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Performance Evaluation of a Novel Wearable HIS Patch Antenna for Mobile Applications

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***Abstract*-In this paper an artificial magnetic material known as High Impedance Surface (HIS) is used for the performance evaluation and design of wearable patch antenna. HIS is actually a new type of ground plane that has considerably high surface impedance. Hence surface wave propagation on the ground plane is not supported. The use of HIS is now rapidly increasing due to its improved performance. In this paper, HIS is introduced with a new type of feeding technique known as line feeding technique at an operating frequency of 5.1 GHz and the antenna parameters evaluated here are Gain, Antenna efficiency and radiation efficiency. These parameters are improved to 15.54%, 28.84% and 3.4% respectively.**

Keywords: Patch Antenna, HIS, Antenna efficiency, Radiation efficiency.

I. INTRODUCTION

Patch or microstrip antenna is a kind of antenna which has lower size that can be mounted on a metallic sheet of rectangular shape which in turn is mounted on another metallic sheet usually of copper ground plane. The popularity of patch antenna is increased because it can be directly impressed on circuit board. A patch antenna having minimum cost, constructed easily with small size and gives optimal performance through wide band frequencies is known as Micro strip patch antenna [1]. Its light weight makes it easy to adhere to human bodies. One way to enhance the performance of antenna is to make its substrate thicker but with low di-electric constant in order to have improved efficiency, wide bandwidth and enhanced radiations. The microstrip patch antenna can be classified on the basis of length, width, and its height, gain and radiation patterns. These antennas are made such a small that they can be fitted easily on a human body. For this purpose, maximum work has been done at frequencies of WLAN or UWB in development of these antennas. A low Profile wearable antenna minimizes the effects of body on the overall antenna performance. Therefore, majority of the applications should be low profile and modest in the construction of wearable antennas. Hence, it is also practicable to integrate a ground-plane to fulfill these challenges

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(like PIFA) [2]. .Hence both the civil and military sectors have shown an immensive interest in the growth of human wearable antennas.

Figure 1 shows the structure of simple patch antenna. The problem with the ordinary ground plane was the propagation of surface waves that was resulted from leaky currents which could easily flow around the edges of ground plane and caused the surface waves to disturb our desired waves. In order to avoid this disturbance construction of high impedance surface is the only solution left. Ground plane is made rough and precipitous to make the flow of leaky currents arduous so that of surface waves. This modified surface is called as High Impedance Surface .High Impedance Surface (HIS) antenna is a typical example of wearable devices used in communication sector. Its design is complex as this antenna consists of a metallic electromagnetic structure with High Surface Impedance.

This surface estimates many of its electromagnetic problems and is considered as lumped parameter circuit [3]. The surface properties can be altered using conductive surface texture [4]. This modified structure has high impedance and does not cause reversal of reflected waves and thus in phase currents of images appears, on contrary to normal conducting phase. For the design of Micro strip Patch antenna by modern mobile communication, it leads to the requirement of antennas with minimum size, high gain and bandwidth. These antennas should provide better performance over a wide range of frequency spectrum [5].

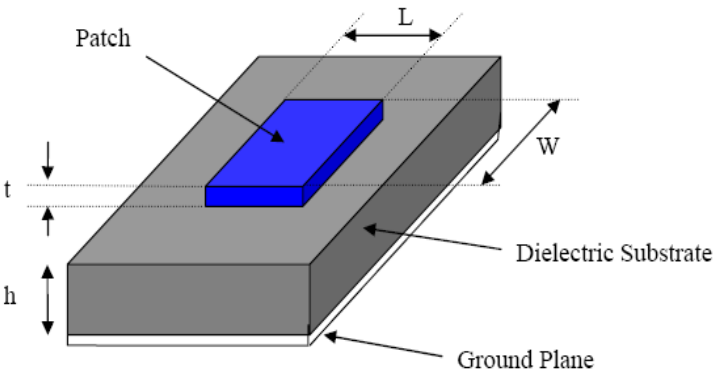


Figure 1. Microstrip Patch Antenna

The modified ground plane with HIS is also recognized as electromagnetic band gap (EBG) plate because of presence of insulative gaps whose function is to eliminate the surface waves. These electromagnetic band gap structures display some interesting electromagnetic properties, which includes phase reflection and surface suppression [6] and thus afforded the researchers with a new research area working in the field of electromagnetic and antennas. Their designs have been grown vigorously and the associated research has been developed from various perspectives including materials and geometries [7-8].

HIS can precisely minimize the induced current that flows on the ground plane surfaces. This result is showed by measurement and simulations [9]. It is the wearable antenna, which play an important part in maintaining an optimal and reliable wireless communication bridge between the surrounding and human body worn electronics. Materials used to help in manufacturing of wearable antennas are conductive textiles (electro textiles), having outstanding durability, flexibility and radio frequency [10]. Wearable antenna has numerous useful applications such as for military and police work, in medical science, in mines to measure the amount of uncut coal in mines and on can measure the thickness of ice on roadway. A high impedance surface consists of an array of metal extrusions on a flat metal plate or sheet as shown in Figure 2. They are arranged in a two dimensional lattice and each of these small extrusions are connected to ground via vertical conductor. They seem like mushrooms or pushpin extending from surface. A top view is shown in Figure 3. The evolution of high impedance surface has led to the emergence of a lot of applications.

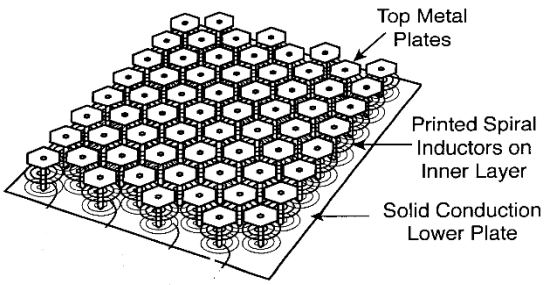


Figure 2. Cross Section View of High Impedance Surface

The aim behind such design is to analyze the improved performance of the modified HIS surface for a wearable patch antenna at frequency of 5.1 GHz applications. The parameters that we will discuss in this work will be Gain, antenna efficiency and radiation efficiency. Dimensions and

parameters of antenna are measured by high frequency simulation software, includes length, dielectric constant and width as dimensions and gain, impedance and return loss as parameters [11].

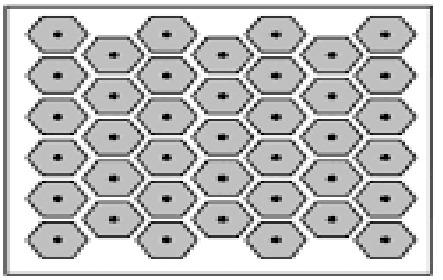


Figure 3. Top View of a High Impedance Surface

This paper is organized as follows: Section II illustrates the proposed antenna design. Section III presents the simulation results in CST Microstripes software. The paper is concluded in Section IV.

II. ANTENNA DESIGN

Computer simulation technology (CST) Micro stripe is the designing tool that was selected for designing and simulation purpose. CST is a full package tool for the implementation of 3D electromagnetic analysis. It uses high frequency range for designing systems. Followings are the most known features of CST.

- Supported by TLM technology, it is speedy, quick, efficient, correct and time domain problem solver.
- Parallel problems solved by multi-processor hardware stages
- Uses the acquainted Windows computer program.
- New advanced history bar, permits the user to easily select their approach

First we designed a simple patch antenna at the frequency of 5.1 GHz and simulated it in CST and noted the results for comparison. Then we moved to our proposed model to design the Novel HIS wearable microstrip patch antenna. So we started with designing High Impedance Surface using square patches. Then we impressed a substrate over it to avoid the short circuiting between the upper main patch and these small patches on HIS surface. The full structure view of our proposed antenna is given in Figure 4. The proposed HIS design is such that to work as artificial magnetic surface at frequency of 5.1 GHz. This antenna will work specifically for the mobile applications mentioned above that's why we designed this antenna on 5.1GHz. Figure 5 shows the working condition of our

patch antenna. In other words, the return loss should not exceed than -10db in order to place the antenna in operating state.

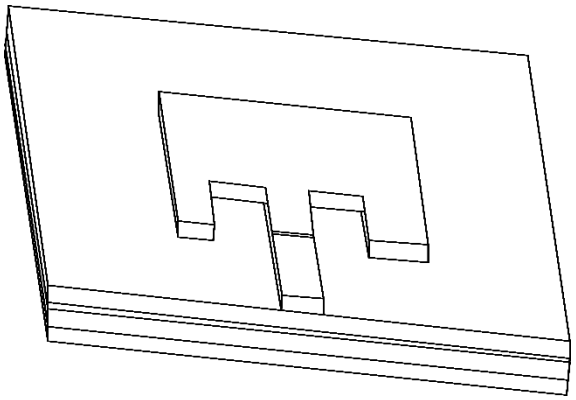


Figure 4. Structure of Wearable HIS Patch Antenna

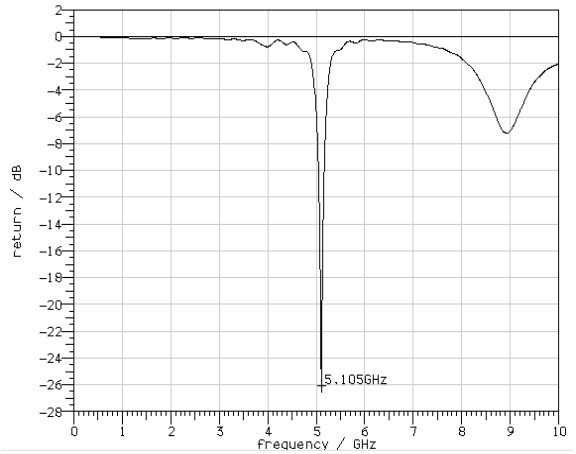


Figure 5. Working Condition of HIS Wearable Patch Antenna

A simple patch antenna is then impressed on the HIS as shown in Figure 4. Figure 6 shows our designed High Impedance surface while the side view of HIS patch antenna is shown in Figure 7.

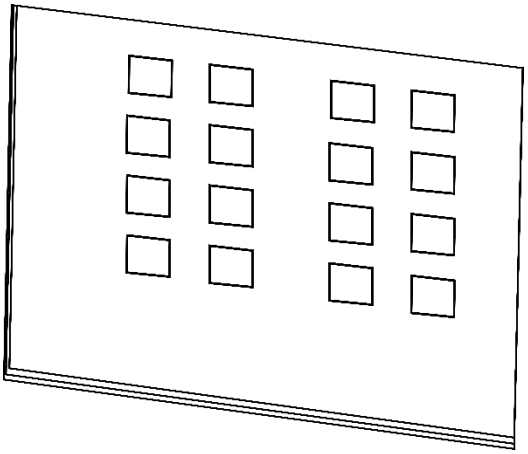


Figure 6. High Impedance Surface

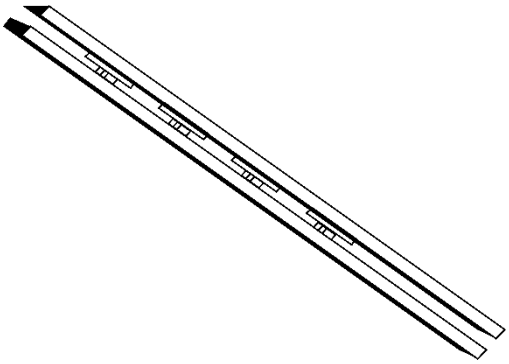


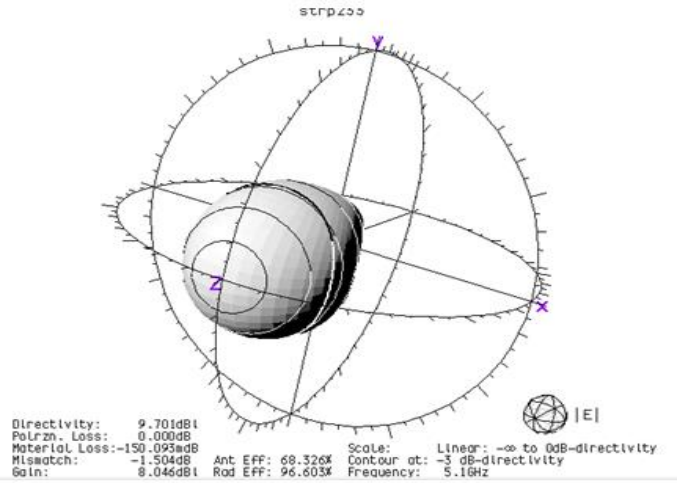
Figure 7. Side View of Wearable HIS Patch Antenna

III. RESULTS

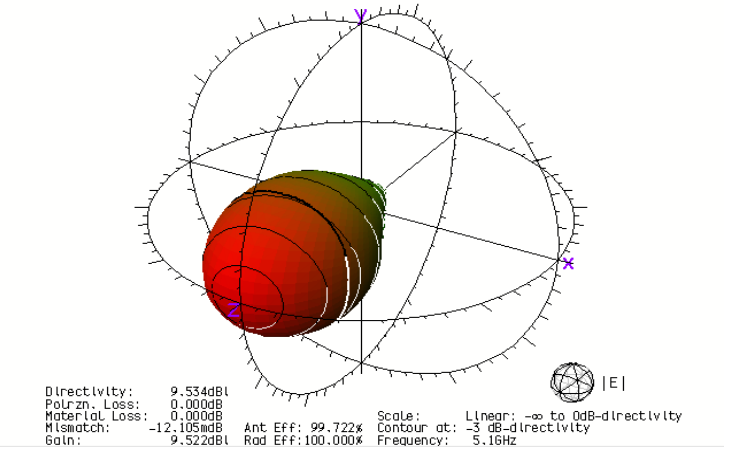
The performance of wearable Microstrip patch antenna with HIS was evaluated by comparing the proposed antenna with a simple patch antenna without HIS. Results for comparison of Gain, Antenna efficiency and Radiation efficiency for Patch antenna without and with HIS are shown in Figure 8.

This is the considerable amount of improvement in gain, the more is the gain more the antenna will be directive i.e. it will focus electromagnetic energy in the desired direction. Antenna efficiency describes the percentage of the physical aperture area which actually captures radio frequency (RF) energy, so improvement in antenna efficiency also enhanced the performance of antenna. Measurement of the power radiated through the antenna in the form of electromagnetic wave to the

power fed to the antenna terminals is known as radiation efficiency, and improvement in it helped the antenna to perform more efficiently.



(a). Radiation Pattern of The Patch Without HIS



(b). Radiation Pattern of the Patch with HIS.

Figure 8. Comparison of Radiation Pattern of Patch Antenna (a) Without and (b) With HIS

Figure 8 (a) shows the radiation pattern without HIS while (b) shows the radiation pattern with HIS. After comparing both patterns, the improvements in these parameters are tabulated in Table 1.

Table1. Comparison of Antenna Parameters for Patch Antenna with and Without HIS

TABLE I
COMPARISON OF ANTENNA PARAMETERS FOR PATCH ANTENNA WITH AND WITHOUT HIS

S. No.	Antenna Parameters	With HIS	Without HIS	Percent Improvement
1.	Gain	9.52 dbi	8.04 dbi	15.52 %
2.	Antenna Efficiency	96.29 %	68.52%	28.84%
3.	Radiation Efficiency	100 %	86.60%	3.4%

IV. CONCLUSION

The use of HIS for improving antenna performance is growing rapidly. This paper is a modified portable form of HIS defined as a non-uniform HIS is presented and Successful antenna integration for improved low profile performance. The HIS has also been integrated into a normal patch antenna to reduce its size and improve its gain and impedance bandwidth. The percentage improvement in-shape of Gain, Antenna and Radiation efficiency has showed. Performance evaluation of wearable patch antenna having High Impedance Surface at a frequency of 5.1GHz has been presented. Based on this, superior results containing various features of antenna performance have been achieved. Simulation results consist of Antenna efficiency, Gain and radiation efficiency are displayed to view the performance index. It can be deducted that HIS ground has enhanced the performance of antenna compared to the ordinary ground plane structure.

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