A compact wideband antenna with an integrated balun

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Abstract

A compact wideband antenna with an integrated balun, which achieves a very large bandwidth (2.5 GHz-14 GHz), is presented. It consists of a printed modified Bow-tie antenna fed by an integrated compact wideband balun. The overall size of the antenna printed on FR4 substrate is 75 × 58 mm2. The antenna achieves a gain greater than 2.5 dBi and exhibits a quasi-omni-directional radiation patterns over the whole frequency bandwidth. A good agreement between simulation and measurement results is observed, which confirms the good behavior of the proposed antenna.

1 Introduction

Today, in both civil and military applications there is an ever-growing demand for antennas with highly desirable features: wideband, compact size and low profile, Printed patch antennas are commonly used for their low profile and light weight [1], [2]. However, these antennas suffer from very narrow bandwidth. Although several techniques were proposed to enhance this crucial performance [3], [4], the improved bandwidth remains limited. For a wideband behavior, a printed bow-tie antenna can be a good candidate. Besides its very simple profile, bow-tie antenna is compact and low-cost. However, this type of antenna is symmetrical and has input impedance greater than 50Ω. This can be overcome using wideband printed balun. A variety of wideband antennas using a balun have been reported in literature. In [5], the proposed antenna comprised of dipole and microstrip feed-line, both printed on the top side of the substrate, and the slot balun embedded in the ground plane on the bottom side of the substrate. The entire size of the antenna is only 16mm×28mm×0.8mm. However, the radiation patterns present unstable radiation performance at the high frequencies. In [6], a miniaturized half bow-tie printed dipole antenna is presented. It contains on the top surface two layered with a feed line, and the radiating arms on the bottom surface. Its dimensions are 37.5mm × 19mm × 0.787mm but it covers only the band from 2.26 GHz to 3.43 GHz with an omnidirectional radiation. Another study proposed to design a balun-fed printed log-periodic trapezoidal array antenna with a good radiation performance and covering the frequency band from 2 GHz to 18 GHz [7]. The antenna has a simple structure, although the overall size of this antenna is 180mm × 80mm. In [8], the bowtie antenna with an integrated balun provides the operating frequency ranges from 3.2 to 11.2 GHz.

The total size of the antenna is 54 mm × 40 mm. This antenna has the disadvantage of having 10 vias which makes the realization more complex. Furthermore, the radiation patterns of this antenna are not stable over the UWB frequencies.

In this paper, we design a wideband printed bow-tie antenna which covers a very large bandwidth (2.5 GHz-14 GHz). The proposed solution integrates a wideband microstrip balun printed on the same substrate of the antenna in order to keep the antenna structure compact and low profile.

2 Proposed Antenna

2.1 Bow-Tie Antenna

A modified bow-tie antenna, as shown in Figure 1, is printed on 75×58 mm2 FR4 substrate with a thickness of 1.6 mm and permittivity of 4.3. The dimensions of this structure are as follows: L_p = 35 mm, W_p = 29 mm, Wadd= 14 mm and X = 0.3 mm.

Simulations have been performed with CST Microwave Studio using a 90Ω discrete port. The simulated reflection coefficient of the antenna is depicted by Figure 2.

It is observed that the antenna achieves a 4.91 GHz bandwidth (79.64 %) with a return loss greater than 10 dB from 3.71 to 8.62 GHz.

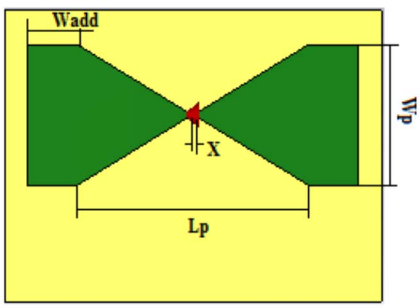


Figure 1. Geometry of the proposed bow-tie antenna.

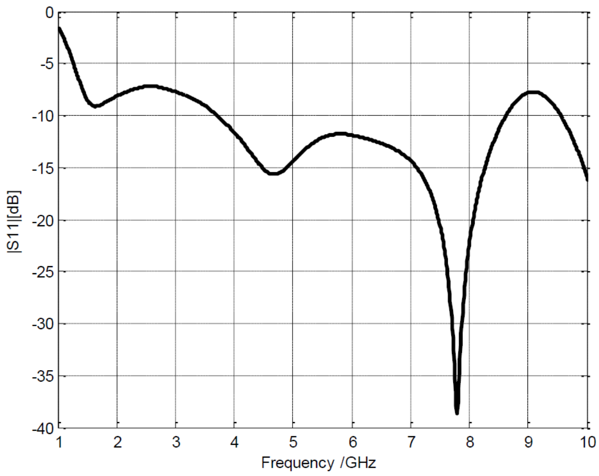
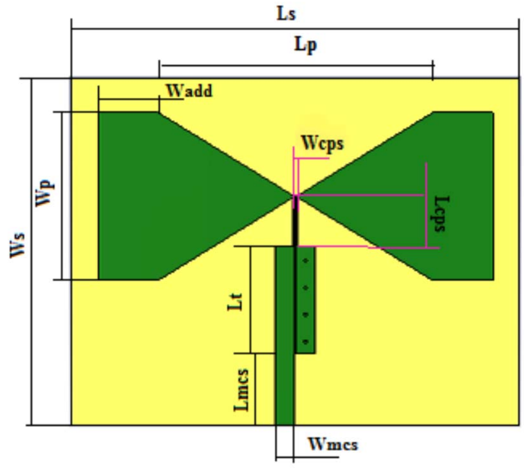


Figure 2. Simulated reflection coefficient of the bow-tie antenna fed by a 90 Ω discrete port.

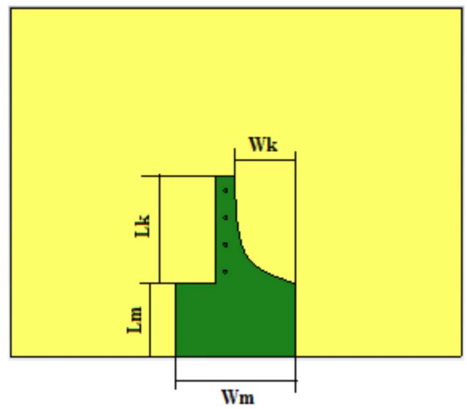
2.2 Bow-Tie Antenna with an Integrated Balun

In order to feed the Bow-tie antenna with an asymmetric feed line, a balun is needed. The design of this latter has been inspired from [9]. Figure 3 shows the overall designed structure (bow-tie antenna + balun). The optimized dimensions of the bow-tie antenna and the balun are as follows: L_s = 75mm, Ws = 58mm, L_p = 46 mm, W_p = 28 mm, X = 0.3 mm, W_{add} = 10 mm, L_{mcs} = L_m = 12 mm, W_{mcs} = 3.137 mm, W_m = 20 mm, L_{cps} = 8.25 mm, W_{cps}= 0.3mm, L_t = L_k = 18 mm, W_k = 10.15 mm.

On the upper surface of the substrate (Figure 3.a), the two MCS (Micro-Coplanar Strip) and CPS (Coplanar Strip) lines are printed on a low-cost substrate FR4 (thickness = 1.6 mm, ε_r = 4.3 and tan δ=0.025). The width of the MCS and CPS lines of 3.137 mm and 0.3 mm are chosen, respectively, to achieve the transition between 50Ω (SMA) and the bow-tie input impedance (90.29Ω).The right part of the CPS line (Figure 3.a) is electrically connected to the ground plane on the bottom surface of the substrate, through 4 via holes with radius of 0.3 mm. The width of the ground plane (Wk), illustrated in Figure 3.b, is progressively reduced according to a conical shape of the Klopfenstein taper [10]. This transition does not disturb the electric field distribution between the MCS and the CPS lines and yields better performance in terms of impedance matching.



(a)



(b)

Figure 3. Dimensions of the overall structure (bowtie + balun): (a) Top view and (b) Bottom view.

3 Results and Discussion

A photo of the realized wideband antenna with an integrated balun is shown in Figure 4. The total dimension of this structure is 75 × 58 mm^2. Simulated and measured reflection coefficients are compared in Figure 5. The results show a good agreement between simulations and measurements.

(a) (b)

Figure 4. Photographs of the realized antenna: (a) Top view and (b) Bottom view.

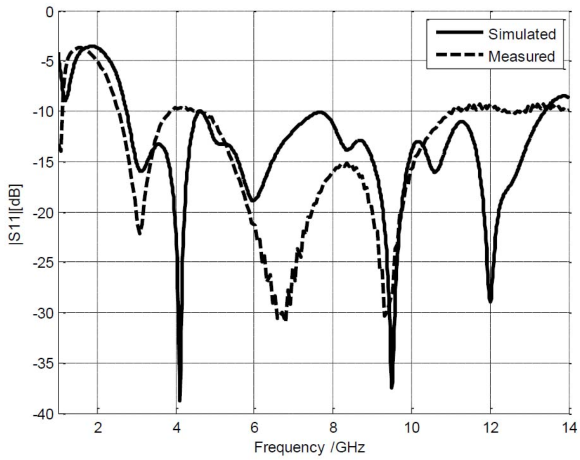


Figure 5. Simulated and measured reflection coefficients of the designed antenna.

The measured relative bandwidth is about 138.6 % (2.54–14 GHz). This is a considerable bandwidth for a compact (2 λ_c×1.56 λ_c at the frequency 8.3 GHz) single-layer antenna.

Figure 6 shows the simulated realized gain as a function of frequency. This gain varies between 2.47 dBi and 5.15 dBi where the antenna is well matched.

Figure 7 shows the radiations patterns of the designed antenna with its balun at different frequencies (2.74, 3, 4, 5, 7, 9, 11 and 13.38 GHz).

At the low frequencies (from 2.74 to 5 GHz), a quasi-omnidirectional radiation patterns are obtained, this is primarily due to the high current concentration on the balun and the edges of the bow-tie as shown in Figure 8.a and Figure 8.b. However, for frequencies above 7 GHz, the currents are more spread out over the structure leading to the degradation of the radiation patterns as shown in Figure 8.c and Figure 8.d.

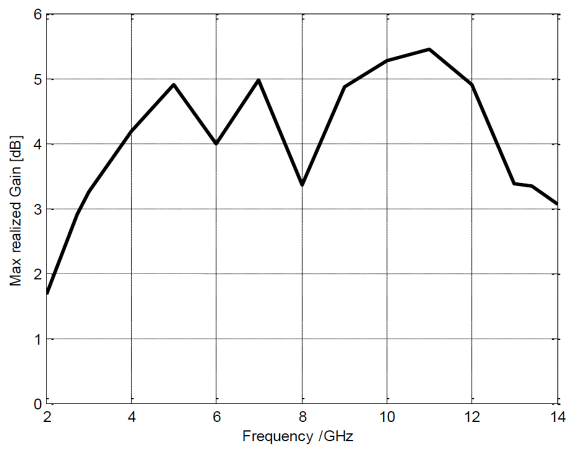


Figure 6. Simulated maximum realized gain versus frequency.

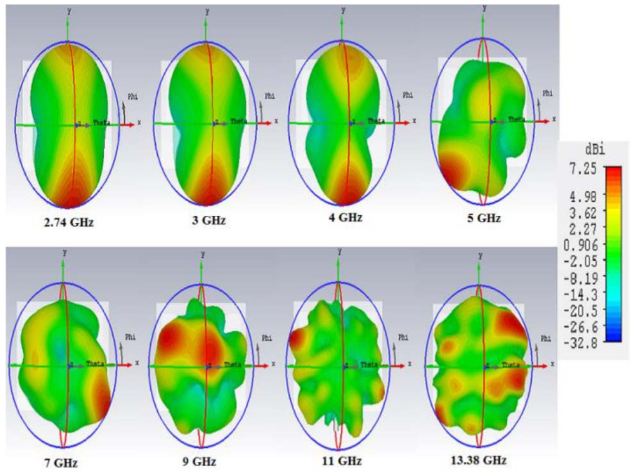


Figure 7. Radiation patterns of the antenna at: 2.74, 3, 4, 5, 7, 9, 11 and 13.38 GHz.

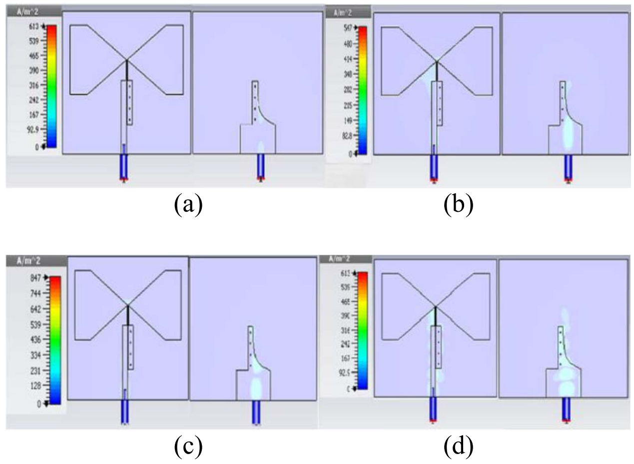


Figure 8. Surface current density on the two faces of the antenna at: (a) 2.74, (b) 5, (c) 7 and (d) 13.38 GHz.

4 Conclusion

In this paper a compact wideband antenna with an integrated balun has been designed and fabricated. Besides, its low dimensions (2λ_c×1.56 λ_c), this structure is very simple and low cost. This antenna operates over a very wide band, i.e. from 2.54 to 14 GHz. Its radiation patterns are quasi-omnidirectional and stable up to 7 GHz. The simulation results show good agreement with the experiments. Finally, a work is underway to design an artificial magnetic conductor (AMC) reflector for the antenna. The aim is to provide a better stable radiation patterns and allow its integration on an airplane.

5 References

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