WIDEBAND MICROSTRIP-FED PRINTED BOW-TIE ANTENNA FOR PHASEDARRAY SYSTEMS

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ABSTRACT: *A micro strip-fed printed bow-tie antenna is presented inorder to achieve wide bandwidth, high gain, and size reduction. A comparisonbetween the bow-tie and the quasi-Yagi (dipole and director)antennas shows that the bow-tie antenna has a wider bandwidth, highergain, lower front-to-back ratio, lower cross-polarization level, andsmaller size. Two-element arrays are designed and their characteristics are compared. The bow-tie antenna yields lower coupling for the same distance between elements.*

Key words: *wideband antennas; printed bow-tie antenna; printed quasi-Yagi antenna*

1. INTRODUCTION

Printed microstrip antennas are widely used in phased-array applicationsbecause they exhibit a very low profile, small size, lightweight, low cost, high efficiency and easy methods of fabricationand installation. Among the most widely used printed antennas inphased-array systems are printed dipoles and quasi-Yagi antennasfed by coplanar strip line (CPS), which are usually used to yieldend-fire radiation patterns. In order to feed this antenna, someresearchers suggest microstrip-to-CPS transition that includes a180° phase shifter [1]. Other researchers feed the dipole with twomicrostrip lines where the upper is an extension of the microstripfeed line and lower is connected to the ground plane directly orthrough a tapered microstrip [2, 3]. However, the latter methodssuffer from low radiation efficiency (88% in [2]) and low bandwidth(37% in [2] and 19% in [3]). Moreover, unbalanced radiationpatterns are noticed in [2] and omnidirectional patterns areobtained in [3]. Other researchers use coplanar waveguide (CPW) -to-CPS transitions to feed printed dipole and bow-tie antennas [4].However, these two antennas are designed for 100_, not 50_,characteristic impedance, in addition to having an omnidirectionalpattern.An attractive design that uses the transition in [1] is presentedin [5, 6] and exhibits wide bandwidth and good radiation charac-teristics.

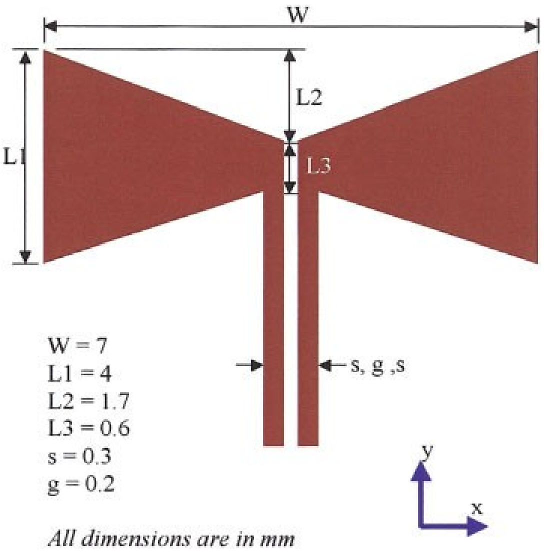

Figure 1 Geometry and dimensions of the printed bow-tie antenna

The antenna consists of a half-wavelength dipole and anapproximately quarter-wavelength rectangular director in order toincrease the gain and improve the front-to-back ratio. In this paper,the printed dipole and the director of [5, 6] are replaced by aprinted bow-tie, which results in an improvement in bandwidth andgain. That is because printed bow-tie antennas are planar-typevariations of the biconical antenna that has wideband characteristics.Moreover, the radiating area of the bow-tie is larger than thatof the dipole; therefore, gain improvement is expected. The simulationand analysis for this new antenna are performed using thecommercial software package an soft HFSS, which is based on thefinite-element method. The measurements of the return loss andradiation pattern are also conducted.

2. SINGLE ELEMENT

The proposed antenna element is printed on a Rogers RT/Duroid6010/6010 LM substrate with a dielectric constant of 10.2, athickness of 25 mil, and a conductor loss (tan _) of 0.0023. Themicrostrip-to-CPS transition is almost the same as that in [1]. Thebow-tie geometry and dimensions are shown in Figure 1. Thequasi-Yagi antenna [5, 6] is simulated in order to compare it withthe new bow-tie design on the same material-type substrate andground-plane dimensions.The simulated and measured return losses of the bow-tie antenna,compared to those of the quasi-Yagi, are shown in Figures2 and 3, respectively. According to the HFSS simulation results,the bow-tie shows about 13% improvements in the bandwidth,where it operates from 6.8 to 11.9 GHz with a bandwidth of54.5%, while the quasi-Yagi operates from 7.9 to 12.1 GHz, witha bandwidth of 41.6%. In the measurements, the bow-tie showsabout 19.6% improvements in the bandwidth, where it operatesfrom 6.7 to 12.45 GHz with a bandwidth of 60.1%, while thequasi-Yagi operates from 8.2 to 12.5 GHz, with a bandwidth of41.5%.The copolarized (*E*_) and cross-polarized (*E*_) far-field radiationpatterns for the two antennas are computed at 10 GHz. Figure4 shows the radiation patterns of the bow-tie antennas, while
Figure 5 shows the radiation pattern of the quasi-Yagi antenna.

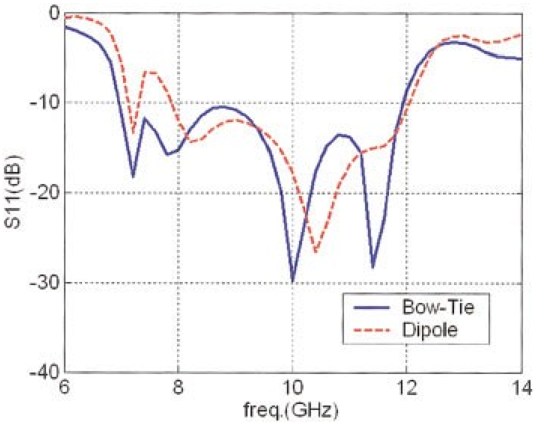

Figure 2 Computed return losses of the bow-tie and the quasi-Yagi Antennas.

The simulation results show that at least 1.3-dB improvement inthe gain has been obtained when using the bow-tie. The maximumgain for the bow-tie is around 5.7 dB, while it is around 4.4 dB forthe quasi-Yagi. The 3-dB beam width in the E-plane (*x*–*y*) isalmost the same for both antennas: 106° and 108° for the bow-tieand the quasi-Yagi antennas, respectively. However, in the Hplane(y–*z*), the quasi-Yagi shows much wider beam width: 108°for the bow-tie and 153° for the quasi-Yagi antenna. The H-planepattern becomes more focused for the bow-tie, which results inenhanced gain and reduced beam width. As shown in Figures 4 and5, the computed front-to-back ratio is improved by 1.5 dB, whereit is around 14.1 dB for the bow-tie and 12.6 dB for the quasi-Yagi.The cross-polarization level in the E-plane is _22.5 dB for thebow-tie, while it is _20 dB for the quasi-Yagi, and for the H-planeit equals to _23 dB for the bow-tie and _24 dB for the quasi-Yagi,considering only the angles defining by the 3-dB beam width.

3. TWO-ELEMENT ARRAY

Two elements of the bow-tie and quasi-Yagi antennas are simulatedand fabricated in order to compare the coupling (*S*21 in dB)between the array elements. The distance between elements isfixed to 15 mm, which is the free-space half-wavelength at 10

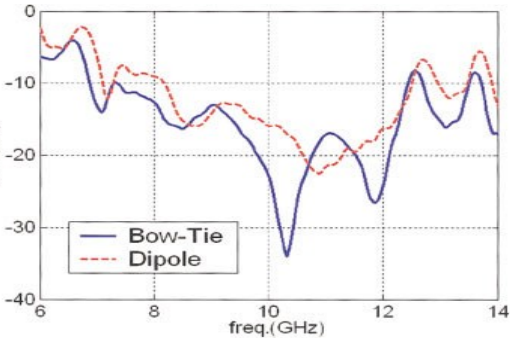

Figure 3 Measured return losses of the bow-tie and the quasi-Yagi antennas.

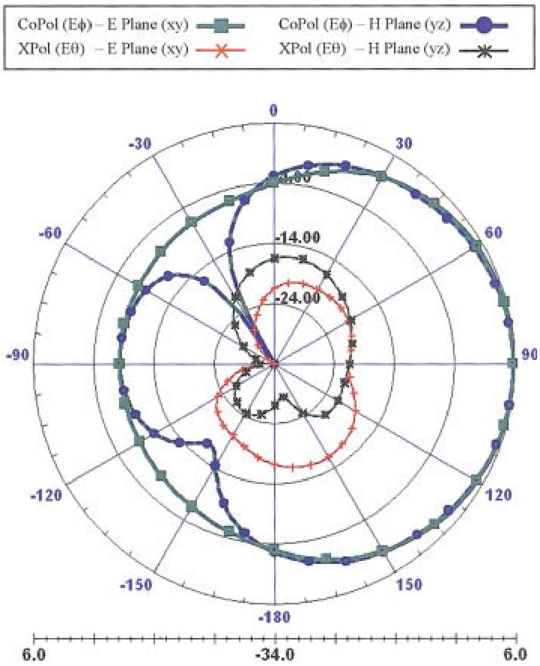

Figure 4 Computed far-field radiation pattern for the bow-tie antenna at 10 GHz.

GHz. Photographs of the two-element arrays are shown in Figure6. Figure 7 shows a comparison of the measured coupling betweenthe bow-tie and quasi-Yagi elements. The coupling is less betweenthe bow-tie elements, as shown in Figure 7, where the couplingimproves by an average value of around 4 dB It is worth mentioning

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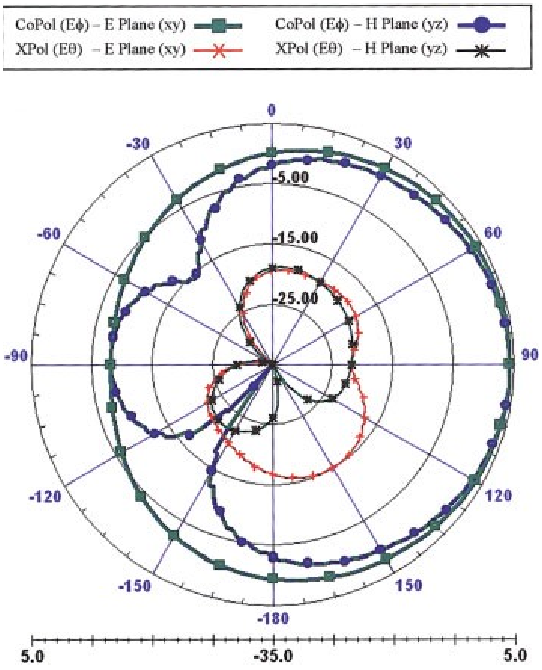

Figure 5 Computed far-field radiation pattern for the quasi-Yagi antennaat 10 GHz.

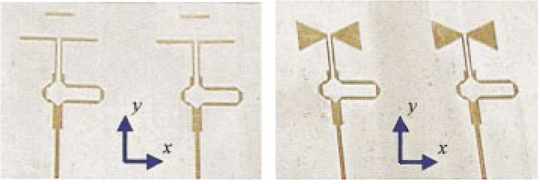

Figure 6 Photograph of a two-element array of the bow-tie and quasi- Yagi antennas.

That this improved coupling is also associated with antenna-size reduction, as the bow-tie edge-to-edge dimension is 7 mmwhile that of the quasi-Yagi is 8.7 mm, which gives a 24%reduction.The co- and cross-polarized far-field radiation patterns fortwo-element arrays of the bow-tie and quasi-Yagi antennas arecomputed at 10 GHz. Figure 8 shows the radiation patterns of thetwo-element array of the bow-tie antenna, while Figure 9 showsthe radiation pattern of the two-element array of the quasi-Yagiantenna. According to these results, approximately 2-dB improvementin the gain has been obtained with the bow-tie array. Themaximum gain for the bow-tie array is around 9.3 dB, while it isaround 7.3 dB for the quasi-Yagi array. The 3-dB beam width ofthe co-polarized pattern in the E-plane is 46° and 48° for thebow-tie and the quasi-Yagi, respectively. The beam width in theH-plane for the quasi-Yagi is 120°, while that for the bow-tie it is90°; this are different from that of the one-element configurationdue to the coupling between the elements. The front-to-back ratiois also found to be improved, as it is 20.7 dB for the bow-tieantenna array and 11.7 dB for the quasi-Yagi antenna array. Thecross-polarization level is also enhanced using bow-tie elements.In the E-plane, the cross polarization level is -29 dB for thebow-tie while it is -26 dB for the quasi-Yagi, and for the H-planeit equals to -26 dB for the bow-tie and -24 dB for the quasi-Yagi.

4. CONCLUSION

In this paper, a printed bow-tie antenna has been designed toreplace the dipole and the director in the printed quasi-Yagiantenna configuration. This new bow-tie design provides widerbandwidth, smaller size, higher gain, and smaller cross polarizationthan the quasi-Yagi, and shows an improvement in the front-to-backratios for one- and two-element arrays. The design oflarger arrays based on this type of antenna is therefore moreappropriate for phased-array systems.

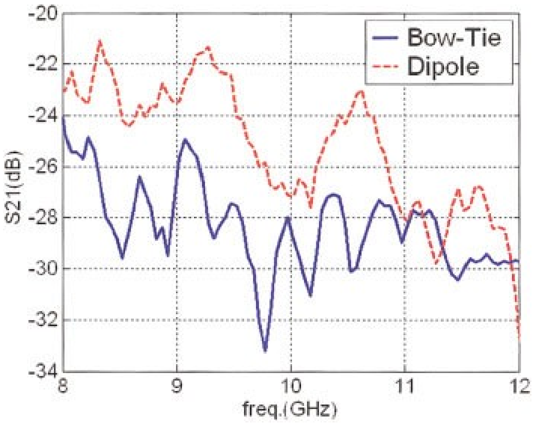

Figure 7 Comparison of the measured coupling for two-element arraysof the bow-tie and quasi-Yagi antennas.

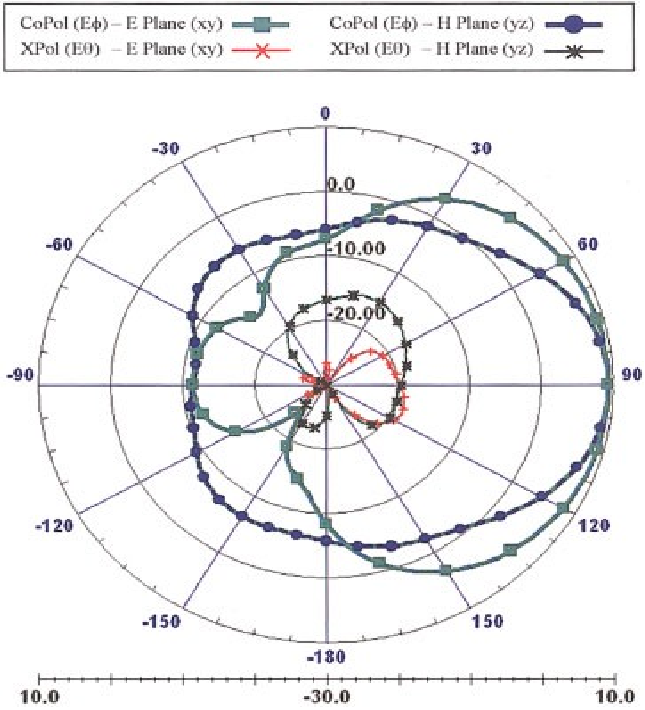

Figure 8 Computed far-field radiation pattern for the two-element arrayof the bow-tie antenna at 10 GHz.

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