Compact Ultra-Wideband Balun Filter and Its Quasi-Yagi Antenna Application

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***Abstract*—In this paper, a compact quasi-Yagi antenna with ultra-wideband balun filter is presented. The proposed balun filter is constructed with composite microstrip and slotline resonators. With the excited three resonant modes of slotline resonator and two additional resonant modes of microstrip lines, the balun filter with ultra-wideband response can be realized. Thus, with this proposed ultra-wideband balun filter, the designed quasi-Yagi antenna presents an impedance bandwidth from 5.95 to 10.63 GHz with return loss $|S_{11}|$ > 10 dB, and the antenna gain about 1.8–6.2 dBi of the interested passband can be achieved.**

Keywords—quasi-Yagi antenna; ultra-wideband; balun filter; microstrip and slotline resonators.

I. INTRODUCTION

The development of quasi-Yagi antenna with broad operating bandwidth is always attracted with great attentions, owing to its wide applications in the modern wireless communication systems. Several methods on the design of wideband quasi-Yagi antennas have been reported [1]–[4]. In [1], a compact and uniplanar antenna was fed by a broadband microstrip balun, which consisted of two microstrip lines with 180^{o} electrical length difference. With utilizing the coplanar waveguide as a fed network, a simple wideband planar quasi-Yagi antenna was designed in [2]. By integrating with a wideband balun designed by a four-port balanced bandpass filter, a quasi-Yagi antenna was proposed in a two-layered substrate [3]. With the microstrip-to-slotline transitions, a wideband quasi-Yagi antenna was studied in [4]. Although the compact circuitry was realized, the balun feeding network designed with microstrip-to-slotline transitions presented a poor filtering performance.

In this paper, a compact quasi-Yagi antenna designed with ultra-wideband balun filter is presented and simulated by using RT/Duriod 6010 with dielectric constant of 10.8 and thickness of 0.635 mm. With the excited resonant modes of composite microstrip and slotline resonators, the proposed ultra-wideband balun filter with good filtering response can be achieved. By integrating with this proposed balun filter, a quasi-Yagi antenna with wideband characteristics is simulated.

II. ANSLYSIS OF BALUN FILTER

The structure of proposed quasi-Yagi antenna is illustrated in Fig. 1. It is composed of ultra-wideband balun filter and antenna, in which the balun filter is designed with the composite microstrip and slotline resonators, whilst the antenna with the truncated ground plane contains a microstrip dipole as the driver and two parasitic microstip resonators as the director.

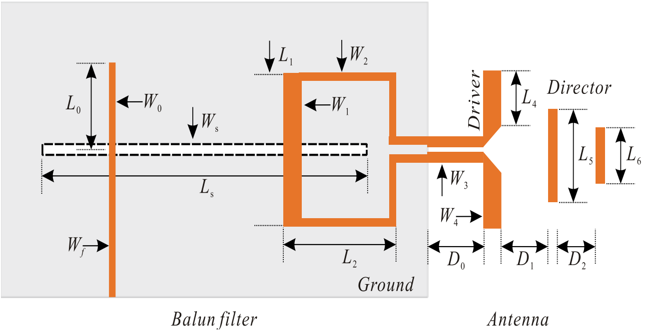


Fig. 1. Layout of compact quasi-Yagi antenna.

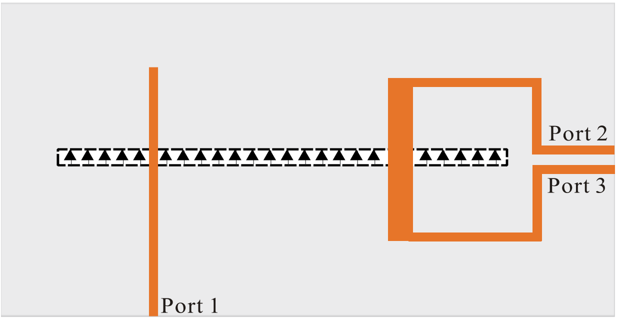


Fig. 2. Electric-field distribution of proposed UWB balun filter.

The proposed balun filter is constructed with hybrid microstrip and slotline resonators, which can be analyzed with the ideal transmission-line model [5]. With utilizing a full-wavelength slotline resonator and stretching the electrical length of the aperture-coupled microstrip to quarter-wavelength at the operating frequency f_0, a balun bandpass filter with ultra-wideband filtering performance can be realized. Herein, by selecting a half-wavelength slotline section as the distance between two microstrip lines as shown in Fig. 2, a five-pole filtering response for proposed balun filter is achieved. For this designed ultra-wideband balun, the middle three tramission poles are provided by the first three resonant modes of full-wavelength slotline resonator and another two poles are contributed by the coupled microstrip resonators. Due to the unbalanced electric field along the slotline resonator, the out-

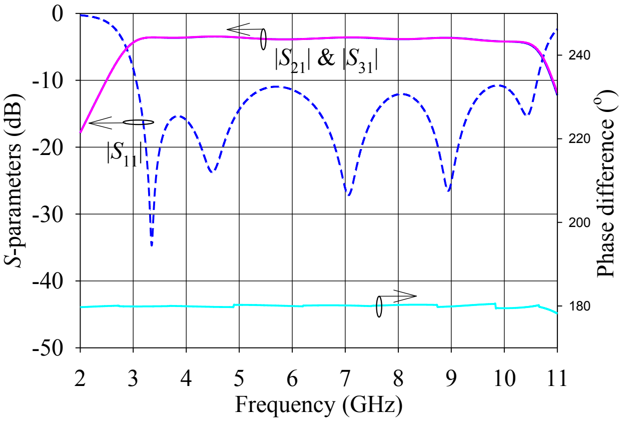


Fig. 3. Simulation results of proposed UWB balun filter with $L_0 = 4.1$, $L_1 = 7.84$, $L_2 = 8.09$, $L_s = 21$, $W_f = W_0 = W_2 = 0.55$, $W_1 = 1.09$ and $W_s = 0.4$ (Unit: mm).

of-phase performance for the output ports (port2 and port3) can be easily obtained. Moreover, to achieve a good impedance matching of the output signals, the characteristic impedance of the microstrip line with width W_1 around 35.35 Ω is selected. To verify the expected ultra-wideband balun filtering responses, the simulation balun bandpass filter centered at 6.85 GHz are plotted in Fig. 3. Obviously, an ultra-wideband bandpass filtering response with five in-band transmission poles is realized, with operating band from 2.8 to 10.7 GHz, and the simulated phase difference between two out-of-phase output ports is less than 1.8°.

III. ANTENNA DESIGN

By connecting the above discussed ultra-wideband balun bandpass filter, a wideband quasi-Yagi antenna is presented as shown in Fig. 1. The proposed antenna is designed with a microstrip dipole antenna and two parasitic microstrip resonators as the director is placed in front of the dipole. In order to realize the proposed antenna with a wide impedance bandwidth, the characteristic impedances and electrical lengths of the microstrip dipole antenna and the director are optimized. The simulation return loss is recorded as shown in Fig .4. The simulated antenna centered at 8.29 GHz is achieved, the operating band from 5.95 to 10.63 GHz with return loss $|S_{11}| > 10$ dB and impedance bandwidth around 56% is obtained. Fig. 5 shows the simulated radiation patterns of *E*- and *H*-plane at 8.05 GHz. The front-to-back ratio at the end-fired direction is higher than 17.9 dB, and the cross-polarizations of *E*- and *H*-plane are better than 19.1 dB and 15.1 dB, respectively. Moreover, Fig. 6 demonstrates the simulated antenna gain versus different frequencies, around 1.8–6.2 dBi of the interested passband can be achieved.

IV. CONCLUSION

A compact quasi-Yagi antenna designed with an ultra-wideband balun bandpass filter is introduced in this paper. With analysis the excited resonant modes of the composite microstrip and slotline resonators, an ultra-wideband balun filter with five transmission poles is presented. Based on the

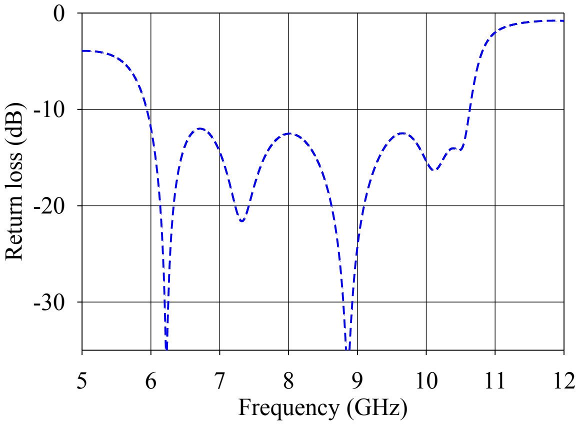
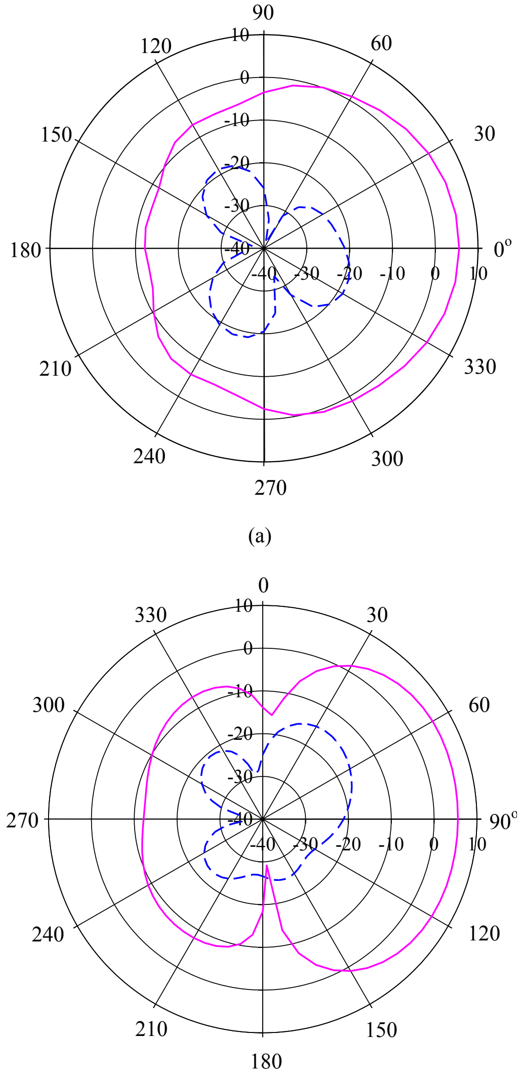


Fig. 4. Simulation results of proposed quasi-Yagi antenna with $L_4 = 6.67$, $L_5 = 5.4$, $L_6 = 4.4$, $W_3 = 1.35$, $W_4 = 2.6$, $D_0 = 4$, $D_1 = 2.93$ and $D_2 = 2.45$ (Unit: mm).



(a)

(b)

Fig. 5 Simulated radiation patterns of proposed quasi-Yagi antenna at 8.05 GHz. (a) *E*-plane, (b) *H*-plane. (——— co-polarization, - - - - cross-polarization)

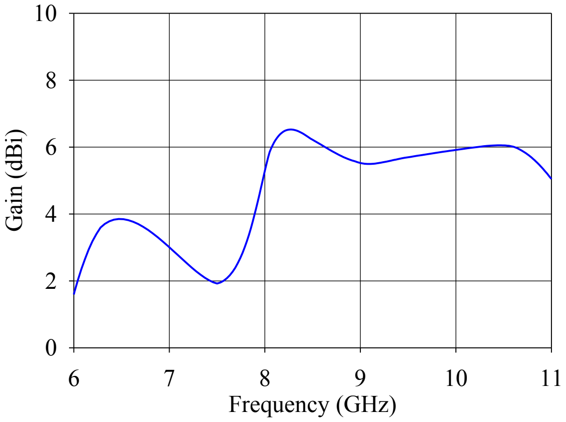


Fig.6 Simulated antenna gain of proposed quasi-Yagi antenna.

proposed structure of balun filter, a wide impedance bandwidth for proposed quasi-Yagi antenna is simulated. In addition, the bandwidth of proposed antenna controlled by the connected balun filter will be further analyzed.

ACKNOWLEDGMENTS

This work was supported by Science and Technology Development Fund of Macao SAR, Grant No. 068/2013/A2.

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