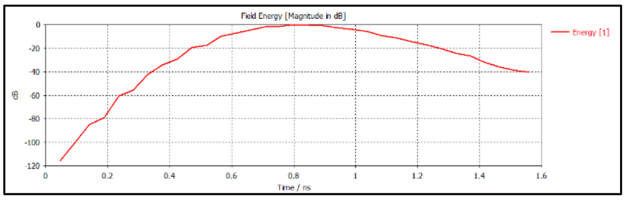

Figure 8: Field Energy for Monopole Antenna

III. Simulation Results and Discussion

S (1,1) reflection coefficient of the designed antenna is measured in free space (without placing it on any material. At first, we have computed the result of CPW fed monopole antenna and afterwards with the array of AMC layer.

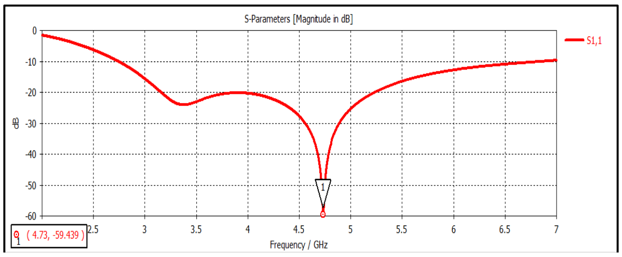

Figure 4: S (1,1) parameter of Monopole Antenna

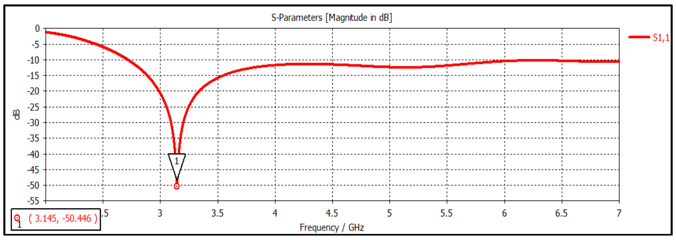

Figure 5: S (1,1) parameter of Monopole Antenna with AMC

By including the AMC layer, the change in the resonant frequency is observed, the frequency is shifted from right to left.

By changing dimensions of both AMC unit cell and monopole antenna, the impedance matching and radiation properties that we want can be figured out by using the ISM 5.8 GHz band. By increasing the array of AMC by one column and row, the gain can be increased up to some limit.

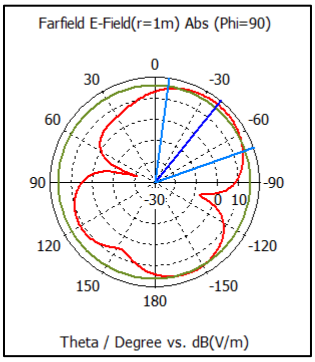

Figure 9: E-Field of Monopole antenna

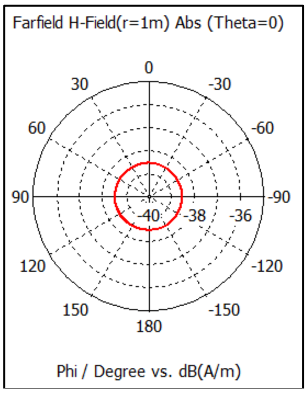

Figure 10: H field of Monopole Antenna

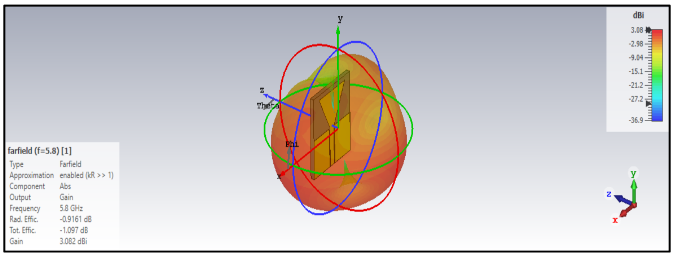

Figure 9 Gain of Monopole Antenna

In the result and analysis of monopole antenna we have faced many difficulties. The properties of material (Pellon Fabric), changing of dimension are one of the major sources for inaccurate data. Thickness in pellon fabric is not constant throughout.

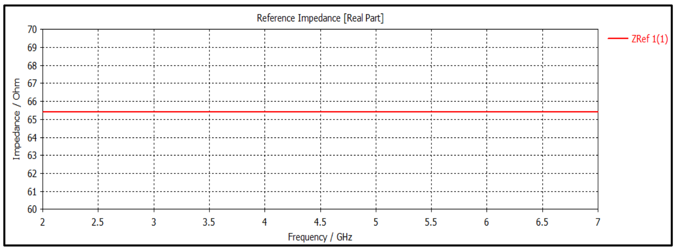

Figure 10 Ref Impedance of monopole with AMC

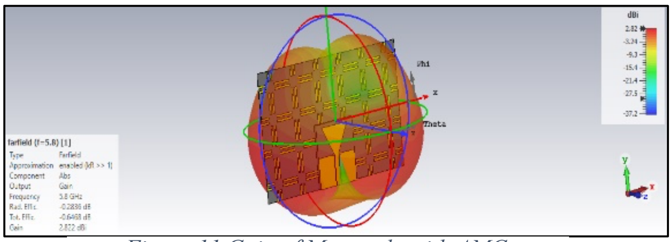

Figure 11 Gain of Monopole with AMC

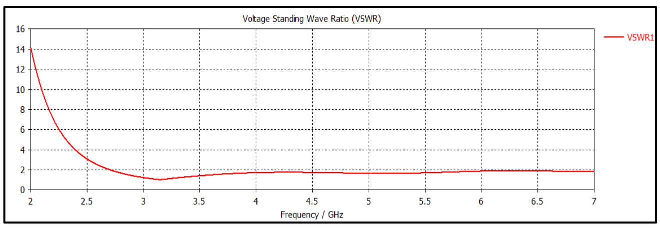

Figure 12 VSWR of Monopole with AMC

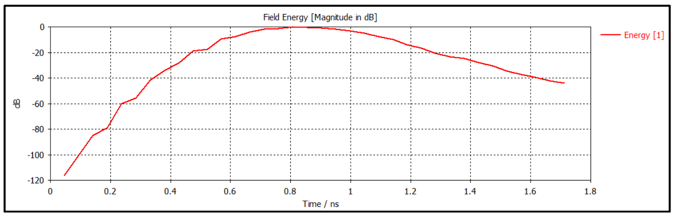

Figure 13 Field Energy for Monopole Antenna

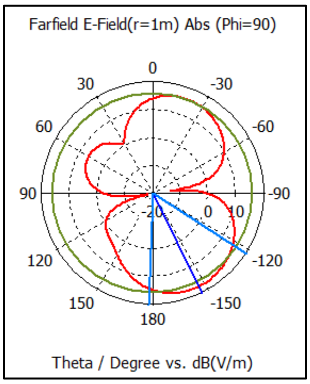

Figure 14 E-Field of Monopole with AMC

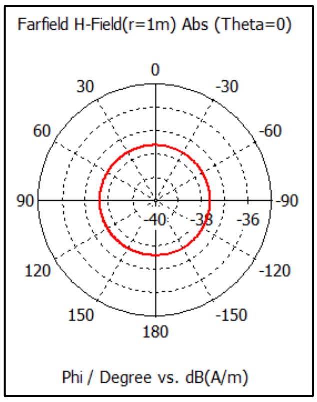

Figure 15 H- field of Monopole with AMC

The far-field radiation patterns of E-plane and H-plane were observed in the CST simulation. The far field radiation patterns measured in E & H plane also gain values matches closely with results simulated in CST for both antennas. The CPW fed monopole antenna holds a shape of pattern similar to dipole in E-plane and a uni-directional pattern in H plane. In both these patterns, the observed radiation patterns are below 20dB. By adding the array of AMC component, it will be resulted into quasi-hemispherical pattern of radiation. The gain that is measured for monopole with AMC antenna is 2.822 dBi and 3.082 dBi for the monopole antenna.

IV. Antenna Performance in Planar Configuration

The antenna's performance of monopole and monopole with AMC antennas in body and on free space will be discussed in this section. For monopole antenna, similar kinds of loading effect will be occurred when different models specific to human body are analyzed. These effects will shift the higher frequency towards the lower frequencies. The higher frequency mainly occurs high constant values of dielectric of different tissues that are specified in the human body models.

V. Conclusion

In this paper, we have designed a sustainable AMC antenna on the textile material for applications (mostly wearable). The design process was simulated in the CST software. In the free-space, the AMC antenna displayed a bandwidth of 3.32 GHz – 4.73 GHz having a gain of 2.82 dBi. On CST, we have observed Simulations and different experimental analysis which have given detailed information about the design of AMC antenna. The results of AMC antenna show that it is powerful regarding resonance frequency. It shows that slight deviations may occur due to structural changes like bending and creasing. Also, the addition of the AMC reflector significantly decreases the back radiation and SAR values, which makes the AMC antenna design extra efficient as compared to single monopole antenna.

VI. Reference

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