# *Design of a Novel Wideband Printed Dipole Array Antenna*

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***Abstract*—In this paper, a 32-element wideband low-profile printed-dipole array antenna is presented. Elliptical dipole is used as the array element, which exhibits a good wideband characteristic. Further bandwidth enhancement can be realized by loading a circular parasitic patch above the dipole. The parallel double transmission line, printed on the both sides of the substrate is utilized as feeding network, and a metal reflector is employed for gain enhancement and unidirectional radiation. The measurement results show that the antenna has an impedance bandwidth of 100% from 3GHz to 9GHz for VSWR ≤ 2.3, and stable directional radiation patterns. The total size is 3.6 λ×3.6 λ×0.38 λ (λ is the free-space wavelength at the center frequency).**

***Keywords—printed dipole; broadband antennas; low profile; gain enhancement; directional radition***

## I. Introduction

With the development of modern wireless communications, antennas with characteristics of wide impedance bandwidths, low cost, low-profile and ease of fabrication are necessary in many systems. Microstrip antennas [1] have been widely investigated and are attractive for their small size, and cost effectiveness. However, the bandwidth is often insufficient for many applications. Vivaldi antennas [2] are easy to achieve a wide bandwidth, but their large electrical size along the maximum radiation direction have restricted the use in low profile environment.

Bowtie dipoles are attracting more and more attentions due to their simple and planar structures, and what's more they can provide much larger impedance bandwidth than thin line dipoles [3][4][5][6]. This paper has proposed a modified printed-dipole antenna element with wide impedance bandwidth and a 32-element printed dipole array antenna, which appears an impedance bandwidth of 100%, low-profile of 0.38 λ and good directional radiation patterns within the frequency range. The maximum gain is 20.3 dB and the minimum gain is 14.4 dB.

The design of the single element and the array antenna is explained in section II, III. The conclusions are reported in section IV.

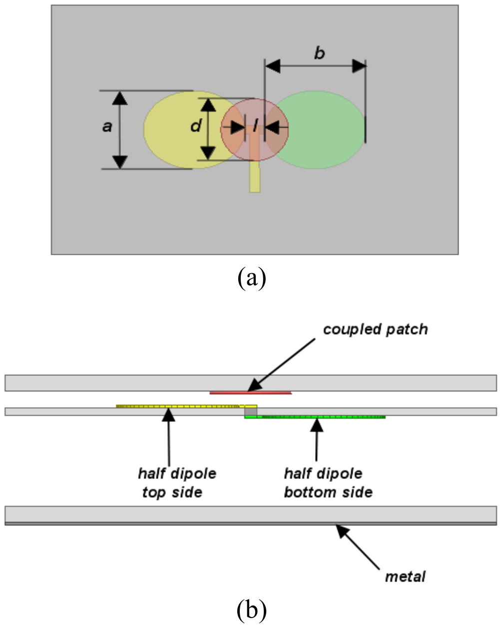


Fig. 1. Array element configuration, (a) Top view, (b) Side view.

## II. Modified Array Element

The design consists of a 32-element array of wide-band printed dipole, and the configuration of the array element is illustrated in Fig. 1. The major dimensions are as follows: a=14.6mm, b=17.5mm, d=12mm, l=2.9mm.

Each element consists of three dielectric layers and two air layers. The first layer dielectric substrate is FR4 with dielectric constant of 4.5 and thickness of 2mm. It acts as an antenna radome and the circular coupled patch is implemented on the bottom of the layer. The second layer is a 2mm air layer. The third layer is a 1mm dielectric layer ($\varepsilon_r$=2.65). Each arm of the elliptical dipole is printed on opposite sides of the third layer and fed by a balanced transmission line. The fourth layer is air with thickness of 11mm. The fifth layer dielectric substrate uses FR4 with thickness of 2mm. The metal reflector is etched on the lower surface of this layer.

Fig. 2 shows the curves of VSWR (both loaded and unloaded element). Fig. 3 shows the radiation patterns comparison between the loaded and unloaded element in x-z plane (H-plane). The input impedance of the unmodified printed dipole appears characteristics of inductance and mismatch at low frequency. Loading a coupled patch is equivalent to adding a capacitive element, and its value decreases with the increase of frequency. Therefore, the impedance matching characteristics at low frequencies are greatly improved, and have little influences on the impedance matching characteristics at high frequencies. Fig. 3 indicates that loading a circle coupled patch can improve the impedance performance and increase gain at 3GHz. At 6GHz, the spacing between the coupled patch and the dipole is small, the coupled patch cannot play the role of a director, so antenna gain is decreased. At 9 GHz, the electric length between the coupled patch and the dipole become longer, the coupled patch act as a director to the dipole, so the main lobe of the antenna radiation pattern is narrower and antenna gain is improved.

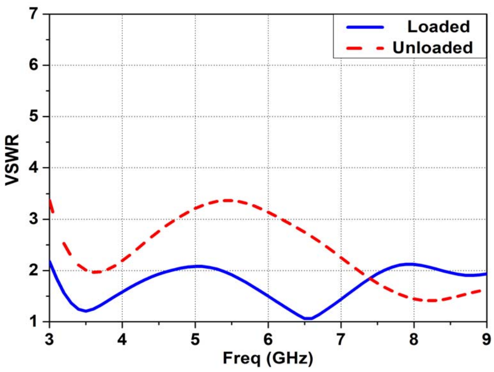


Fig.2. VSWR of the array element.

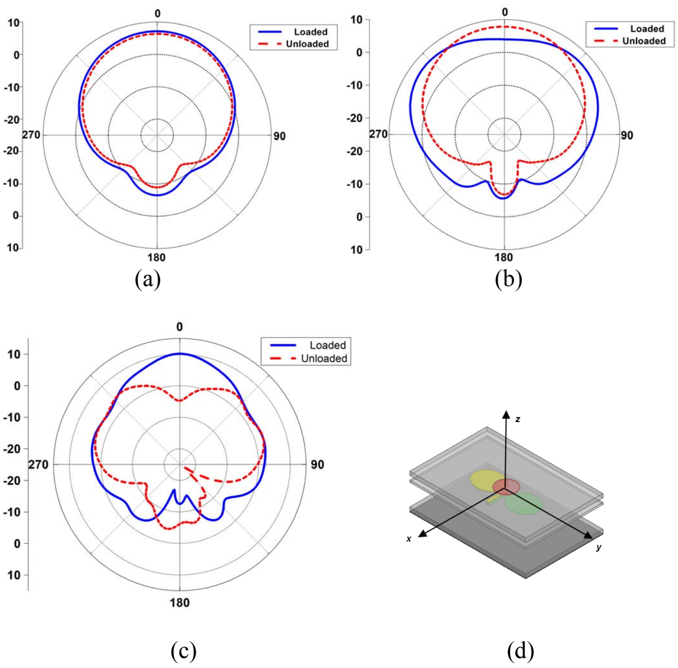


Fig.3. Radiation patterns comparison between the loaded and unloaded element in x-z plane at (a) 3GHz (b) 6GHz and (c) 9GHz, (d) coordinate relationship of array element.

## III. PRINTED DIPOLE ARRAY

In order to feed the wideband antenna array, a design of wideband feed network is designed in this paper. In order to reduce the insertion loss and facilitate the fabrication, the balanced twin line feeding network is used. The transmission twin line uses both surfaces of the thin substrate which each arm of the dipole etches on. A wide-band balun is designed to connect the 50Ω coaxial connector to the balanced twin line feeding network. The reflection cavity frames with a metal reflector are put on the bottom of the printed-dipole array. In order to stabilize the array antenna structure, medium blocks and screws are added in it. The array size is 180 × 180 × 19 $mm^3$. Fig. 4 shows the configuration of the wide-band printed-dipole array. Fig. 5 shows the photo of array.

The VSWR and gain in the boresight direction of array are shown in Fig. 6. Over the whole frequency band (3~9GHz), the measured VSWR is blew 2.3 and the boresight gain has maintained a high gain and the maximum and the minimum values are 20.3 and 14.4 dB, respectively. The simulated and measured radiation patterns of the printed-dipole array antenna in x-z and y-z planes at frequencies of 3, 6 and 9GHz are illustrated in Fig. 7. The properties of these patterns are summarized in Table I.

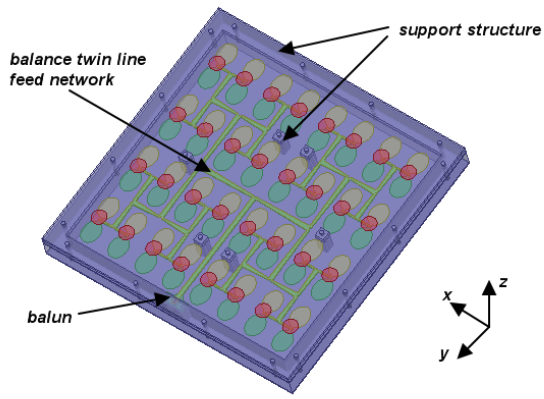


Fig. 4 Configuration of the wide-band printed-dipole array.

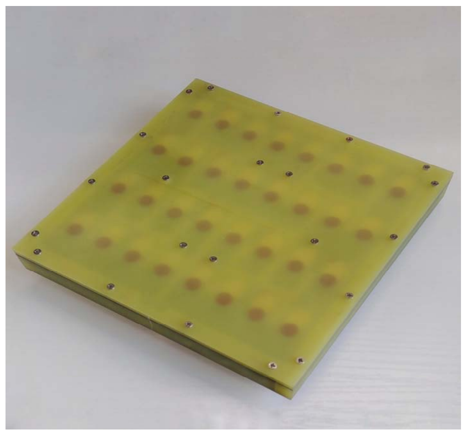

Fig. 5 Photo of the fabricated wide-band printed-dipole array.

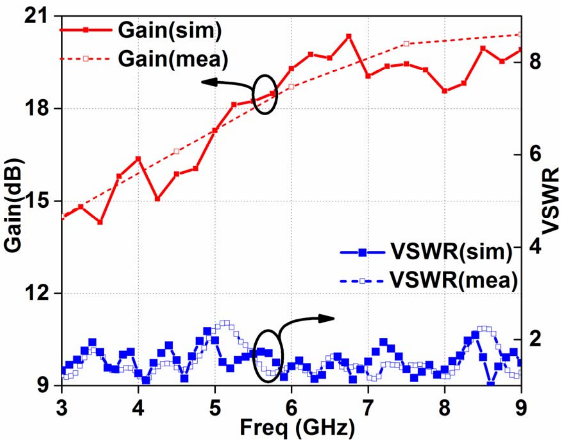


Fig. 6 VSWR and gain of the array.

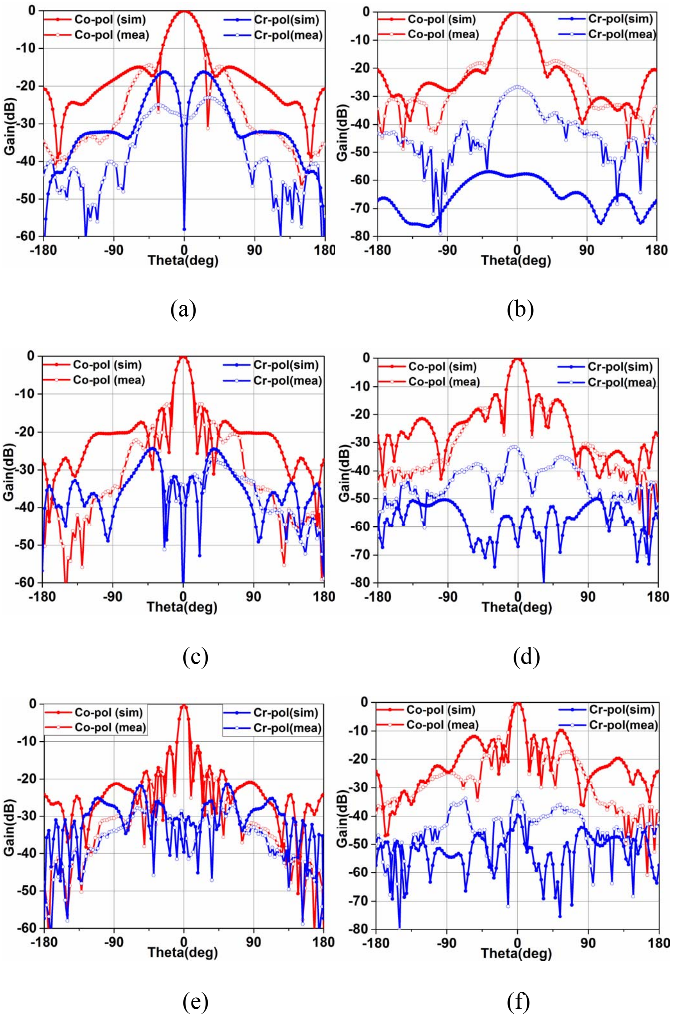


Fig. 7 Radiation patterns of the printed-dipole array antenna: (a) x-z plane 3GHz, (b) y-z plane 3GHz, (c) x-z plane 6GHz, (d) y-z plane 6GHz, (e) x-z plane 9GHz, and (f) y-z plane 9GHz.

TABLE I FAR FIELD RADIATION PROPERTIES

| F(GHz) | 3dB beam width (°) | | First side-lobe Level(dB) | | X-pol. Level(dB) | Gain (dB) |
|---|---|---|---|---|---|---|
| | *E-plane* | *H-plane* | *E-plane* | *H-plane* | | |
| 3 | 31 | 31 | -17.6 | -14.2 | -26.7 | 14.5 |
| 6 | 15 | 13 | -12.8 | -12.5 | -32.8 | 18.7 |
| 9 | 15 | 11 | -12.2 | -11.8 | -31.1 | 20.4 |

## IV. CONCLUSION

A 32-element wideband printed-dipole array antenna with loaded patch has been described and investigated in this paper. The use of coupled circle patch not only improve the impedance matching in low frequencies but also enhance the radiation pattern characteristics in high frequencies, and directional radiation patterns and gain enhancement can also be obtained. The measurement results show that the printed-dipole array antenna VSWR is below 2.3 from 3 GHz to 9 GHz with a wide impedance bandwidth of 100% and maintain good directional radiation patterns in the frequency band. With the characteristics of wideband, low-profile, high gain and directional radiation patterns, the proposed array antenna is applicable for a vehicle communication system requiring a wide bandwidth.

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