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A NOVEL DUAL-BAND PATCH ANTENNA FOR WLAN COMMUNICATION

E. Wang

Information Engineering College of NCUT
China

J. Zheng

Beijing Electro-mechanical Engineering Institute
China

Y. Liu

Information Engineering College of NCUT
China

Abstract—This paper describes a novel dual-band patch antenna on organic magnetic substrate for wireless local area networks (WLAN) wireless communication (at 2.4 and 5 GHz). The dual-band operation is obtained by embedding a pair of *L*-shaped slots. The magnetic material is adopted because the substrate can reduce the size of antenna 40%, comparing with rectangular microstrip antennas on normal dielectric substrate, and have wider bandwidths for both bands. Details of the proposed antenna design are presented and discussed, which can be a candidate for the requirement of WLAN, operating in 2.4 and 5 GHz.

1. INTRODUCTION

In wireless communication systems, such as wireless local area networks, reach and development efforts are aiming at smaller size and better performance. WLAN has made rapid progress and there are several IEEE standards already, namely 802.11a, b, g and j. From the frequency spectrum, it is observed that the band is limited at

Corresponding author: E. Wang (enchwang@yahoo.com).

2.4 GHz band (2.4–2.483 GHz), and it must be shifted to the higher and more abundant band 4.9 GHz (4.9–5.1 GHz) and 5.2 GHz (5.15–5.35 GHz) with the development of WLAN. So there is a need of dual band transceiver working at these frequency bands.

The organic magnetic materials have stable magnetic performance, higher permeability and permittivity so that microstrip antennas on such a material are characterized with compact size, wide band, and simple structure and are easy to be fabricated. Some kinds of antennas with magnetic materials have been reported for different purposes [1–4].

Microstrip patch antennas are attractive and popular antenna due to their natural advantages such as light weight, conformability and low costs. Dual-band operation is an important subject in microstrip antenna designs [5, 6]. Recently, several designs of the dual-band slot-loaded microstrip antennas have been reported [7–9]. These related dual-band designs are achieved by embedding a narrow arc-shaped slot or placing an open-ring slot close to the boundary of the patch [10, 11]. However, the antennas adopted these designs have narrow impedance bandwidths of the two operating frequencies, usually on the order of 2% or less. In this paper, we present a novel dual-band WLAN antenna printed on organic magnetic material, and report the results of the proposed antenna on its S_{11} characteristic along with the radiation patterns.

2. ANTENNA STRUCTURE

Prototypes of the proposed design were constructed and studied. Figure 1 shows the configuration of the proposed microstrip patch antenna. The parameters of organic magnetic materials provided by

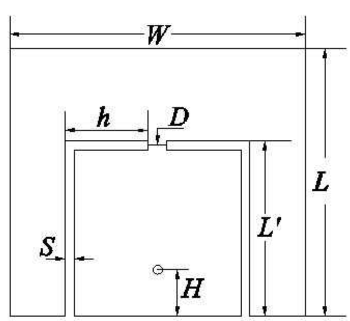

Figure 1. Configuration of the antenna.

manufacturer are $\mu_r = 3.5$, $\varepsilon_r = 2$, $h = 3.2\,\text{mm}$, $\tan\delta = 0.01$. The patch is fed by a $50\,\Omega$ coaxial probe placed along the central line with a distance H to the bottom side. The dimensions of the rectangular patch are $W \times L$. The dual L-slots are located symmetrically along the center line of the patch and have a narrow width of S. The lengths of vertical and horizontal arms are denoted as h and L'. The symbol D represents the length between the horizontal arms.

For a regular rectangular patch without slot [12], its resonant frequency of TM_{mn} mode is given by

$$f_{mn} = \frac{C}{2\sqrt{\mu_r \varepsilon_r}} \sqrt{\left[\frac{m}{W}\right]^2 + \left[\frac{n}{L}\right]^2} \ (m = 0,\ n = 1),$$

where C is the light velocity in free space, μ_r is the equivalent permeability and ε_r is the equivalent permittivity. By choosing the feed location, the first two modes TM_{10} and TM_{11} can he excitedIn the study, we found that with the increase of H, the resonant frequency shift to low frequency and the bandwidth of low frequency band becomes narrow while the bandwidth of high frequency band becomes broad.

In our design, the resonant frequency is slightly affected by the narrow slots. The height of magnetic substrate and the width of slots are very small comparing with the central frequencies' wavelength; the antenna can be understood by the classical cavity method. Therefore, the frequency is decided by the geometry of the rectangular patch, the dimensions of which can be estimated. When electromagnetic wave transmit in the media which has equivalent permeability (μ_r) and equivalent permittivity (ε_r), the wavelength of it will be reduced to $1/\sqrt{\mu_r \varepsilon_r}$, comparing with the wavelength in vacuum. That is an important theoretical basis to design microstrip antenna in any frequency bands.

The detail dimensions of the antenna are obtained from many calculations and simulations: $L = 32\,\text{mm}$, $W = 24\,\text{mm}$, $L' = 18\,\text{mm}$, $S = 1\,\text{mm}$, $H = 6\,\text{mm}$, $h = 9\,\text{mm}$, $D = 2\,\text{mm}$.

3. RESULTS AND ANALYSIS

The characteristics of the slotted patch antenna have been simulated by HFSS software, which is based on Finite Element Method. Using the organic magnetic substrate, a test antenna has been fabricated, which is shown in Figure 2, four bolts are used to fix the antenna. Figure 3 shows the simulated and measured S_{11} versus frequency, from which, we can see that the S_{11} characteristics of the antenna in the bandwidths of 2.4–2.483 GHz and 4.9–5.35 GHz are below −11 dB. The S-parameter of the antenna was measured using Agilent 8753D network analyzer. The simulated radiation patterns of the antenna at 2.45 GHz are shown in Figure 4 and Figure 5. Figure 6 and Figure 7 show the simulated radiation patterns of the antenna at 5.2 GHz. For the antenna, the lower operating band has a peak gain of 3.8 dBi, and that of the higher band is 5.8 dBi. The two operating bands of the proposed antenna are of the same polarization planes and also have similar radiation characteristics. Figure 8 and Figure 9 is the E plane and H plane radiation pattern of experiment results at 2.45 GHz. Figure 10 and Figure 11 are the E-plane and H-plane radiation patterns of experiment results at 5.2 GHz. The patterns are found to be stable across their passbands, and the results at other frequencies are not shown for brevity. However, the wider bandwidth may be come from the larger magnetic loss. Thus, its gain will be decreased as the payment for the bandwidth broadening. The application prospect of the antenna can be attractive if we pay more efforts to improve the antenna gain. Comparing with rectangular microstrip antennas on normal dielectric substrate, the overall size of this antenna is reduced by 40% [10].

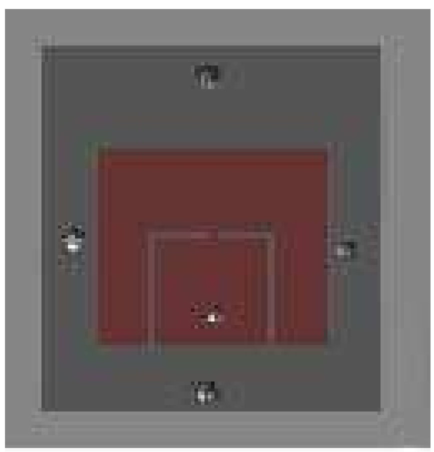

Figure 2. Photo of the fabricated antenna.

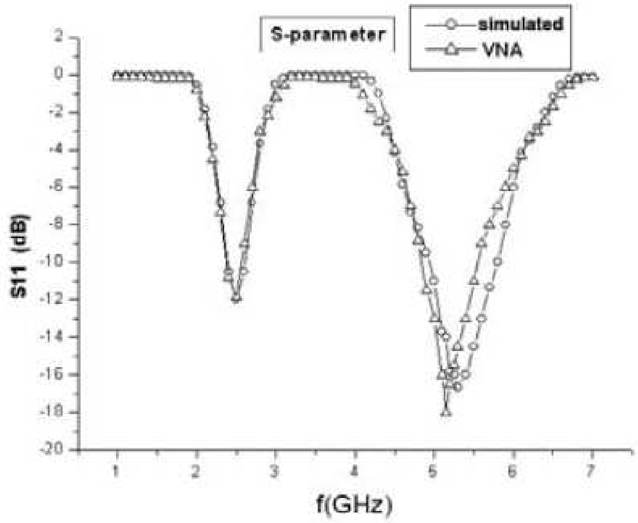

Figure 3. Simulated and measured S_{11}.

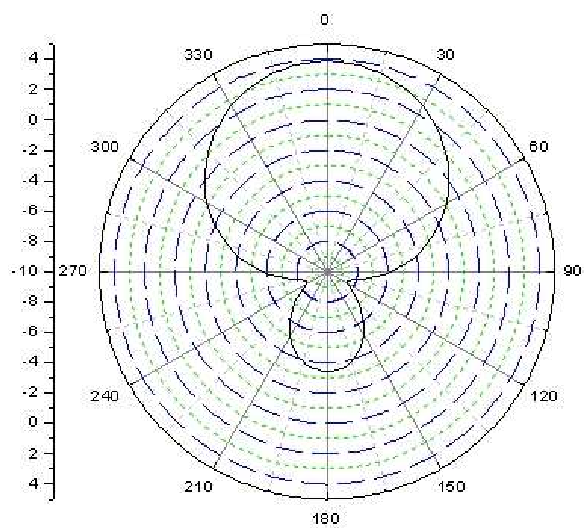

Figure 4. E plane radiation pattern at 2.45 GHz (the unit of vertical axis is dBi).

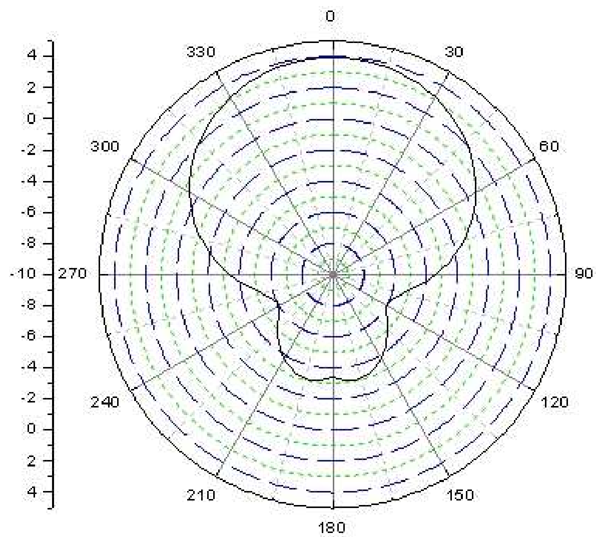

Figure 5. H plane radiation pattern at 2.45 GHz (the unit of vertical axis is dBi).

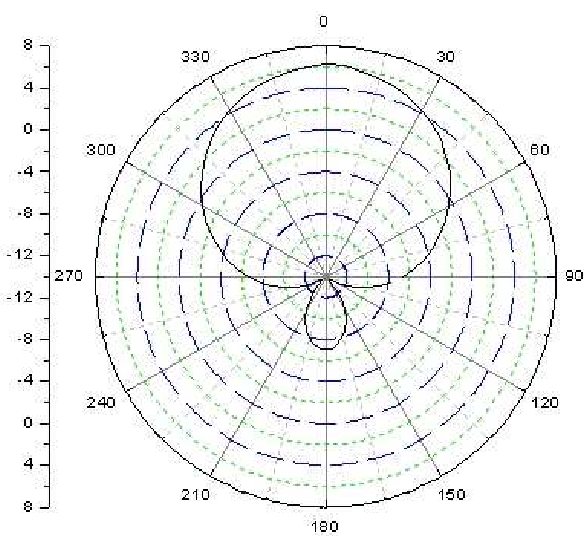

Figure 6. E plane radiation pattern at 5.2 GHz (the unit of vertical axis is dBi).

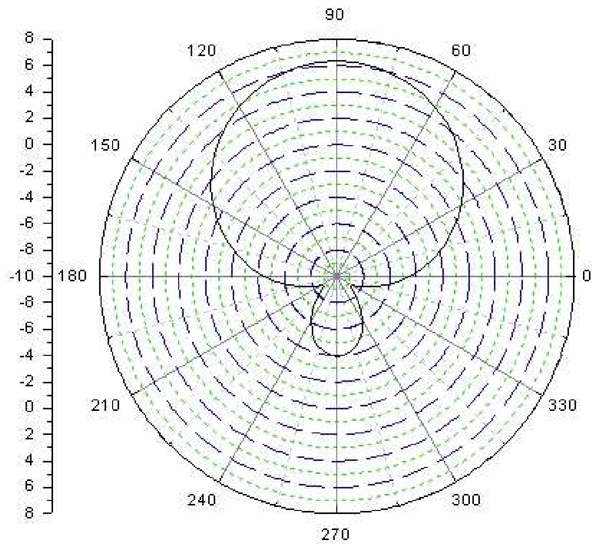

Figure 7. H plane radiation pattern at 5.2 GHz (the unit of vertical axis is dBi).

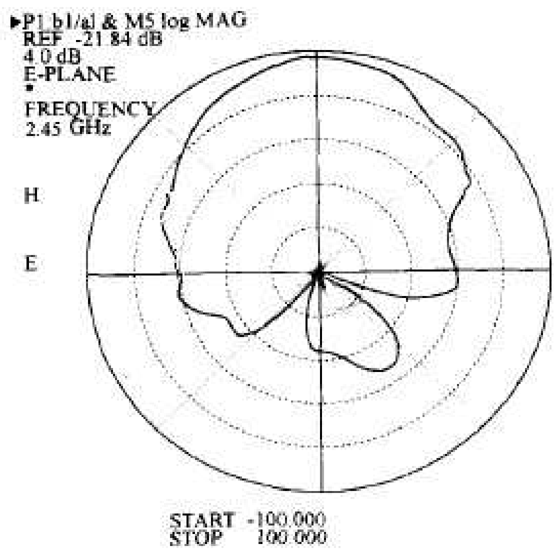

Figure 8. E plane radiation pattern at 2.45 GHz (experiment result).

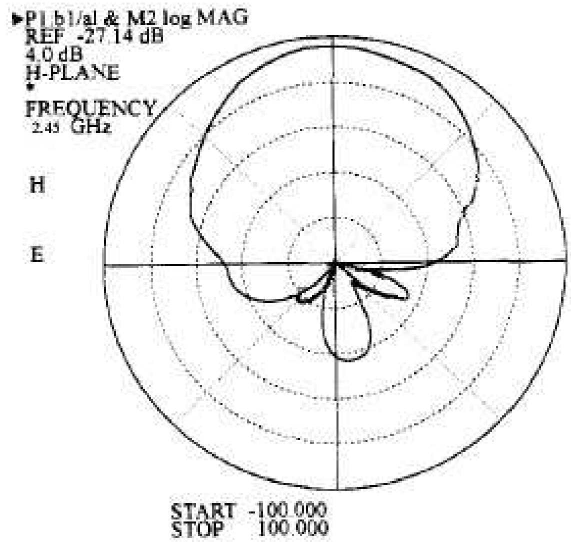

Figure 9. H plane radiation pattern at 2.45 GHz (experiment result).

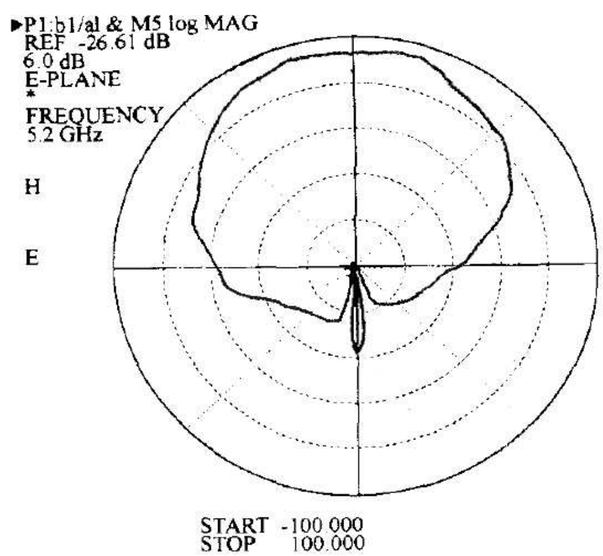

Figure 10. E plane radiation pattern at 5.2 GHz (experiment result).

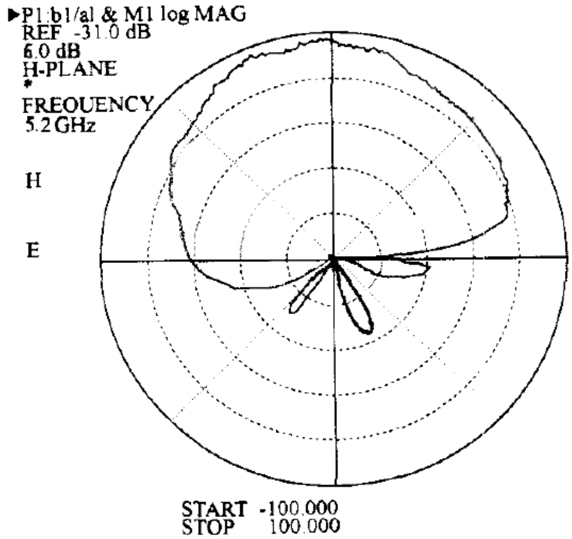

Figure 11. *H* plane radiation pattern at 5.2 GHz (experiment result).

4. CONCLUSIONS

A new design of a dual-frequency antenna printed on magnetic substrate has been described. The simulation and experiment results of the antenna show that enhanced impedance bandwidth can be achieved by using magnetic substrate. It is seen that the proposed antenna achieved good performance, which well meets the requirements of WLAN applications with smaller size.

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