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Microstrip-Fed Quasi-Yagi Antenna Featuring Compact Characteristics

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***Abstract* — In this paper, a compact quasi-Yagi antenna consisting of uniform-impedance director, stepped-impedance driven dipole and stepped-impedance reflector is presented. Compared with the conventional uniform-impedance dipoles, the proposed stepped-impedance dipoles achieve 31% length reduction. The measured 10-dB bandwidth is 28% at the center frequency of 2.6 GHz, and the antenna gain varies within the operating band is from 2.6 dBi to 4.2 dBi. Also, a 10-dB front-to-back ratio is obtained.**

***Index Terms*—Microstrip antenna, quasi-Yagi antenna, stepped-impedance resonator (SIR)**

I. INTRODUCTION

Quasi-Yagi antenna has drawn a great deal of attention thanks to its end-fire radiation patterns so that it has been widely used in wireless communication system. It features simple structure, high antenna gain, and ease of integration with other planar components, which makes it a unique candidate for a variety of applications such as millimeter-wave sensors, power combining, and phased-array systems. However, the feeding mechanism of a quasi-Yagi antenna is the most distinctive part to introduce a 180° phase difference between two signal paths. Some papers have been reported [1]-[5]. In [1], in order to simplify the circuit design, a coplanar waveguide-fed quasi-Yagi antenna was presented. The CPW feed solved the complex topology of a balun transforming the transmission mode into the coplanar stripline (CPS). In [2], the authors proposed a symmetric slot-line-fed quasi-Yagi antenna. Each arm of driven dipole connected to the metalized part of the slot line. In [3], [4], the authors employed the most straightforward method, microstrip feeding structure, to feed quasi-Yagi antenna with broadband characteristics.

In this paper, a microstrip-fed quasi-Yagi antenna featuring compact size is proposed. To obtain a wide operation bandwidth, smooth tapper lines are used to alleviate abrupt change between microstrip line and parallel stripline connecting the driven dipole [5]. Meanwhile, it is clear that the previous works usually focus on the transition instead of the antenna itself. The proposed antenna uses SIR to replace the conventional uniform-impedance resonator, which not only miniaturizes the circuit size, but also is suitable for array antenna where size reduction is critical for a close arrangement.

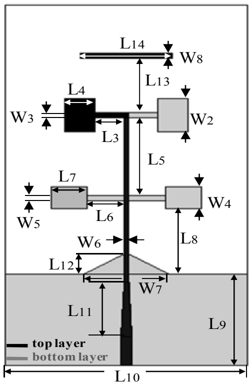

Fig. 1. The configuration of the proposed antenna.

II. ANALYSIS AND DESIGN

A configuration of the proposed compact quasi-Yagi antenna is shown in Fig. 1. The antenna is composed of a uniform director at top layer, a stepped-impedance driven dipole at top and bottom layers, a stepped-impedance reflector at bottom layer, and a truncated ground plane. The truncated ground plane provides a smooth impedance matching and field distribution matching between the microstrip feeding line and parallel stripline. Since director is normally shorter than driven dipole and reflector, a uniform-impedance director is used for simplicity. On the other hand, four sections comprise the stepped-impedance resonator, as depicted in Fig. 2(a). The inner lines of the SIR are W_1 in width along with L_1 in length, and the outer part of the SIR are W_2 in width along with L_2 in length. It is fed by a differential signal. For the sake of elaborating how the proposed resonator works, there are some simulations conducted by full-wave simulator HFSS and presented in Fig. 2(b). The antenna in this paper is fabricated on a 1.6-mm FR4 substrate with a relative dielectric constant of 4.4 and a loss tangent of 0.02. $L_2 / (L_1+L_2)$ is the length ratio, where $L_1+L_2 = 17.45$ mm, while W_2/W_1 is the width ratio, and $W_1 = 1.9$ mm. When width ratio = 1, it is a uniform-impedance case as reference, whose fundamental frequency is designed as $f_0 = 2.3$ GHz. On the contrary, f_{s0} is defined as the fundamental frequency of the stepped-impedance resonator. It is clear that, for SIR, not only length but also width control the resonant frequency. Also, the bigger width ratio, the lower fundamental resonant frequency f_{s0} of the SIR is. For different width ratios, one could obtain a length ratio for the smallest resonant frequency. This is the key to design the compact driven dipole and reflector. The design procedure for the antenna is as

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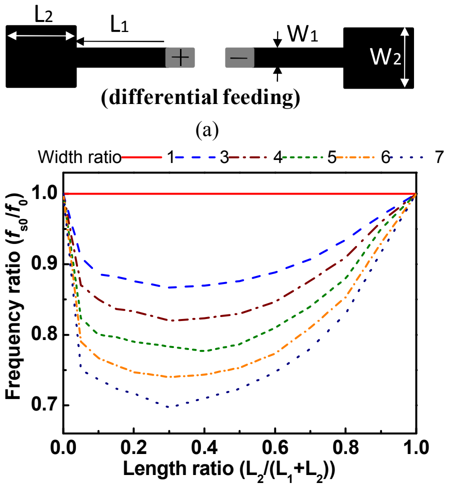

(a)

(b)

Fig. 2. Stepped-impedance resonator (a) layout (b) frequency ratio vs. length ratio.

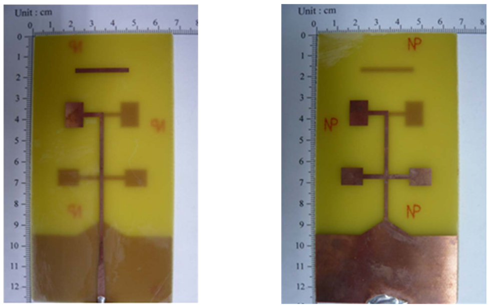

Fig. 3. Photograph of the proposed antenna: top view (left) and bottom view (right).

following:

1) According to the desired fundamental frequency, the distance between elements can be determined by well-known document.

2) At the center frequency, one could design the uniform-impedance director, the stepped-impedance driven dipole, and the stepped-impedance reflector.

3) Design a proper transition between microstrip line and parallel stripline.

4) Final optimization is necessary as the mutual coupling between resonators are neglected in the initial design.

III. RESULTS

The photograph of the proposed antenna is shown in Fig. 3. The dimensions of the antenna are: $W_2 = 11.4$, $W_3 = 1.9$, $W_4 = 7.6$, $W_5 = 1.9$, $W_6 = 1.6$, $W_7 = 23$, $W_8 = 1.9$, $L_3 = 7.75$, $L_4 = 8.2$, $L_5 = 26.75$, $L_6 = 9.8$, $L_7 = 9.8$, $L_8 = 22$, $L_9 = 32$, $L_{10} = 65$, $L_{11} = 19$, $L_{12} = 7$, $L_{13} = 19$, and $L_{14} = 24.5$, all units are in mm. The length of the proposed resonator is $L_3+L_4 = 15.95$ mm, while the length of the UIR at the same resonant frequent is 23 mm, which implies 31% length reduction is achieved. Fig. 4 shows the simulated and measured *S* parameters of the antenna. The 10-dB fractional bandwidth is 28%. Fig. 5 shows the measured radiation pattern at center frequency. The antenna gain is 4.2 dBi and the front-to-back ratio is better than 10 dB. In the passband, the antenna gain varies from 4.3 dBi to 2.6 dBi.

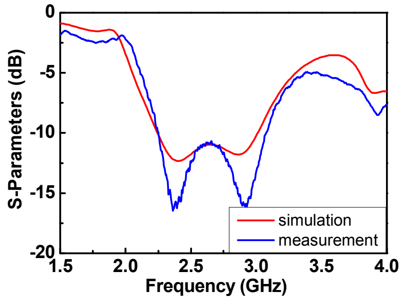

Fig. 4. Simulated and measured *S* parameters of the proposed antenna.

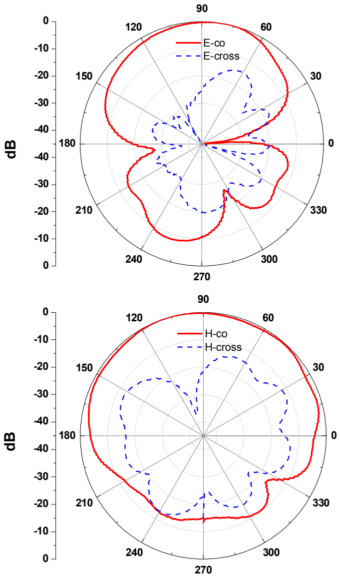

Fig. 5. Measured antenna patters at center frequency in (a) E-plane and (b) H-plane.

IV. CONCLUSION

A compact quasi-Yagi antenna is presented in this paper. It is shown that the SIR resonant frequency can be lowered in comparison to that of UIR with the same physical length. In this way, not only can the circuit be minimized, but also shorten the distance between elements of array antenna. Here is another merit that the proposed antenna is extremely suitable for array design.

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