A Broadband Printed Conical Bowtie Dipole Antenna with an Integrated Balun

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***Abstract*—A novel design for a broadband printed dipole antenna element is presented. The broad bandwidth is achieved by introducing a conical bowtie dipole geometry and optimization of the feeding network, which is implemented as a microstrip integrated balun. The proposed printed dipole antenna achieves an impedance bandwidth of 820 MHz with good radiation characteristics. The antenna is designed for 2.45 GHz and finds application in a variety of wireless energy harvesting and power transfer systems and has potential for dual-polarized operation.**

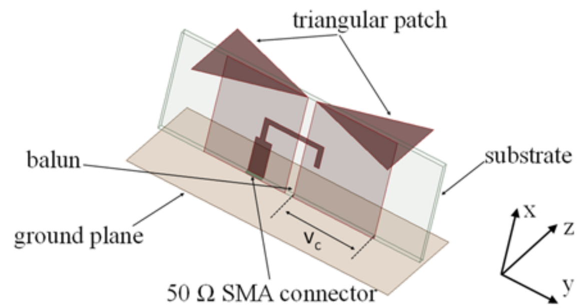
I. INTRODUCTION

Printed antennas are commonly used in wireless communications due to the simplicity in design and fabrication. These types of antenna are also suitable to be integrated into wireless electronic devices. Hence, research towards the miniaturization of printed antennas has become an important design consideration. The dipole antenna is a symmetrical structure and for good efficiency needs to be fed using a balanced feed to its arms [1, 2]. In most cases, antennas are fed using a coaxial cable which is an unbalanced feed, thus a balanced to unbalanced convertor (balun) [3-5] is used as an interface between the dipole arms and the coaxial line. Balun adds to the complexity and size of the structure. In some cases it also restricts the bandwidth of the antenna.

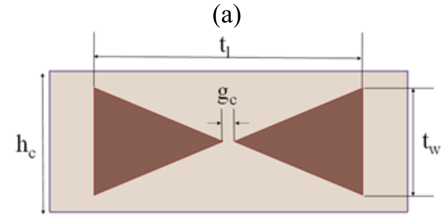
In this paper, we demonstrate a broadband printed dipole antenna with integrated balun that is matched to a 50-Ω feed simply through an adjustment of the feed point of the integrated balun. Parametric studies on the design parameters of the antenna are conducted and a broadband printed conical bowtie dipole antenna with an impedance bandwidth of 820 MHz and good radiation characteristics is presented.

II. THE PRINTED BOWTIE DIPOLE ANTENNA

The basic geometry of a printed bowtie dipole antenna is shown in Fig. 1. This antenna employs a horizontal substrate, a vertical substrate and a horizontal metalized ground plane. The vertical substrate is mounted between the horizontal substrate and the ground plane. Two triangular patches are printed on the bottom side of the horizontal substrate symmetrically to form the bowtie.Two vertical rectangular patches etched on one side of the vertical substrate are connected to the triangular patches and shorted to the ground, respectively [6]. An integrated balun connected to the feeding probe of a 50 SMA launcher is printed on the other side of the vertical substrate. A 62 mil Rogers Duroid 5880 laminate is used for the design (ε_r = 2.2, tan δ = 0.009), and analysis is conducted using Ansys HFSS [7].



(a)



(b)

Fig. 1. The bowtie dipole antenna. (a) 3D, (b) top view.

This dipole antenna achieves an impendence bandwidth of 640 MHz ranging from 2.395 GHz to 3.035 GHz. Two major design parameters of the antenna which strongly impacted the impedance matching were g_c and v_c (as shown in Fig. 1) which were determined to be 2 mm, and 50 mm, respectively.

III. A PRINTED CONICAL BOWTIE DIPOLE ANTENNA

A modified printed bowtie dipole with a conical shape is introduced in this work and the top view of the antenna is depicted in Fig. 2. The important parameters of the antenna are the cone angle, radius of the cone, and gap between the cones. Based on our parametric studies, the optimum cone angle α is chosen to be 45 degrees while the optimal length of dipole (t_l) was determined to be 45 mm. Also, our parametric studies (Fig. 3) showed that increasing the dimension of v_c to 55 mm for this design yields a broader bandwidth and better impedance matching.

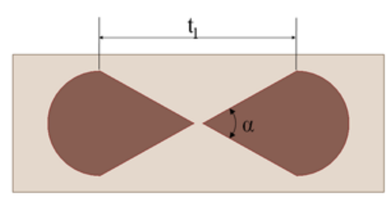


Fig. 2. Top view of the conical bowtie dipole antenna.

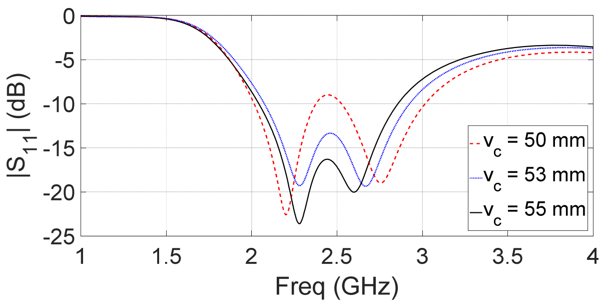


Fig. 3. $|S_{11}|$ versus frequency for different values. of v_c.

The mechanism of impedance matching is explained by the Γ-shaped balun shown in Fig. 4. The dipole is excited by the slot line which is coupled by the Γ-shaped microstrip line at the feed point. The lengths of l_a and l_b are 11m and 16mm, respectively. The width of the transmission lines are $W_a = 4$mm and W = 1.5 mm which correspond to 50 and 100 Ohms, respectively. The open stub length plays a major role in the impedance matching process which is shown in the parametric studies given in Fig.5. An optimum length of 7 mm is selected from the studies.

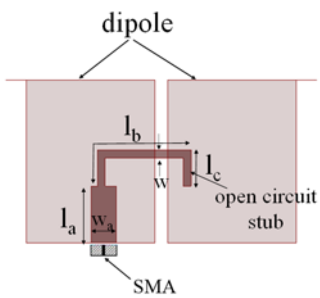


Fig. 4. The balun and design parameters.

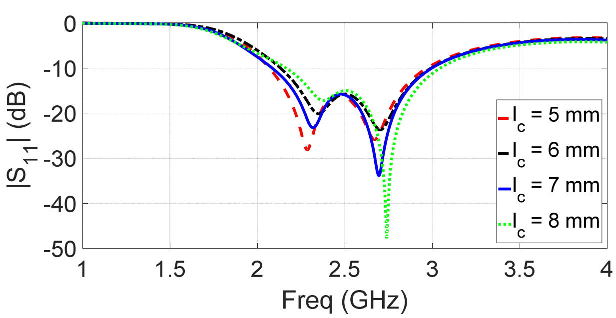


Fig. 5. $|S_{11}|$ versus frequency for different values. of l_c.

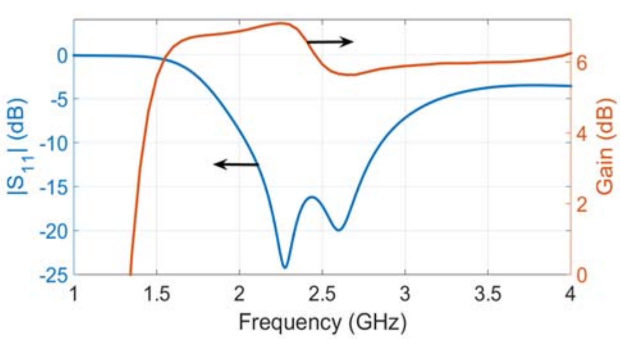


Fig. 6. $|S_{11}|$ and gain versus frequency for the optimized printed conical bowtie dipole antenna.

Gain and $|S_{11}|$ as a function of frequency are given in Fig. 6 for the optimized design. The antenna achieves an impedance bandwidth of 820 MHz (from 2.035 GHz to 2.855 GHz) that outperforms the classic bowtie configuration. The gain varies between 6 to 7 dBi over the matched frequency band. The 3D radiation pattern of the antenna at 2.45 GHz is given in Fig. 7.

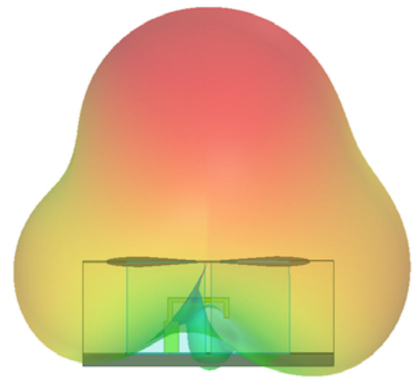


Fig. 2. 3D pattern of the dipole antenna at 2.45 GHz.

IV . CONCLUSIONS

A novel design for a printed conical bowtie dipole antenna with an integrated balun is presented. The dipole antenna yields a bandwidth of 33% (from 2.035 GHz to 2.855GHz). The enhancement in bandwidth is achieved by modification of the geometry of the bowtie antenna and optimization of the integrated balun feed system. The proposed antenna is designed for 2.45 GHz WLAN band operation and finds applications in a variety of wireless energy harvesting and power transfer systems. Moreover, this topology has the potential for dual-polarized and polarization reconfigurable operation by a simple addition of a second orthogonal dipole in the antenna setup.

ACKNOWLEDGEMENT

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