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# A Dual-band Magnetoelectric Dipole Antenna by Microstrip Line

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## ABSTRACT

This paper proposes a dual-band magnetoelectric dipole antenna. By changing the size of the electric dipole and the magnetic dipole in the traditional magnetoelectric dipole, the two resonant frequencies are moved to high and low frequencies respectively, so as to realize the dual-band characteristics of the magnetoelectric dipole antenna. Finally, the two impedance bandwidths are measured to be 14.94% (1.6-1.86GHz) and 11.01% (4.25-4.74GHz), and the average gains are 9.8dBi and 6.3dBi respectively.

## KEYWORDS

Magnetoelectric Dipole; Dual-band; Antenna.

## 1. INTRODUCTION

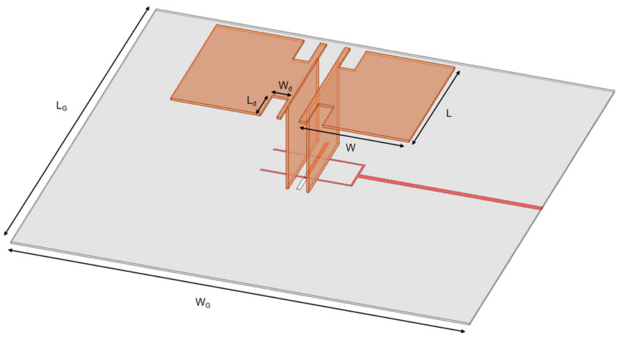
The magnetoelectric dipole antenna is an innovative antenna structure that combines the characteristics of electric dipole and magnetic dipole, and can achieve the synergistic effect of the two radiation modes of electric dipole and magnetic dipole at the same time[1][2]. Magnetoelectric dipole antennas have attracted widespread attention due to their wide bandwidth, high gain, stable radiation characteristics and low cross-polarization [3][4], and have potential applications in modern wireless communications, radar systems and satellite communications. value.

In order to make the magnetoelectric dipole antenna have dual-passband characteristics, it is necessary to have a certain understanding of the characteristics of the magnetoelectric dipole antenna. Two resonance points usually appear in the S11 curve of a magnetoelectric dipole antenna. The generation of these two resonance points is mainly attributed to the interaction and characteristics of the electric dipole and magnetic dipole in the antenna structure.

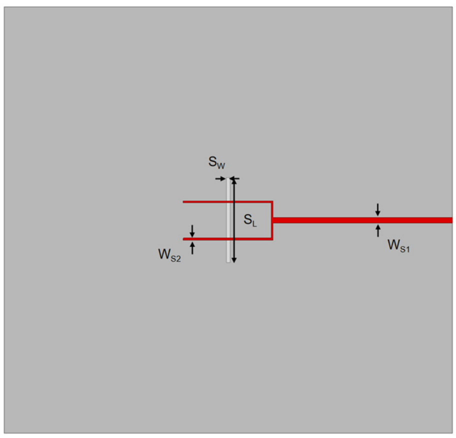
The structural design of the magnetoelectric dipole antenna has a significant impact on the generation and performance of the two resonance points. The design of the geometric size and the relative position and loading design of the magnetic and electric dipoles are all key factors. The length of the electric dipole is usually designed to be close to half a wavelength of the operating frequency to achieve electric field resonance, while the size of the magnetic dipole is adjusted by the diameter of the frame or ring to match the magnetic field resonance at the target frequency. These two different geometric designs determine the resonance effect of the antenna at two different frequencies, which appear as two significant resonance points on the S11 curve. In addition, the relative position of the magnetic dipole and the electric dipole and the loading design will also affect the position and depth of the resonance point. Precisely tuning the coupling effect between the two is crucial to ensure good radiation performance and impedance matching at both resonant frequencies. This structural design ensures that the antenna has good performance and stable resonance characteristics over a wider frequency band.

In this chapter, the positions of the two resonance points in the magnetoelectric dipole antenna are changed by changing the sizes of the electric dipole and the magnetic dipole, so that the resonance point generated by the electric dipole moves to the left and the magnetic dipole The resulting resonance point shifts to the right to form a double passband characteristic. After simulation verification, the two impedance bandwidths of the antenna in the microwave band are 14.94% (1.6-1.86GHz) and 11.01% (4.25-4.74GHz) respectively, and the average gains are 9.8dBi and 6.3dBi respectively.

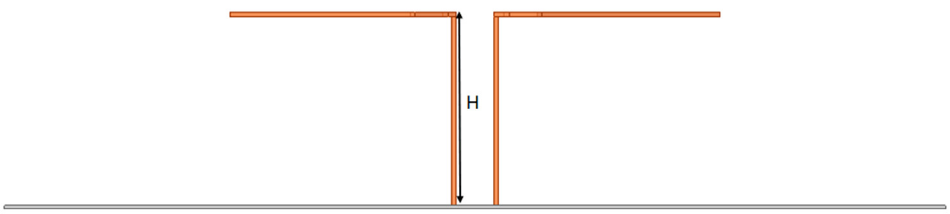
## 2. ANTENNA STRUCTURE




(a)Perspective view of a magnetoelectric dipole antenna




(b)Bottom view of magnetoelectric dipole antenna




(c)Side view of magnetoelectric dipole antenna

**Figure 1.** Structure of the proposed magnetoelectric dipole antenna

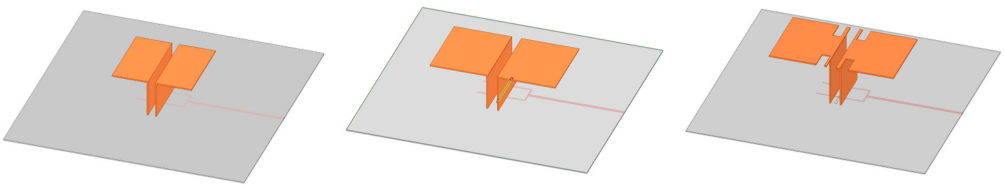
Figure 1 shows the geometry and detailed dimensions of the antenna. The antenna consists of a pair of horizontal plane metal patches, a pair of vertically oriented metal patches, a feeding microstrip line, and a ground plane. The horizontal plane metal patches consist of a pair of metal plates with length L, width W, thickness T, and two pairs of symmetrical rectangular slots with length Ld and width Wd. The vertically oriented metal patches consist of a pair of metal plates with height H, width Wm, and thickness T. The ground plane with rectangular slots with length SL and width SW is printed on a rectangular substrate with length LG and width WG. The substrate is Rogers 5880 with a thickness of 0.787mm.

The two horizontal plane metal patches of the designed antenna work together as an electric dipole. The two horizontal plane metal patches are attached to the top of the two metal patches placed vertically to the ground, and the two vertically placed metal patches work together as a magnetic dipole. The ground plane is printed on the upper part of the lower dielectric substrate, and a slot is etched in its center. The forked microstrip printed on the lower part of the dielectric substrate feeds the antenna through the slot.

**Table 1.** Detailed Dimensions of the Antenna (unit: mm)

| PRM. | $L$ | $W$ | $L_G$ | $W_G$ | $L_d$ | $W_d$ |
|---|---|---|---|---|---|---|
| VALUE | 60 | 48 | 200 | 190 | 15 | 7 |
| PRM. | $H$ | $S_W$ | $S_L$ | $W_{S1}$ | $W_{S2}$ | |
| VALUE | 27 | 1.6 | 38 | 1.2 | 0.9 | |

## 3. ANTENNA PRINCIPLE ANALYSIS



(a)Ant.1 (b)Ant.2 (c)Target Antenna

**Figure 2.** Reference Antenna Structure

In this section, we also designed two reference antennas. By changing the antenna size and comparing them with the target antenna, we explored the impact of the size of each part of the antenna on the antenna performance, as shown in Figure 2. Ant.1 is a traditional magneto-electric dipole antenna fed by a microstrip line slot; Ant.2 is a new magneto-electric dipole antenna obtained by changing the size of the E dipole and magnetic dipole of Ant.1; the target antenna is obtained by digging two pairs of rectangular grooves in the electric dipole of Ant.2. Except for the magnetic dipole and electric dipole parts, the sizes of the three antennas are the same. The reflection coefficients of the two reference antennas and the target antenna and the gain of the target antenna are shown in Figure 3. As shown in the figure, Ant.1 has an operating frequency band of 1.79-2.8GHz (S11<-10dB), an impedance bandwidth of 43.5%, and two evil points generated by the E dipole and the magnetic dipole appear at 1.9GHz and 2.6GHz respectively; Ant.2 changes the size of the electric dipole to explore the influence of the size of the E dipole on the frequency band and the position of the resonance point. It can be seen that the antenna has a dual-frequency characteristic after the size is changed, and the resonance point generated by the electric dipole shifts right from 2.6GHz to 4.2GHz;

Ant.3 changes the size of the magnetic dipole and digs a groove on the electric dipole. It can be seen that the resonance point generated by the smaller magnetic dipole shifts left from 1.79GHz to 1.6GHz, and digging a groove on the electric dipole can increase the bandwidth.

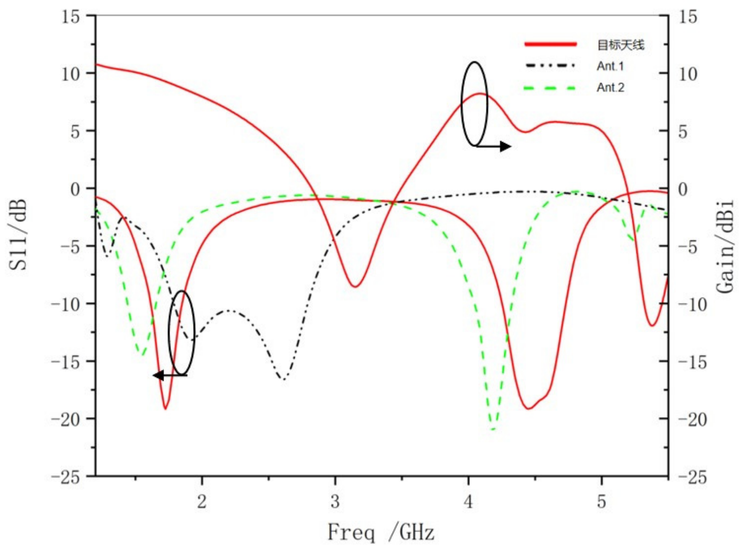



**Figure 3.** Reflection coefficient of reference antenna and proposed antenna and gain of proposed antenna

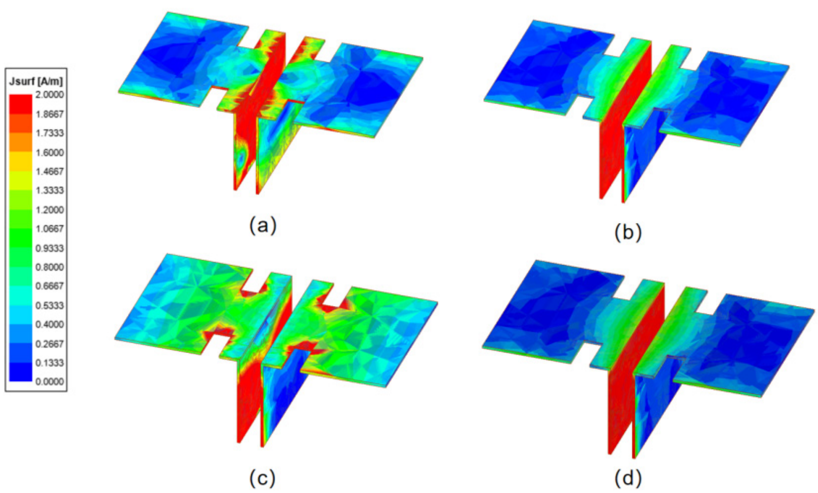



**Figure 4.** The current distribution of the antenna at different times within one cycle at 1.7 GHz. (a) t=0, (b) t=T/4, (c) t=T/2, (d) t=3T/4, where T represents one current cycle of the proposed antenna

Figure 4 shows the distribution of the electric field intensity at different times during one cycle of the antenna at 1.7 GHz. At t=0, the horizontal current on the plane dipole is dominant in one direction, and the current on the two vertical folded short-circuit pieces is minimal. Therefore, at t=0, the electric dipole mode is strongly excited. At t=T/4, the horizontal current is minimal, and the current on the two vertical folded short-circuit pieces is dominant in the opposite direction. Therefore, at t=T/4, the current loop radiating in the form of a magnetic dipole is strongly excited. At t=T/2, the electric dipole mode is strongly excited again with the current direction opposite to that at t=0. At t=3T/4, the magnetic dipole mode is excited again with the current direction opposite to that at t=T/4. Therefore, it can be concluded that the electric dipole mode and the magnetic dipole mode are excited.

## 4. ANTENNA RESULTS

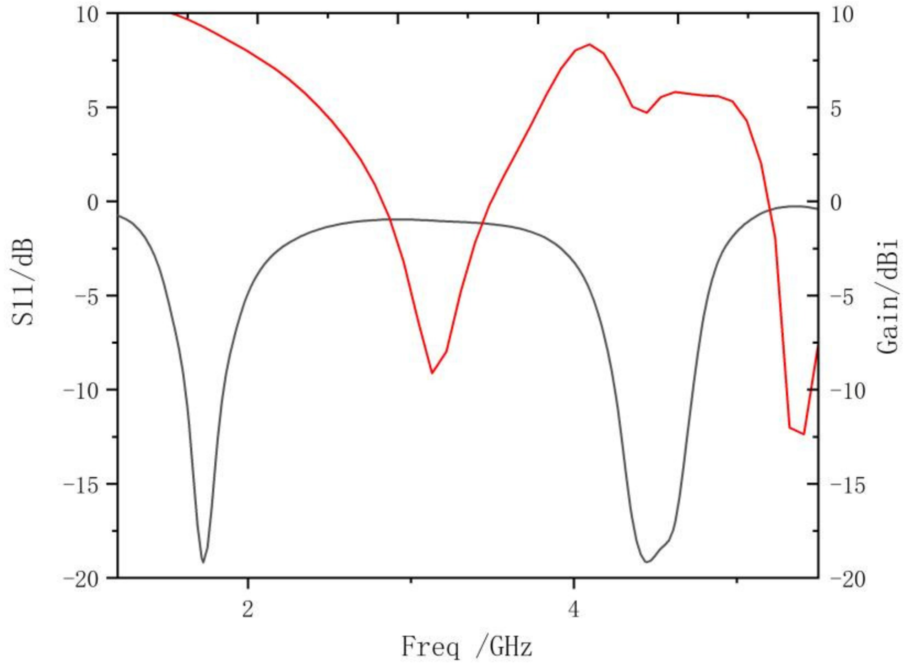



**Figure 5.** Simulated gain and impedance bandwidth of the proposed antenna

As can be seen from Figure 5, the two impedance bandwidths of the proposed antenna simulation are 14.94% (1.6 - 1.86GHz) and 11.01% (4.25-4.74GHz), respectively, and it has dual-frequency characteristics in the microwave band. At the same time, Figure 3-10 shows the simulated gain of the proposed antenna, and the average gain in the two frequency bands is 9.8dBi and 6.3dBi respectively.

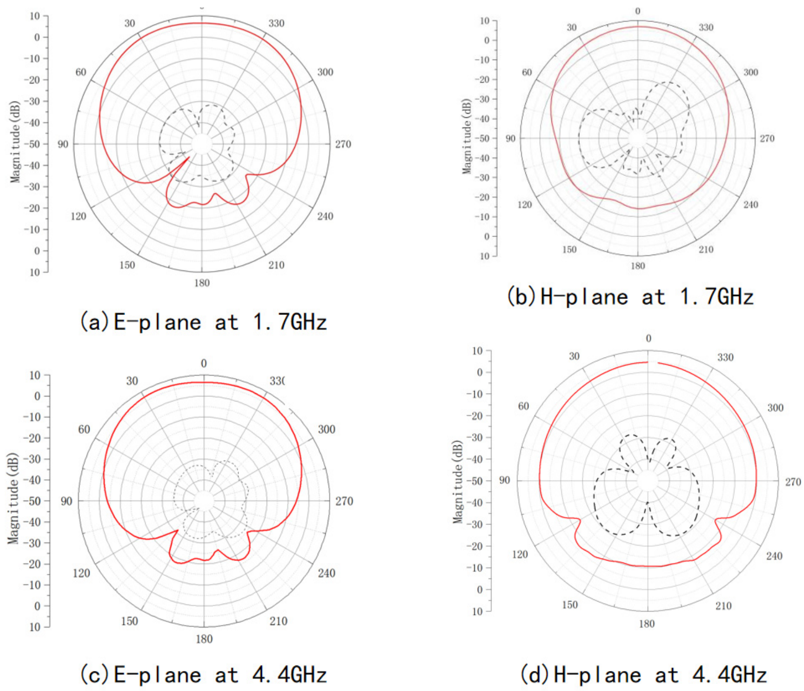



**Figure 6.** Antenna simulated radiation patterns at 1.7 GHz and 4.4 GHz

Figure 6 shows the simulated radiation patterns of the proposed antenna at 1.72 GHz and 4.4 GHz. A simulated cross-polarization of less than -30 dB is observed in the H plane (xoz plane) and the E plane (yoz plane). In addition, a measured front-to-back ratio of more than 20 dB can be obtained from the figure. The above results show that the proposed antenna has a good unidirectional radiation pattern in its operating frequency band.

## 5. CONCLUSION

This chapter proposes a method to achieve dual passband characteristics by changing the size of the electric dipole and magnetic dipole in the magnetoelectric dipole. And the effect of various parameters on the dual passband of the dipole is studied. The study found that by changing the size of the magnetic dipole and electric dipole in the magnetoelectric dipole antenna, the antenna can have dual passband characteristics, so that the designed antenna has two passbands in the millimeter wave band. Through ANSYS HFSS simulation software simulation verification, it is found that the two impedance bandwidths of the antenna in the band are 14.94% (1.6-1.86GHz) and 11.01% (4.25-4.74GHz), and the average gains are 9.8dBi and 6.3dBi respectively.

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