New Planar Magnetic Monopole Antenna with Periodically Arrayed Patches and Equilateral Slots for Reduced Size and Improved Bandwidth

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1. Introduction

In recent years, various researches onto microstrip patch antennas have been actively conducted because of a low profile, a light weight, a small volume and an easy fabrication [1]. As a microstrip patch antenna yields a narrow bandwidth [2], a stacked multi-resonator structure [3] and a coupled feed method [4] have been proposed to improve its bandwidth. However these schemes are complicated in a structure due to a multilayer configuration. In this paper, a new planar magnetic monopole antenna is proposed to improve the bandwidth and reduce size of the antenna via an electromagnetic band-gap (EBG) structure [5], [6]. The proposed antenna consists of isotropically periodic hexagonal patches with equilateral slots on the top side and equilateral triangular slots on the ground plane. This magnetic monopole antenna yields a different radiation pattern compared to a conventional patch antenna and a large bandwidth with a size reduction. The design and analysis of the proposed antenna is described in section 2 and experimental results are discussed in section 3.

2. Antenna Design

As shown in Fig. 1(a), the proposed antenna consists of hexagonal patch array with a side length of d on the top plane and equilateral triangular slots with a side length of L on the bottom ground plane. A 50 Ω coaxial feed line is located on the central point of the antenna. The gap between patches is g and the diameter of a via-hole is r. The proposed antenna is designed on a 0.76 mm-thick substrate with a dielectric constant of 9.7. Fig. 1(b) shows the simulated electric field (E-field) distribution and the magnetic current density at the resonant frequency. The E-field strength is shaped like a circle and the magnetic current density is maximized around the patch with a loop. The resonant mechanism which is modelled with distributed components is depicted in Fig. 2(a). The resonant frequency of the proposed antenna has an effect on an inductance due to a conductor path and a gap capacitance between the patches. C_L is the series capacitance between the patches, L_L is the shunt inductance through a via-hole, L_R is the series inductance of the patch and L_p is the parasitic inductance due to the equilateral triangular slot. In these parameters, L_P and L_L are dominant because these inductors are more effective on the antenna performance. The magnitude and direction of the E-field at the resonance are presented in Fig. 2(b). The peak value of the E-field toward the ground plane is occurred at the patch's edge, while the loop of the magnetic current density on arrayed patches is generated. In addition, the minimum E-field is placed on the via-hole which is located at the centre of each patch. The simulated real and imaginary impedances are depicted in Fig. 3. As the slot length is increased, the resonant frequency is decreased.

3. Experimental Results

The proposed antennas with a slot side length, *L*, of 0.0, 3.1, 4.9, 5.5 and 6.2 mm are fabricated. The side length of the patch, *d*, is 3.5 mm and the diameter of a via-hole is 0.3 mm. In Fig. 4, the measured reflection coefficients are presented with various lengths of *L*. As mentioned before, the resonant frequency is decreased as the slot length is increased. Moreover, the bandwidth of the proposed antennas is also increased as 8.4%. The 3-dB fractional bandwidth is increased from 2.2% to 10.6%. The resonant frequency is decreased from 7.01 GHz to 6.03 GHz. The measured radiation patterns are shown in Fig. 5, which reveal the monopole radiations. It is shown that a slot size hardly ever affects a radiation pattern. Finally, measured results of a 3-dB fractional bandwidth and a resonant frequency vs a slot lengths are presented in Fig. 6.

4. Conclusion

A new planar magnetic monopole antenna with periodically arrayed patches and equilateral slots is designed and implemented. The slots on the bottom plane are resulted in decreasing a resonant frequency and increasing a bandwidth of the antenna. The 3-dB bandwidth of the proposed antenna is increased from 2.2 % to 10.6 %. In addition, The resonant frequency is moved from 7.01 GHz to 6.03 GHz.

5. Figures

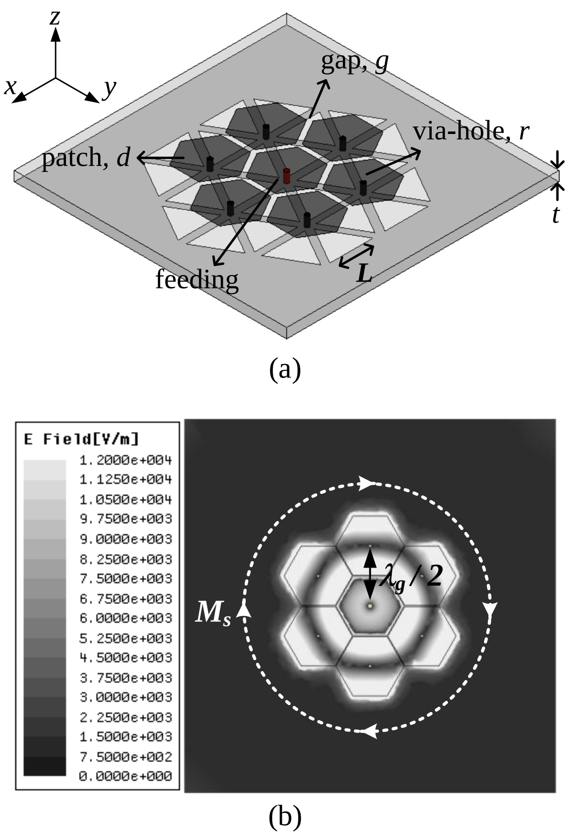


Figure 1. (a) Configuration of proposed antenna. (b) Simulated E-field distributions and their magnetic current densities.

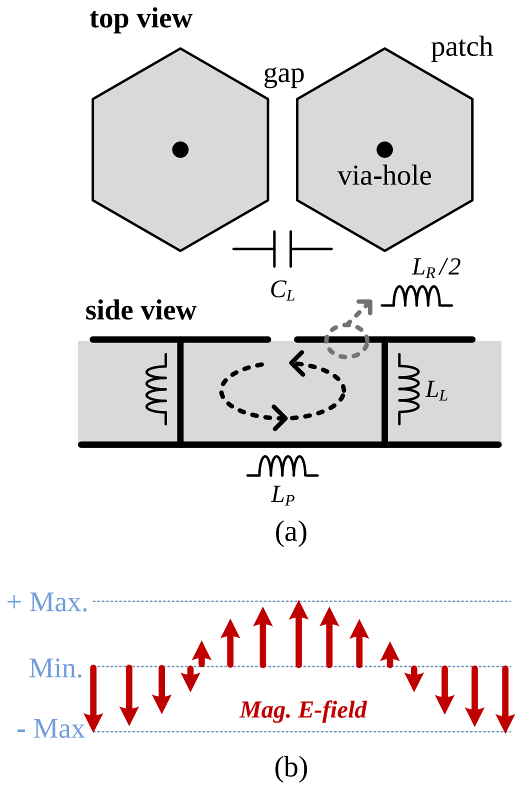


Figure 2. Radiation mechanism. (a) Physical structure and equivalent parameter. (b) Direction and magnitude of E-field.

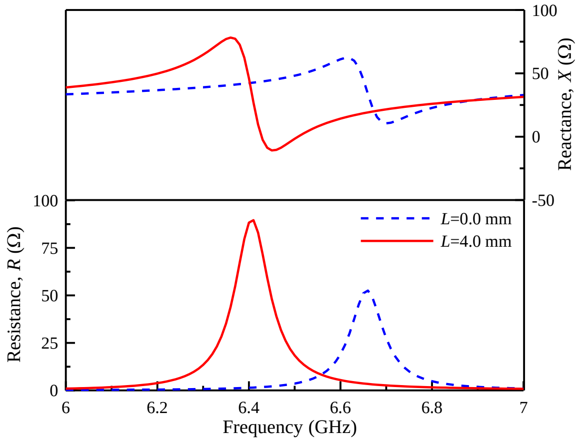


Figure 3. Input impedance of proposed antenna with real part (top) and imaginary part (bottom).

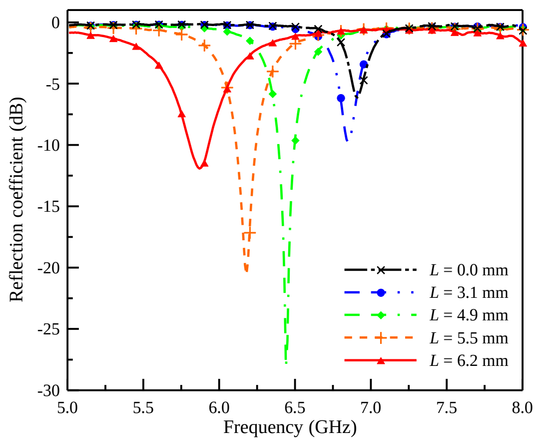
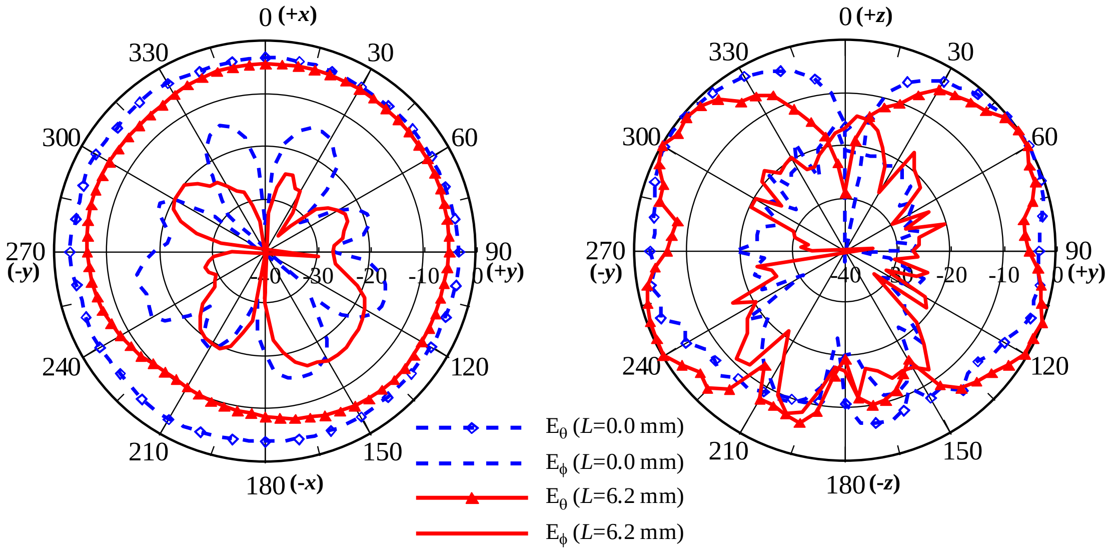


Figure 4. Measured reflection coefficients of variations with slot lengths.



(a) (b)

Figure 5. Measured radiation patterns of proposed antenna with slot lengths of 0.0 and 6.2 mm. (a) *xy*-plane (H-plane). (b) *yz*-plane (E-plane).

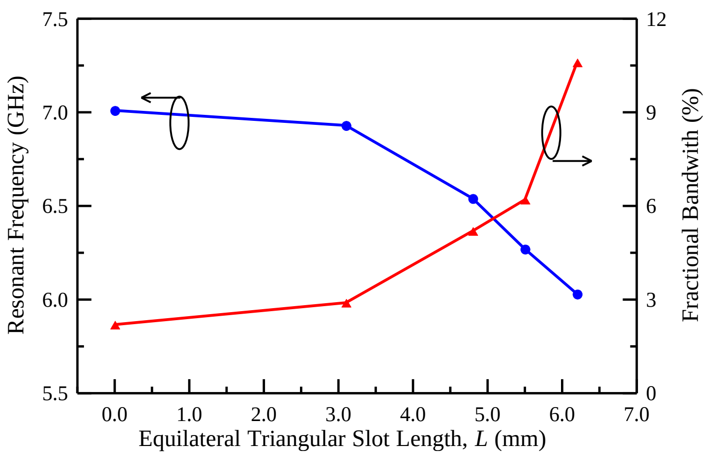


Figure 6. Measured resonant frequency and 3-dB fractional bandwidth varying with slot lengths.

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