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A SHORTED MAGNETO-ELECTRIC DIPOLE WITH Γ-SHAPED STRIP FEED

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Abstract—A wideband unidirectional antenna composed of a magneto-electric dipole with Γ-shaped feed is designed. Simulated and measured results are presented. It achieves an impedance bandwidth of 84% for VSWR ≤ 2 ranging from 2.05 GHz to 5.05 GHz, stable peak gain of around 5 dBi, unidirectional radiation patterns and low cross polarization over the whole operating band. It is sufficient for accommodating recent wireless communication services such as 3G, WiFi, WiMax, Bluetooth, WLAN and Zigbee, etc.

1. INTRODUCTION

In the era of wireless communications, many buildings are installed with wireless networks consisting of numerous ceiling-mounted, indoor base station antennas. In many cases antennas with wide impedance bandwidth (BW), low profile, and unidirectional radiation patterns become necessary components in these systems. Several types of antennas, such as log-periodic [1] and reflector antennas [2], are limited by their large dimensions for these applications. Microstrip patch antenna can provide unidirectional patterns and has major advantages of low profile, low cost, light weight and easy fabrication [3–8], but its impedance BW is not wide enough at the condition of stable unidirectional radiation patterns.

Recently, a wideband complementary antenna impedance bandwidth designated as the magneto-electric dipole was proposed by Luk et al. [9, 10], but impedance bandwidth only has 43.3% for VSWR ≤ 2. The good electrical characteristics such as low back radiation,

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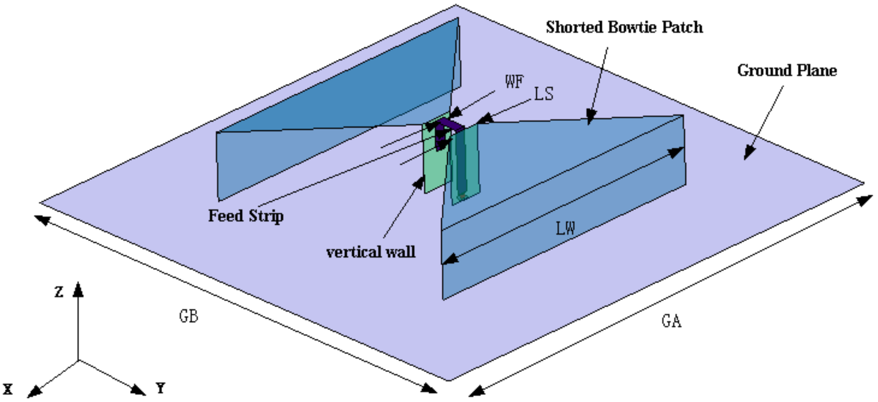
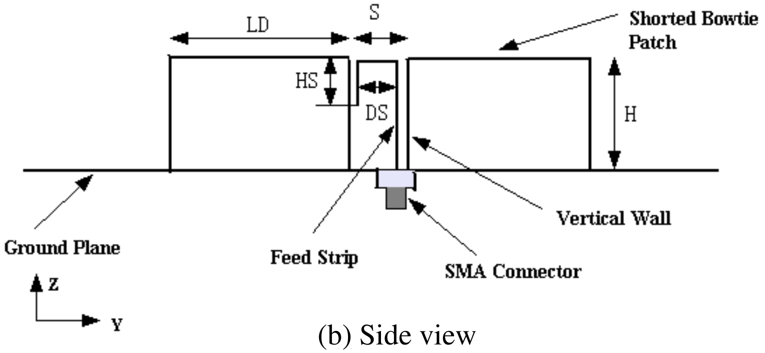
stable antenna gain over the operating band, and unidirectional radiation patterns were demonstrated. Some magneto-electric dipoles have already been designed [11, 12].

In this paper, a wideband unidirectional antenna composed of a magneto-electric dipole with Γ-shaped feed is investigated. In the proposed design, the Γ-shaped feed can enhance the impedance bandwidth. The electric dipole is composed of shorted bowtie antenna which can reduce antenna dimension effectively [13]. The proposed antenna can achieve about 84% impedance bandwidth with good radiation pattern, low cross polarization, and stable antenna gain. Measurement results are conducted to verify this new design.



(a) 3D view



(b) Side view

Figure 1. Geometry of proposed design: (a) 3D view. (b) Side view.

2. ANTENNA DESIGN

The configuration of the proposed shorted magneto-electric dipole antenna along with its design parameters and co-ordinate system is shown in Figure 1. As shown in Figure 1(a), the antenna consists of two triangular shorted patches, vertically-oriented shorted patch, Γ-shaped strip, a ground plane and a SMA connector. The configuration of the magneto-electric dipole is a combination of an electric dipole and a magnetic dipole. The two triangular shorted patches form an electric dipole with $LW = 70\,\text{mm}$, $LS = 6\,\text{mm}$, $LD = 29\,\text{mm}$ and $H = 16\,\text{mm}$. The magnetic dipole is composed of a pair of vertically-oriented shorted patch antennas with height of $H = 16\,\text{mm}$, coupled by a Γ-shaped strip feed to produce a magnetic current along the edge of the two vertical walls. The feed mechanism is Γ-shaped strip which is designed into two parts: a transmission line and a coupled strip. The transmission line acts like a microstrip line. The width of the microstrip line is 2.5 mm (WF), and the distance between the microstrip line and the shorting wall is 1 mm ($(S - DS)/2$). The remaining coupling strip, which is L-shaped, can be adjusted for impedance matching [10]. Similar to the conventional microstrip line, the characteristic impedance of the microstrip line with a ground plane can be adjusted by tuning the width of the line and the distance from the corner of the vertical wall. When a magnetic dipole and an electric dipole are excited simultaneously, they can produce equal E- and H-plane radiation patterns [14].

The proposed antenna was simulated using EM software (HFSS. 11), and the final optimal antenna parameters are shown in Table 1. A prototype of the proposed antenna was fabricated according to these design parameters, as shown in Figure 2.

Table 1. Dimensions of the proposed antenna.

Parameters	GA	GB	LW	LS	LD
Values/mm	120 ($1.42\lambda_0$)	120 ($1.42\lambda_0$)	70 ($0.83\lambda_0$)	8 ($0.09\lambda_0$)	27 ($0.32\lambda_0$)
Parameters	S	H	DS	WF	HS
Values/mm	8 ($0.09\lambda_0$)	16 ($0.18\lambda_0$)	6 ($0.07\lambda_0$)	2.5 ($0.03\lambda_0$)	7 ($0.083\lambda_0$)
λ_0 refers to the center frequency of the antenna					

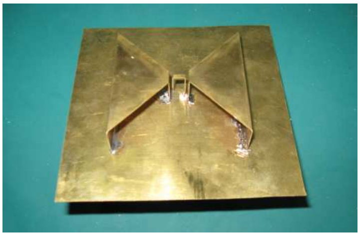
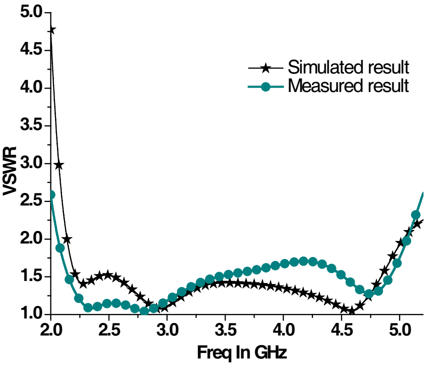


Figure 2. Photograph of proposed antenna.



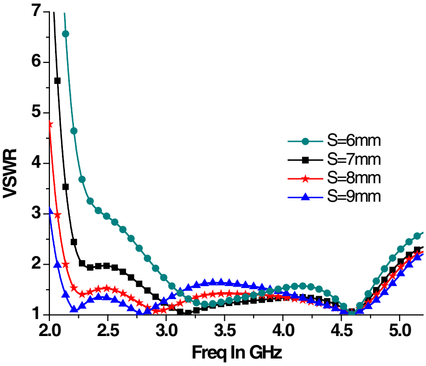


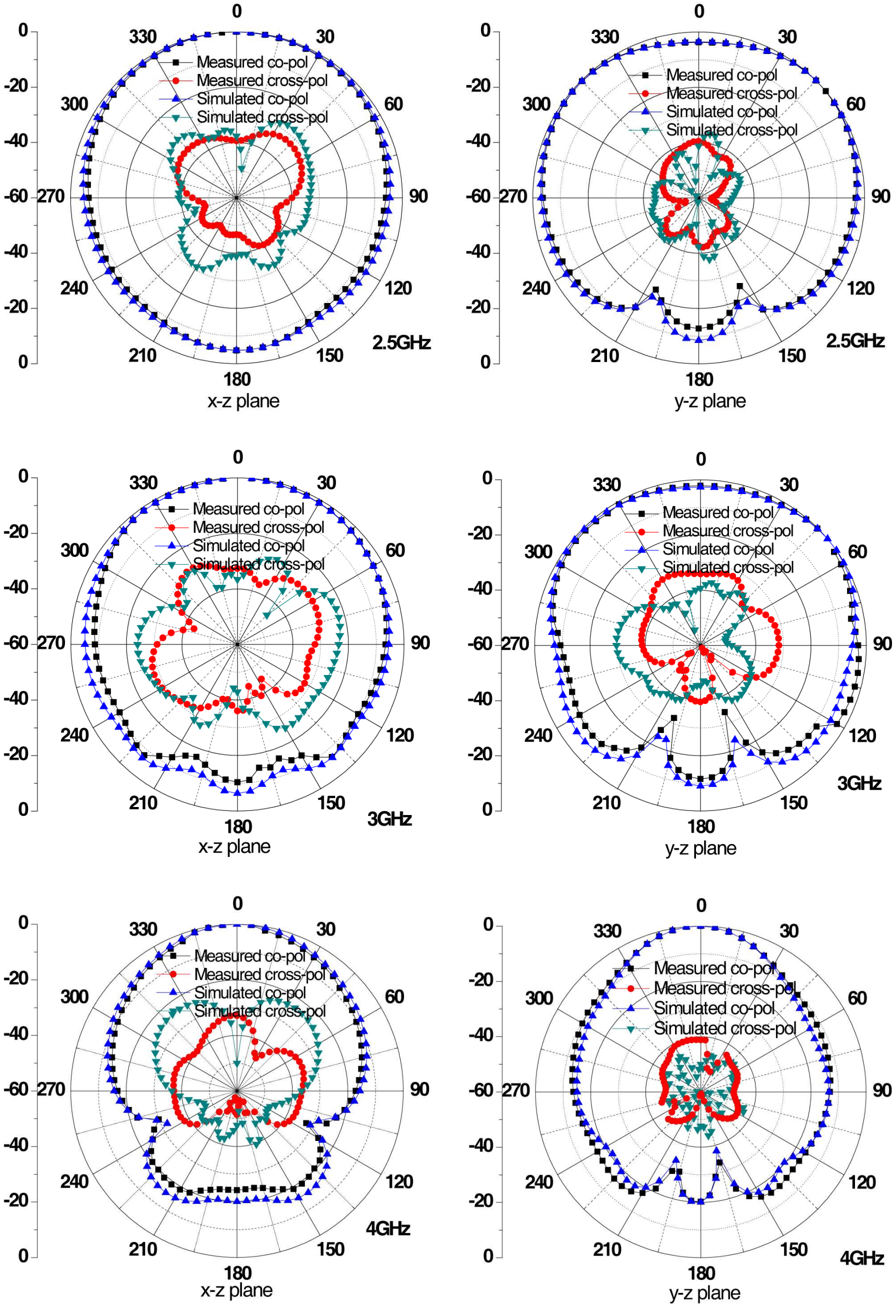
Figure 3. Simulated and measured VSWR against frequency.

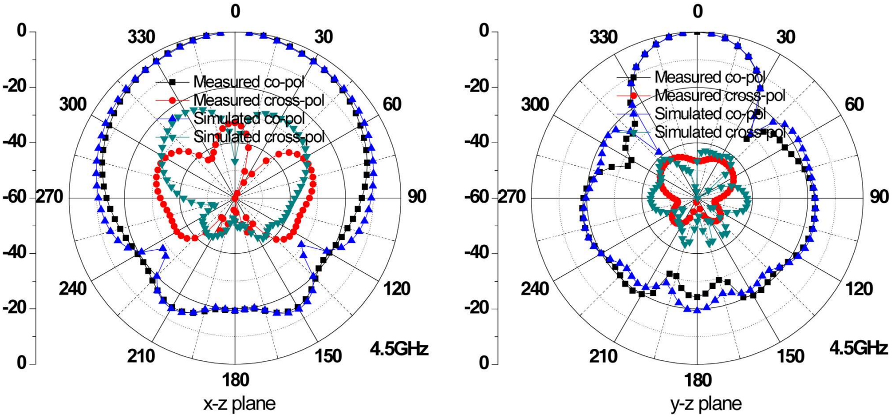
Figure 4. Simulated VSWR versus different S.

3. RESULTS AND DISCUSSION

The proposed antenna was simulated and optimized. The VSWR was measured with Agilent E8363B PNA network analyzer. The simulated and measured VSWR against frequency for the designed antenna are shown in Figure 3. From the figure, it can be observed that the measured results reasonably agree with the simulated results. For VSWR ≤ 2, the measured impedance bandwidth is about 84% (2050–5050 MHz) centered at 3.55 GHz covering 3G, WiFi, WiMax, Bluetooth, WLAN and Zigbee, etc.

The effects of the parameter S are studied. It is to note that the impendence characteristic is sensitive to the gap (S) between the two triangular shorted patches. Figure 4 presents the simulated VSWR for S varied from 6 to 9 mm. It is seen that the antenna's lower band is strongly affected by S. With an increase in S, the lower band impendence characteristic is quickly shifted to matching point. At last, the $S = 8$ was chosen considering the radiation pattern.


0
330
30
300
60
270
90
240
120
210
150
180
0
-20
-40
-60
-40
-20
0
Measured co-pol
Measured cross-pol
Simulated co-pol
Simulated cross-pol
2.5GHz
x-z plane
y-z plane
3GHz
4GHz



x-z plane

y-z plane

Figure 5. Simulated and measured radiation patterns for proposed antenna at 2.5, 3, 4 and 4.5 GHz.

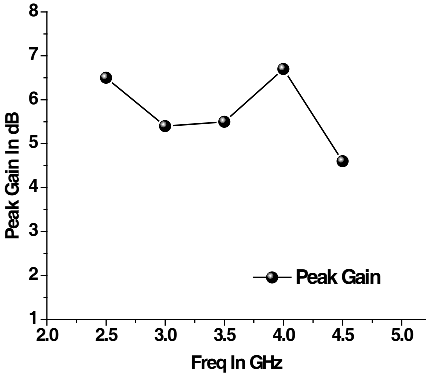


Figure 6. Measured maximum antenna gain for the proposed antenna.

The simulated and measured radiation patterns for the designed antenna in the *E*- and *H*-planes are shown in Figure 5 at 2.5, 3, 4 and 4.5 GHz, respectively. It can be observed that the co-polarization is around 25-dB higher than the cross-polarization. Besides, the proposed antenna exhibits the unidirectional characteristics in the operating band including 3G, WiFi, WiMax, Bluetooth, WLAN and Zigbee, etc. Figure 6 shows the measured peak antenna gain for the proposed antenna. Over the whole band, the antenna gain is varied from about 4.6–6.5 dBi.

4. CONCLUSION

A wideband unidirectional antenna composed of a magneto-electric dipole with Γ-shaped feed has been designed, simulated, fabricated and tested. The proposed antenna exhibits low profile, 84% impedance bandwidth and good radiation characteristics. Due to these performances, the antenna has wide and potential applications in wireless communication.

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