A HIGH GAIN ANTENNA ARRAY FOR WIRELESS HANSETS

ANTEN MẢNG VỚI HỆ SỐ TĂNG ÍCH CAO CHO CÁC THIẾT BỊ VÔ TUYẾN CẦM TAY

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Abstract:

The paper proposed an antenna array consisting of four bow-shaped dipole elements. The antenna array operates at a center frequency of 5 GHz with a bandwidth of 332 MHz. By utilizing the reflector and the directors, the antenna obtains a high gain of 10.6 dBi at 5 GHz and over 10.3 dBi across the operating bandwidth. Meanwhile, the antenna array still obtains a compact size of 134 × 60 × 0.8 mm^3. The antenna is designed on RO5880 substrate and simulated by CST studio software. The antenna can be suitable for stations in Indoor Positioning Systems, or transceivers as handsets for long distances.

Keywords:

Dipole antenna, dipole antenna array, microstrip antenna array.

Tóm tắt:

Bài báo đề xuất một anten mảng gồm bốn phần tử anten lưỡng cực vi dải hình nơ. Anten hoạt động ở tần số trung tâm 5 GHz với băng thông đạt 332 MHz. Bằng cách sử dụng phần tử phản xạ và dẫn xạ, hệ số tăng ích của anten được cải thiện, đạt 10,6 dBi ở tần số trung tâm 5 GHz và đạt trên 10,3 dBi trong toàn dải tần trong lúc vẫn đảm bảo được kích thước của anten nhỏ gọn (134 × 60 × 0,8 mm^3). Anten được thiết kế trên nền đế điện môi RO 5880 và mô phỏng bằng phần mềm CST. Anten phù hợp cho các thiết bị cầm tay cần thu phát với khoảng cách xa hoạt động ở dải tần xung quanh 5 GHz hoặc có thể dùng cho hệ thống định vị trong nhà.

Từ khóa:

Anten dipole, anten mảng lưỡng cực, anten mảng vi dải.

1. INTRODUCTION

High gain antennas are necessary for devices that transmit signals at a long distance. One of the solutions to achieve high gain is utilizing antenna arrays. Among them, microstrip antenna arrays have the advantage of balancing the antenna size and gain.

The antenna arrays can be developed from various element types depending on different requirements such as bandwidth, efficiency, size, gain, etc… Microstrip dipole elements are an efficient solution, being easy to fabricate and feed signal, while still meeting requirements on compact size and high gain.

Normally, antenna arrays with a larger number of elements give higher gain.

Howerver, this leads to an increase in antenna size. Therefore, in order to keep a compacte size of arrays to be suitalbe to handsets, the element number in arrays should be limited.

Recently, there has been a lot of publications on microstrip antenna arrays [1-6]. The arrays in [1-2] consisting of two elements obtain a peak gain under 8.11 dBi, and in [3-6], they are 1×4 antenna arrays. In [3], the 1×4 antenna array operates at a wideband from 2.55 GHz to 6.1 GHz and obtains a peak gain of 7.9 dBi. The array in [4] is designed for WLAN applications operating at a center frequency of 5 GHz with its size of 37 mm × 22 mm × 230 mm. This array has a compact size, but its gain is only around 5 dBi. A 'H'-shaped array in [5] is composed of four elements for WiMAX at 3.5 GHz. The antenna has a large size of 130 mm × 120 mm and limited a gain of 4.7 dBi and 8.4 dBi for FR4 and Duroid substrate respectively. Another 1×4 array in [6] achieves a good gain of 10.58 dBi and its compact size, but this antenna operates at a high band for 5G mobile communications at 28 GHz. [7-8] present the four-element antenna arrays with many significant achievements. However, these antennas are designed for high-frequency bands. Therefore, balancing the requirements of antenna parameters, especially between antenna size and gain, has been a challenge for antenna designers.

In this paper, we propose an antenna array composing of four bow shaped microstrip dipoles and with the attachment of the reflector and the directors to impove antenna gain. The proposed antenna has a zise of 134 × 60 × 0.8 mm^3, and operates at 5 GHz for WLAN with bandwith of 332 MHz. The antenna obtains a peak gain of 10.6 dBi at 5 Ghz and over 10.3 dBi across operating band.

This antenna can be utilized for handsets that need to directly transmit or receive signals over a long distance, and for stations in indoor positioning systems.

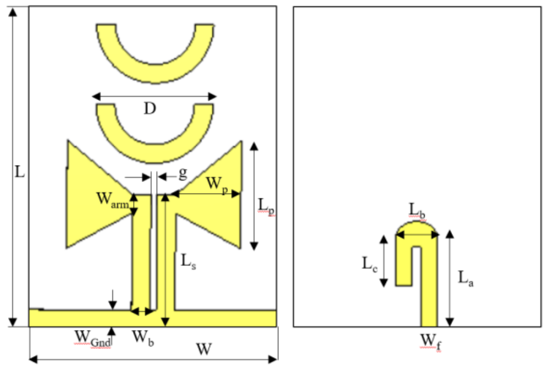
2. ANTENNA DESIGN

2.1. Antenna Element

Figure 1 shows the structures of the antenna element which is developed from a microstrip dipole antenna. It is fed by a 'J' shaped balun.

The antenna has two bow-shaped arms as a radiator with an arm length of half a wavelength at 5 GHz. A reflector is inserted at a distance of λ/4from the center of the radiating arms. Furthermore, the two bow-shaped directors are integrated paralleled to the radiator with a distance between the center of them ranging from 0.1λ to 0.35λ [9]. The antenna is fed by a 'J'-shaped balun based on the transmission line theory of W. Roberts [10] with its equivalent circuit shown in figure 2. The balun impedance is calculated according to equation (1).

$$Z_{in} = -j \cdot Z_{f2} \cdot cotg\theta_{f2} + \frac{j \cdot Z_b \cdot tg\theta_b \cdot Z_L}{j \cdot Z_b \cdot tg\theta_b + Z_L} \quad (1)$$



a) Front view b) Back view

Figure 1. The proposed antenna element

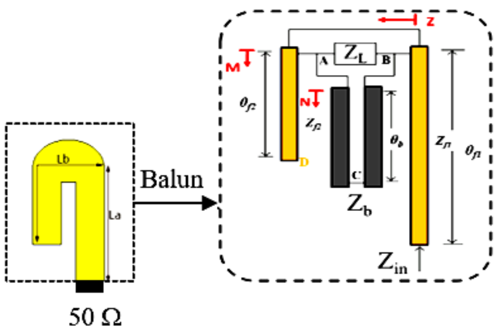


Figure 2. 'J'-shaped equivalent circuit [10]

According to (1), the 'J'-shaped balun's parameters are chosen as follows: $L_{f2} = L_b = \lambda/4$, $\theta = \theta_{f2} = \theta_b = 90°$ when λ is the wavelength at the operating frequency of 5 GHz.

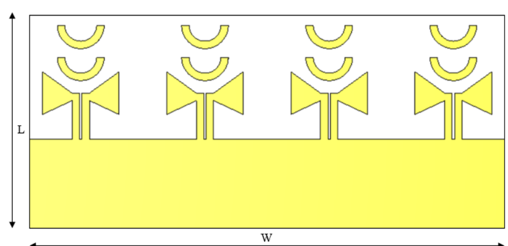
Error! Reference source not found.. **Detail dimensions of antenna element (mm)**

Parameter	Value	Parameter	Value
W	29	Wsg	3
L	37	La	8.09
Lp	12	Lb	10
Wp	8.13	Lc	4.38
g	0.7	Wf	1.97
Warm	2.1	D	13.19
Wb	2.1	Lgnd	3
Ls	12.14	Wgnd	12

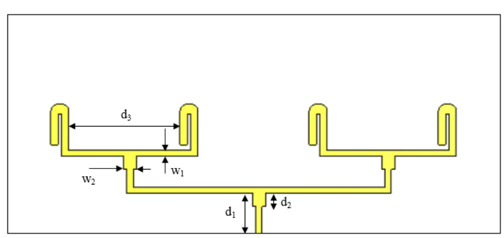
The antenna element is designed to operate at a center frequency of 5 GHz on the Roger RO5880 substrate with a substrate thickness of 0.8 mm, a dielectric constant of 2.2, and a loss of 0.0004. The total element size including in the reflector and the directors is 37 × 29 × 0.8 mm3, and the detail dimensions are shown in table 1.

2.2. Anten array

The antenna array consists of the four elements proposed above. These elements are placed paralleled to each other at a distance of approximately half a wavelength, 35 mm, from the center of the elements. A linear parallel feeding network utilizing a T-shaped power divider is designed based on the line transmission theory of matching impedance [9]. Figure 2 illustrates the front and back antenna structure with an overall size of $134 \times 60 \times 0.8$ mm^3.



(a) Front view



(b) Back view

Figure 2. The structure of the antenna array

Table 1. The detail dimensions of the antenna (mm)

Parameter	Value	Parameter	Value
L	134	d3	30
W	60	w_1	1.7
d_1	11.3	w_2	3.4
d_2	3.5		

The detail dimensions are calculated, then simulated and optimized by CST studio software, and are shown in table 2.

3. RESULTS AND DISCUSS

3.1. Anten Element

The simulated results of reflection coefficient, $|S_{11}|$, and 3D radiation pattern are presented in figures 3 and 4. It is observable that the antenna element operates at a center frequency of 5 GHz with a -10 dB bandwidth ranging from 4676 MHz to 5403 MHz. The antenna achieves a simulated antenna gain of 10.6 dBi at at 5 GHz and an efficiency of 96%.

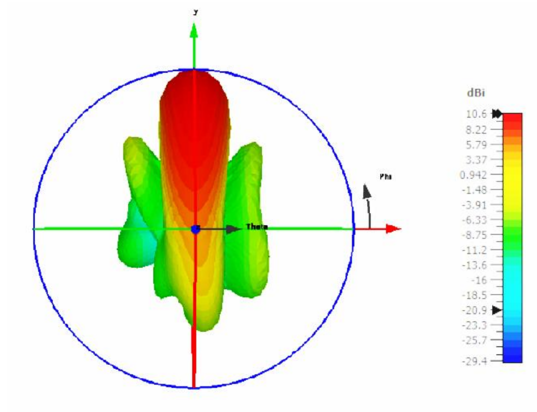
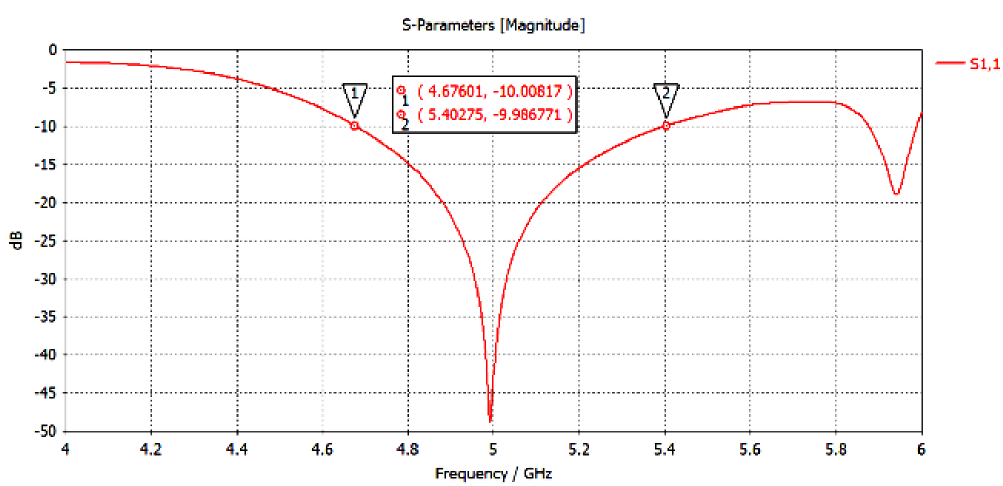


Figure 4. The simulated 3D radiation pattern of antenna element at 5 GHz

3.2. Anten Array

A demonstration of the reflection coefficient of the 1 ×4 antenna array is presented in figure 5. It is shown that the proposed array is well matched at 5 GHz with -10 dB bandwidth of 332 MHz, from 4847 MHz to 5179 MHz.

Figures 6 and 7 illustrate the polar and 3D antenna radiation pattern of the array with the simulated gain of 10.6 dBi at 5 GHz and efficiency of 91.5%.



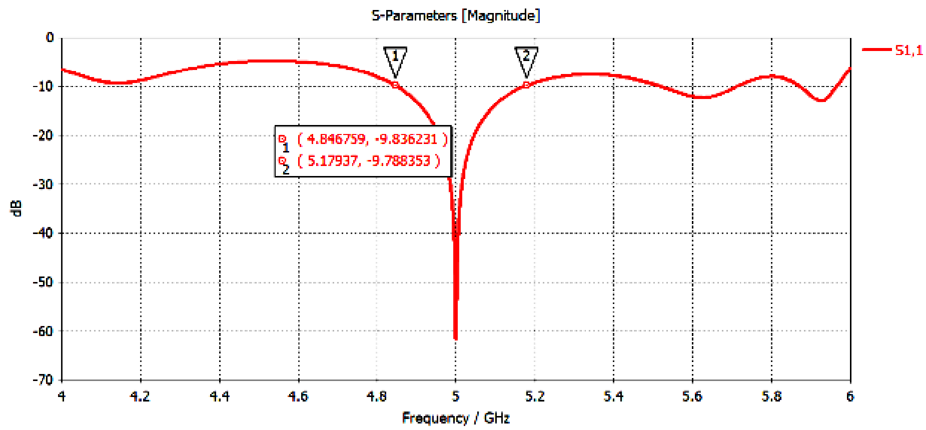


Figure 5. The simulated result of $|S_{11}|$ of antenna array

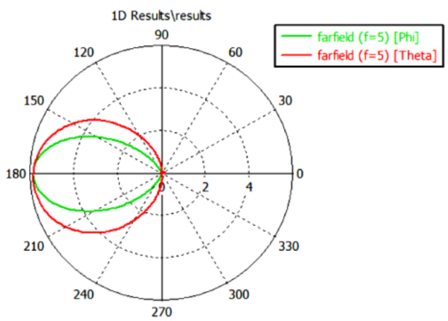


Figure 6. The simulated polar radiation pattern of the antenna array in 5 GHz

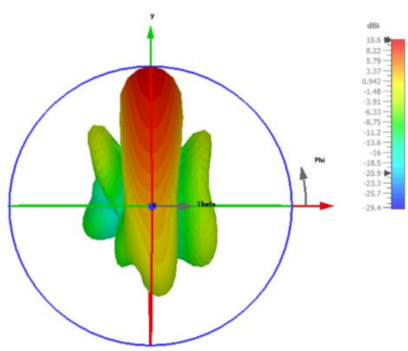


Figure 7. The 3D simulated radiation pattern of the antenna array at 5 GHz

4. CONCLUSION

The paper proposes a 1×4 antenna array developed from microstrip dipoles, which operates at center frequency 5 GHz with a bandwidth of 332 MHz. Despite the relatively compact size of 134 × 60 × 0.8 mm^3, the antenna obtains a high gain of 10.6 dBi at 5 GHz and over 10.3 dBi across the operating band. The antenna possesses a planar, simple, and compact structure, which is suitable for transceivers as handsets for long distances or indoor positioning systems based on Wi-Fi. The antenna is designed on RO5880 substrate and optimized by CST software. The simulated results will be verified by fabricating and measuring a prototype in the next steps in the future.

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Biography:

Hoang Thi Phuong Thao received the Dipl. of Engineer (2004), Master of Science (2007), and PhD degree (2019) in Electronics and Telecommunications from Hanoi University of Science and Technology, Vietnam. Currently, she is a lecturer at Electronics and Telecommunications Faculty, Electric Power University, Vietnam. Her research interests are antenna design, high-frequency circuits, metamaterials, wireless communication, and localization systems. She has had several publications in the ISI, Scopus journals and international conferences in antenna and wireless communication field. She has a total experience of 15 years teaching and researching experience.