A New Wideband Antenna: Comprising Planar-Dipole and Short-Circuited-Patch

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***Abstract*—A wideband unidirectional antenna comprising a planar dipole and a shorted patch antenna is described. The antenna is excited by a square-cap coupled feed line. A wide impedance bandwidth of 62% (SWR≤2) from the frequency of 1.83 to 3.50 GHz is achieved. Stable radiation pattern with low cross-polarization, low backlobe radiation, nearly identical E-and H-plane patterns and an antenna gain of ~8dBi is found across the entire operating bandwidth.**

Index Terms—dipole, shorted patch, L-probe, wideband antenna, low cross-polarization, low back radiation

I. INTRODUCTION

The development of wideband unidirectional antenna element has been studied extensively [1-3]. Placing a dipole one quarter of a wavelength above a finite ground plane [1] is one of the popular ways for unidirectional antenna realization. However, the drawback of the large variation in gain and beamwidth over the operating bandwidth is eminent since the height of this antenna [1] in terms of wavelength is frequency dependant. The microstrip patch antenna is another common choice for unidirectional antenna design [4-7]. Some designs of wideband patch antennas are proposed in the literature, such as using an L-probe feed [4], an aperture coupled feed [5], stacked patches [6] or a U-slot patch [7] etc. By these designs, wide impedance bandwidths (over than 20 % for SWR <2) that are plentiful for many wireless communication systems can be achieved. The disadvantages of these designs are the appearance of instable radiation patterns across the passband [4-7] and the existence of high cross-polarization present in the upper frequency band. In order to suppress the cross-polarization, sine techniques like anti-phased cancellation [8], twin-L probes coupled feed [9], M-probe feed [10] etc were proposed. There are weaknesses in gain and beamwidth variations with frequency as well as different beamwidth in the E- and H-planes.

In 1954, an idea of complementary antenna consisting of an electric dipole and a magnetic dipole was reported by Clavin [11]. An equal E- and H-planes radiation pattern and a stable performance over the operating frequency can be accomplished by this idea. It is known that an electric dipole gives a figure-8 radiation pattern in E-plane and a figure-O pattern in H-plane; whereas a magnetic dipole gives a figure-O pattern in the E-plane and a figure-8 in the H-plane. In such a way, a unidirectional radiation pattern with equal E- and H-planes can be attained if both electric and magnetic dipoles excited with appropriate amplitude and phase at the same time [12]. Another design with a slot situated behind a passive dipole was analyzed by King [13]. The similar idea based on a slot-and-dipole combination [14, 15] was also discussed by other investigators; but there are problems related to narrow bandwidth or bulkiness in structure [11-15].

A new wideband complementary antenna with low cross polarization, low back radiation and symmetric E-and H-plane patterns that composed of a vertical-oriented quarter-wave shorted patch and a planar dipole was described in this paper. This antenna design employed the idea of combining an electric dipole and a magnetic dipole.

II. ANTENNA DESCRIPTION

The proposed design is based on the approach of combining an electric dipole antenna with a magnetic dipole antenna. Among many candidates of electric dipoles, a planar dipole antenna is chosen as shown in Fig.1a; while a wideband short-circuited patch antenna is selected as the magnetic dipole as depicted in Fig. 1b. To realize this idea, the short-circuited patch is placed vertically and is connected to the planar dipole as illustrated in Fig. 1c. Based on this idea, a new wideband antenna is proposed and its geometry is shown in Fig. 2. After a detailed parametric study, an antenna operated at the center frequency of 2.5GHz is

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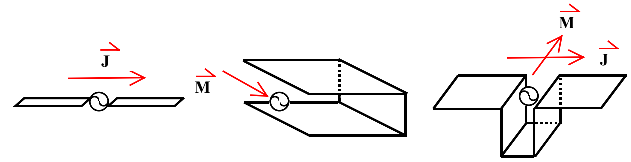
designed for demonstration. Each side of the planar dipole has a width *W=60mm* (0.5 λ), and a length *L=30mm* (0.25 λ). The shorted patch antenna has a length *H=30mm* (also close to 0.25 λ), where λ=2πf. For wideband operation, the separation of the two vertical plates, *S=17mm*, of the shorted patch antenna should be close to 0.14 λ and the width of the dipole and the patch *W* should be around 0.5 λ. The size of the ground plane can be used to adjust the back radiation. The optimum dimensions of the ground plane are 120mm ×120mm (1 λ by 1 λ).

To excite the antenna, a square-cap coupled feed is employed. The square-cap can excite the vertically-oriented shorted patch antennas as well as the planar dipole at the same time. In Fig. 2, this feed is combined with an air-transmission line with a characteristic of 50-ohm. The end of the transmission line is connected to the SMA which is located underneath the ground plane. For the detailed dimensions of the proposed antenna, they are listed in Fig. 2.

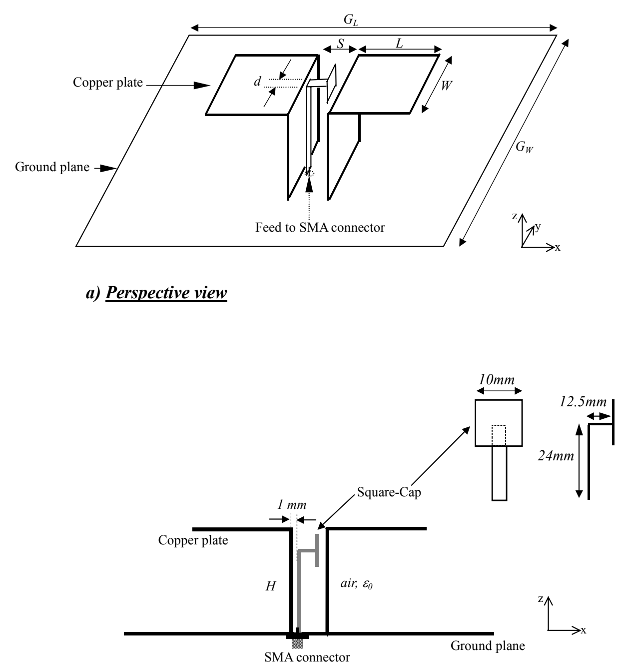


a) Conventional half-wavelength electric dipole antenna

b) Quarter-wave patch antenna fed by L-probe

c) An antenna consisting of an electric dipole and a quarter-wave patch

Fig.1 Principle of operation of the antenna.



a) Perspective view

b) Side view

Parameters	d	H	L	S	W	G_L	G_W
Value/mm	4.91 (0.040λ)	30 (0.25λ)	30 (0.25λ)	17 (0.141λ)	60 (0.5λ)	160 (1.3λ)	160 (1.3λ)

Fig. 2 Configuration of a wideband antenna composed of a planar dipole and a quarter-wavelength patch.

III. EXPERIMENTAL VERIFICATION

To verify the simulated results, a prototype of the proposed antenna was built and tested. Dimensions of the antenna are listed in the table inserted in Fig. 2. and the picture of fabricated antenna is shown in Fig. 6. Experimental results of SWR was obtained by an HP8510C network analyzer and radiation patterns and the antenna gain were measured by a compact range with an HP85103C antenna measurement system. The measured and simulated SWRs of the square-cap coupled fed case is shown in Fig. 3. From the SWR curves, the antenna has wide impedance bandwidth of 62% (SWR≤2) from 1.83 to 3.50 GHz. Fig. 4 displays the measured and simulated gain curves of the antenna. It can be seen that the proposed antenna has the maximum gain of 8.2dBi at frequency of 2.15GHz. Radiation pattern at frequency of 2.5 GHz was measured and shown in Fig. 5. The broadside radiation patterns were obtained for both E and H-planes. And the radiation patterns are stable and symmetric across the operating bandwidth. The beamwidth for the center frequency of 2.5GHz at the H-plane is 77^0, and at the E-plane is 72^0. Low cross-polar radiation level and low back radiation are achieved across the entire operating bandwidth.

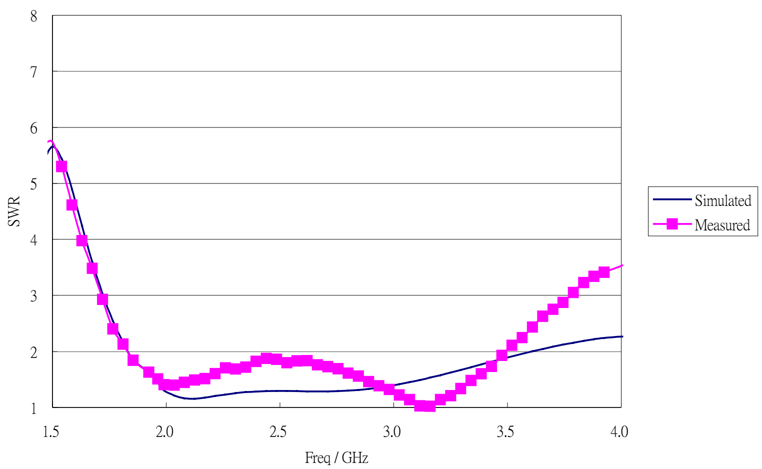


Fig. 3 SWR against Frequency

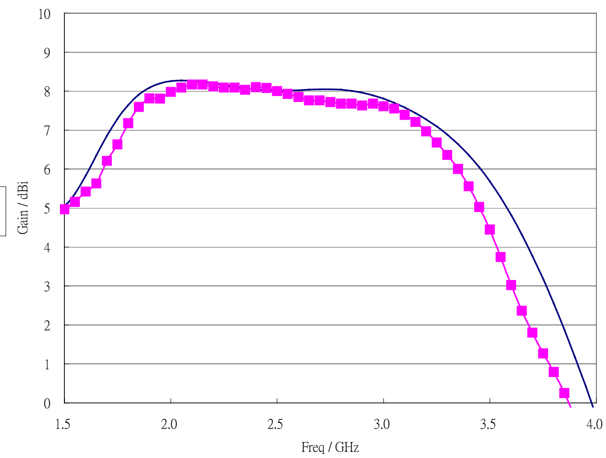
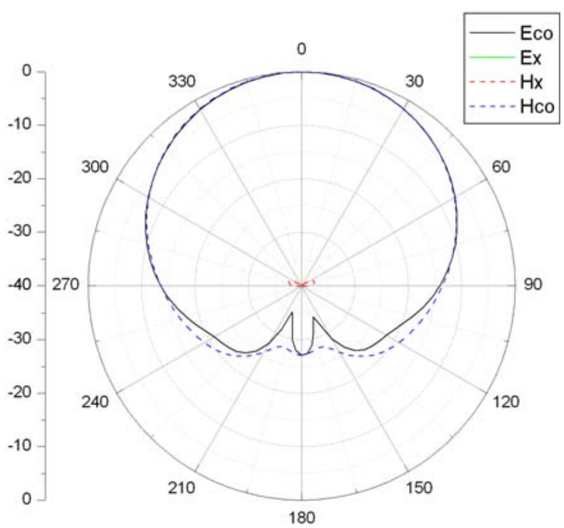
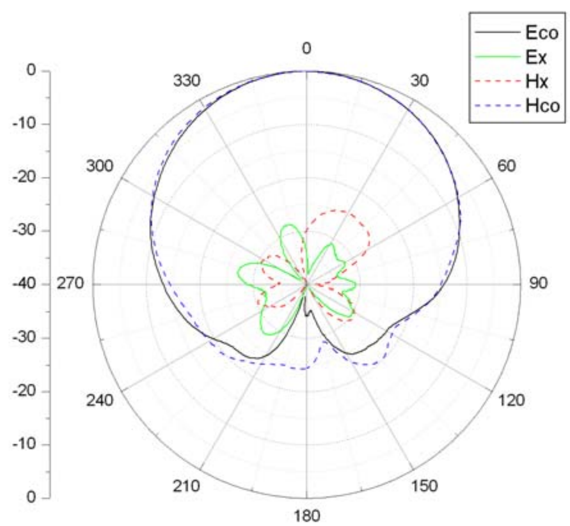


Fig. 4 Gain against Frequency



Simulated



Measured

Fig. 5 Radiation Pattern at 2.5GHz

IV. CONCLUSION

A new wideband antenna composed of a planar dipole and a vertically-oriented quarter-wavelength patch is introduced. It is simply excited by a square-cap. More than 62% impedance bandwidth for SWR<2 and 8dBi maximum gain has been achieved. This new design antenna has many advantages, including simple structure, wide bandwidth, low cross polarization, symmetrical radiation pattern, and in particular, very low back radiation. Moreover, the gain and beam width of the antenna are almost constant over the operating band. The antenna will find many applications in modern wireless communications.

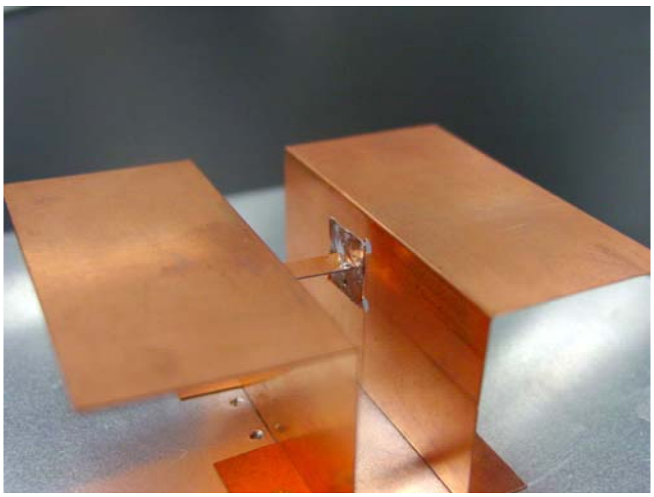


Fig. 6 Photo of the proposed antenna

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