Modified Printed Bow-Tie Antenna For C And X Bands Wideband Phased Array Systems

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This paper presents a modified printed bow-tie antenna for wideband phased array systems. The operating band of the proposed antenna simultaneously covers the operations in the C and X-bands from 5.5 to 12.5 GHz. The antenna provides end fire radiation patterns, which makes it suitable for integration in single and dual polarized phased array systems.

Introduction

Printed microstrip antennas are widely used in wireless communication and phased array applications. They exhibit a low profile, small size, light weight, low cost, high efficiency, and ease of fabrication and installation. Furthermore, they are readily adaptable to hybrid and monolithic microwave integrated circuits' fabrication techniques at RF and microwave frequencies [1].

Communication and phased array systems that operate in the C and X-bands are normally designed using separate antennas for each band. Since it is becoming more and more important to use such systems in one setting, it is desirable to design a single antenna that operates in both frequency bands. This, in turn, requires a wideband antenna that covers the two bands. In addition, many applications require end fire patterns, which can be produced by different types of antenna elements. Among the most widely used printed antennas in phased array systems are the quasi-Yagi antenna [2-4], dipole antenna [5-9], and printed bow-tie antenna [9-12]. The quasi-Yagi provides up to 48% bandwidth [2-4]. The microstrip-fed dipole provides 2:1 VSWR of 19%, 56%, and 40% impedance bandwidth in [5], [6] and [7], respectively, and 1.5:1 VSWR of 30% in [8]. The microstrip fed modified dipole (bow-tie) antennas presented in [10-11] provide up to 50% bandwidth. Recently, the authors showed that replacing the dipole and the director of the quasi-Yagi antenna with a bow-tie for the X-band operations improves the bandwidth (60%), size, and radiation characteristics of the antenna [12]. Further research by the authors resulted in a novel coplanar waveguide fed slot and microstrip fed printed antennas, which are called slot and printed Lotus antennas [13]. The printed Lotus provides 57% bandwidth relative to –15 dB, and 60% relative to –10 dB. The presented antennas, however, cannot simultaneously cover the C and X operating bands, which is the objective of this paper. This paper presents a modified printed bow-tie antenna that exhibits a wide bandwidth (BW). The return loss, VSWR and far field radiation characteristics of this antenna are presented. The simulation and analysis for the presented antennas are

0-7803-8883-6/05/$20.00 ©2005 IEEE

performed using the commercial computer software package, Ansoft HFSS, which is based on the finite element method. Measurements of return loss, VSWR and radiation patterns are also conducted for verification of these new antenna designs.

Antenna Geometry

The proposed antenna is printed on a Rogers RT/Duroid 6010/6010 LM substrate of a dielectric constant of 10.2, a conductor loss (tan δ) of 0.0023 and a thickness of 50 mil (1.27 mm). The geometry, parameters, and top and bottom views for a prototype of the proposed antenna are shown in Fig. 1. The antenna consists of two identical printed bows, one on the top and one on the bottom of the substrate material. The top and bottom bows are connected to the microstrip feedline and the ground plane through a stub and mitered transition to match the bow-tie with the 50 Ω feedline, as illustrated in Fig. 1. The antenna dimensional parameters, shown in Fig. 1, Wf, W1, W2, W3, W4, W5, Lf, L1, L3, L3. L4, L5, L6 and L7 are 1.2, 1.52, 0.45, 0.62, 2, 2.49, 10, 5.34, 0.45, 0.68, 0.24, 2.61, 5.56, and 9.68 mm, respectively. The substrate size (width×length) is (30×29) mm^2.

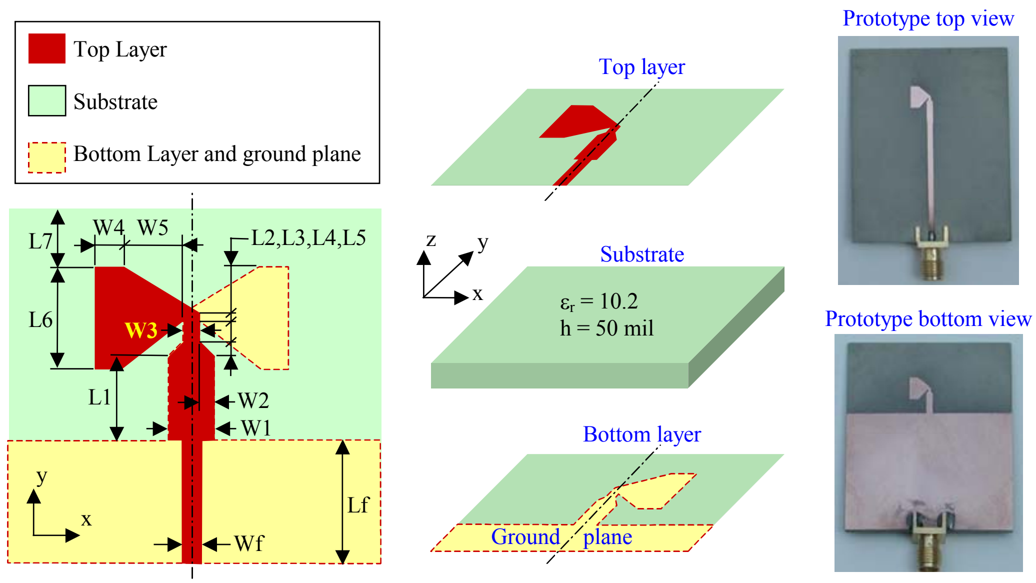

Fig. 1. Antenna geometry, parameters and prototype.

Antenna Characteristics

The VSWR is computed using Ansoft HFSS and measured using a 8510 vector network analyzer. A comparison between measurements and simulation is shown in Fig. 2. The antenna operates over a wide range that extends from 5.3 GHz to more than 14.2 GHz, with an impedance bandwidth of approximately 91%. The measured and computed radiation patterns at the operating band center frequency, 9 GHz, are shown in Fig. 3. A good agreement is noticed, which further verifies the simulation results using Ansoft HFSS.

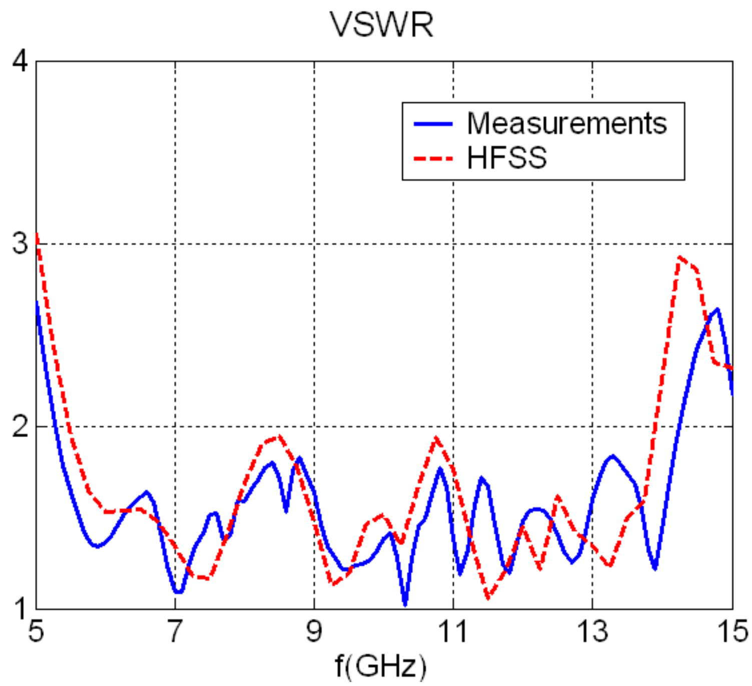

Fig. 2. The measured and computed VSWR for the modified bow-tie antenna.

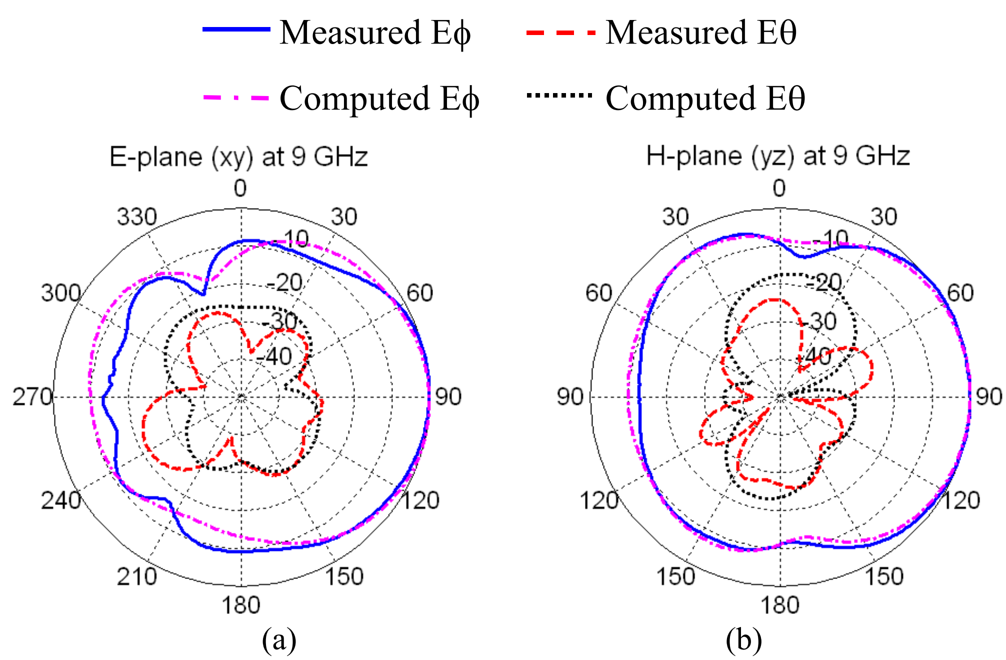

Fig. 3. Comparison between the measured and computed radiation patterns in the (a) E-plane and (b) H-plane, for the modified bow-tie antenna at 9 GHz.

Conclusion

A wideband modified printed bow-tie antenna is designed for C and X-band operations. The modified bow-tie antenna provides 91% impedance bandwidth that covers the entire C and X bands and part of the Ku band. The antenna provides wide beamwidth, low cross polarization level, and high front-to-back ratio. The antenna is a good candidate for wideband phased array systems with single linear, dual linear or circular polarization.

References:

1. L. G. Maloratsky, "Reviewing the basics of microstrip lines," *Microwave & RF.* pp. 79-88, March 2000.
2. W. Deal, N. Kaneda, J. Sor, Y. Qian, and T. Itoh, "A new quasi-Yagi antenna for planar active antenna arrays," *IEEE Trans. Microwave Theory and Tech.* vol. 48, no. 6, pp. 910-918, June 2000.
3. K. M. K. H. Leong, Y. Qian, and T. Itoh, "Surface wave enhanced broadband planar antenna for wireless applications," *IEEE Microwave Wireless Comp. Lett.,* vol. 11, no. 6, pp. 62-64, Feb. 2001.
4. N. Kaneda, W. Deal, Y. Qian, R. Waterhouse, and T. Itoh, "A broad-band planar quasi-Yagi antenna," *IEEE Trans. Antennas and Propagat.* vol. 50, no. 8, pp. 1158-1160, Aug. 2002.
5. G-Y Chen and J-S Sun, "A printed dipole antenna with microstrip tapered balun," *Microwave Opt. Tech. Lett.,* vol. 40, no. 4, pp. 344-346, Feb. 2004.
6. G. A. Evtioushkine, J. W. Kim and K. S. Han, "Very wideband printed dipole antenna array," *Electron Lett.,* vol. 34, no. 24, pp. 2292-2293, 1998.
7. G. Zheng, A. A. Kishk, A. B. Yakovlev, and A. W. Glisson," Simplified feed for a modified printed Yagi antenna," *Electronics Letters*, Volume: 40, no. 8 , pp. 464 – 465, 15 April 2004.
8. F. Tefiku, and C. A. Grimes, "Design of broad-band and dual-band antennas comprised of series-fed printed-strip dipole pairs," *IEEE Trans. Antennas and Propagat.* vol. 48, no. 6, pp. 895-900, June 2000.
9. S. Deay, C. K. Aanandan, P. Mohanan, and K. G. Nair, "Analysis of cavity backed printed dipoles," *Electron Lett.,* vol. 30, no. 30, pp. 173-174, 1994.
10. Y-D Lin, and S-N Tsai, "Analysis and design of broadband-coupled striplines-fed bow-tie antennas," *IEEE Trans. Antennas and Propagat.* vol. 46, no. 3, pp. 459-560, March 1998.
11. G. Zheng, A. A. Kishk, A. B. Yakovlev, and A. W. Glisson, "A broad band printed bow-tie antenna with a simplified feed," Antennas and Propagation Society International Symposium, Vol. IV, pp. 4024-4027, Monterey, CA, June 2004.
12. A. A. Eldek, A. Z. Elsherbeni, and C. E. Smith, "Characteristics of microstrip fed printed bow-tie antenna," *Microwave Opt. Tech. Lett.,* vol. 43, no. 2, pp. 123-126, Oct. 2004.
13. A. Z. Elsherbeni, A. A. Eldek, and C. E. Smith, "Wideband slot and printed antennas," Book chapter in *Encyclopedia of RF and Microwave Engineering*, Editor: K. Change, John Wiley, Jan. 2005.