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Miniaturization of A Patch Antenna Using Magneto-dielectric Material

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Abstract

The miniaturization of a patch antenna using magneto-dielectric material substrate is presented. The proposed antenna features an electrically small size, only 0.13λ at the operating frequency. Reasonable electrical properties are also achieved.

Keywords : magneto-dielectric material,patch antenna

1. Introduction

Microstrip antennas are widespreadly used in modern wireless systems owing to its low profile structure. The physical dimension of conventional microstrip antennas is about λ/2 wavelength at its operating frequency. For some space limited applications, it would be desirable to design a miniaturised antenna without compromising its electrical performance.

In this paper, a patch antenna printed on a magneto-dielectric material substrate is designed and developed to demonstrate the feasibility of size reduction by employing the novel magneto-dielectric material [2]-[4]. The measured results show that the proposed antenna exhibits an electrical small size with reasonable electrical performance.

2. Design Consideration

The proposed antenna, as shown in Fig.1, is designed using the novel magneto-dielectric material which was developed by Advanced Material Group from Temasek Laboratories @ NUS [2]-[4]. The detailed results of the developed magneto-dielectric material were reported in [2]-[4].

A U-shaped patch is printed on the magneto-dielectric material, which is backed by a ground plane. Generally, the purpose of a substrate is to provide proper spacing and mechanical support between the patch and its ground plane. It can be also used for antenna size reduction if employing a high dielectric constant.

In this paper, the magneto-dielectric material whose permittivity and permeability are of the same values is used to miniaturize the antenna. Theoretically, the magneto-dielectric material loading can reduce the antenna size by the square times compared to that of dielectric material loading. The characteristic impedance of the magneto-dielectric medium is close to the surround medium which enables impedance matching over a wide bandwidth. In order to keep a good performance of the antenna, the loss tangent value of the magneto-dielectric material is considered sufficiently low ($\leq 10^{-2}$).

3. Design Result and Discussion

The Ansoft HFSS software is used to simulate the antenna's performance. The antenna is excited at the centre of the patch by a 50Ω coaxial feed through the bottom of the magneto-dielectric substrate. The magneto-dielectric material with the values of relative permittivity and permeability 12 ($\epsilon_r = \mu_r = 12$) is used. The four magneto-dielectric material rods are used as the substrate for antenna design. The size of each magneto-dielectric material rod is 9.8cm by 1cm and

the thickness of material is only 5mm. Such an antenna structure is used because of the limited size and form factor of the magneto-dielectric material available.

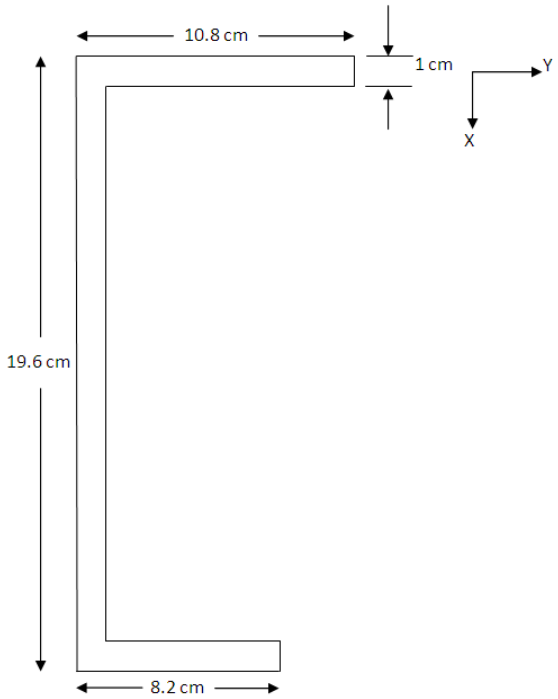

Figure 1: Top view of U-shaped patch antenna design

Figure 2: Photo of the prototype of the proposed antenna design

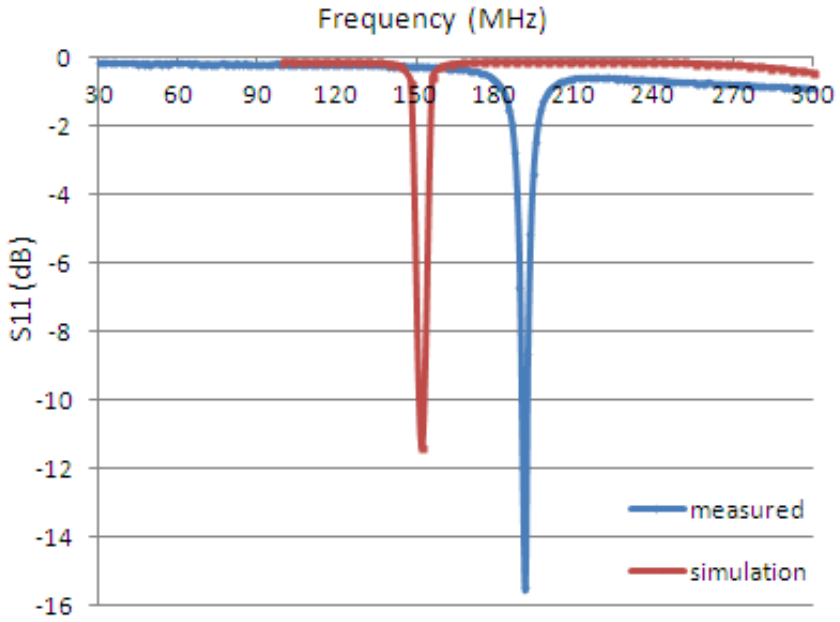

Figure 3: Simulated and measured return loss of U-shaped patch antenna

The comparison of the simulated and measured Return Loss (S11) of the proposed U-shaped patch antenna is shown in Fig.3. The measured result shows its operating frequency at 192MHz (antenna size 0.13λ at the operating frequency), therefore demonstrate its effectiveness of the size reduction, 45% decreased in dimension compared to the previously antenna design with FR4 loading. There is a slight difference between the simulated and measured results. The measured result shows a slightly higher operating frequency compared to the simulation result. This may be due to the variation of material property with the frequency and the fabrication tolerance. The measured radiation pattern at 192MHz is shown in Fig.4, the asymmetrical measured results are due to the asymmetrical antenna structure. With higher permittivity and permeability constant of the substrate material, the patch size can be further reduced. However, with even higher permittivity and permeability constant, the antenna features a narrower bandwidth.

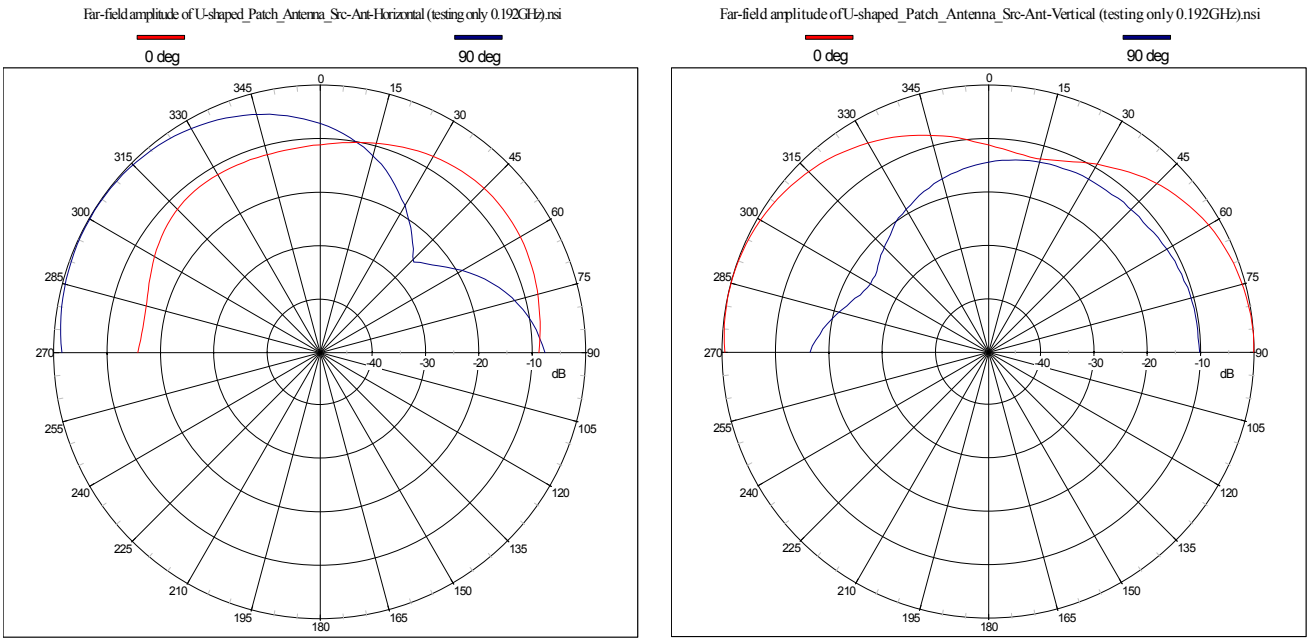

Figure 4: Measured radiation pattern of U-shaped patch antenna at 192MHz

4. Conclusion

The proposed microstrip patch antenna loaded with the magneto-dielectric material has demonstrated a small electrical size, only 0.13λ at the operating frequency. However, the bandwidth is limited due to the use of the magneto-dielectric material. The bandwidth may be widened by other bandwidth enhancement techniques.

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