A Broadband Printed Dipole and a Printed Array for Base Station Applications

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Abstract: A printed dipole with an adjustable integrated balun is presented, featuring a broadband performance and flexibility for the matching to different impedance values. As a benchmarking topology, an eight-element linear antenna array is designed and built for base stations used in broadband wireless communications.

I. INTRODUCTION

A dipole antenna usually needs a balanced feed for practical operation. For a printed dipole, the balun can be integrated with the dipole. The printed dipole with the integrated balun features a broadband performance [1] and has found applications in wireless communications [2] and antenna arrays [3]. However, the printed dipole with an integrated balun whose feed point is fixed at its top has to be designed at the dipole's resonant resistance of ~80 Ω, hence requiring a 63-Ω quarter wavelength transformer to match with 50-Ω test equipment [1]. In this paper, we will demonstrate that the printed dipole with integrated balun can be matched to a 50-Ω feed simply through an adjustment of the feed point of the integrated balun. Because the position of the feed point is an adjustable parameter, the adjusted integrated balun may match to different impedance values, which is useful for antenna arrays because the mutual coupling between array elements may change the input impedance of each antenna element. An eight-element linear antenna array is designed for base station wireless communications as a benchmarking topology.

II. ANTENNA ELEMENT

Consider a printed dipole with an adjusted integrated balun as illustrated in Fig. 1, that has been fabricated on a substrate of RO4230, a Rogers Corporation's high frequency circuit material with a dielectric constant of 3.0 and a loss tangent of 0.002. The thickness of the substrate is 1.0 mm. The integrated balun consists of a micrstrip line and a slot line which are printed on the front side and the back side of the substrate, respectively; the dipole is printed on the backside as well. This structure is designed for wireless base station applications at the 2-GHz band, which covers the frequency range from 1.7 GHz to 2.5 GHz. The printed dipole with adjusted integrated balun is mounted above a ground plane with dimensions of 200 mm × 160 mm and fed by an SMA connector underneath the ground plane. To keep the antenna profile as low as possible, the slot line is short-circuited directly by the ground plane. As a result, the height of the antenna (from the center of the printed dipole to the ground) is roughly a quarter wavelength of the slotline.

The simulation result using *MicroStripes* for return loss of the printed dipole with adjusted integrated balun was crosschecked using *HFSS* and is compared with experimental result in Fig. 2. Good agreement is observed and the bandwidth for RL≥10 dB is about 41%, covering the frequency band 1.7-2.5 GHz. To demonstrate the advantage of the printed dipole with adjusted integrated balun, we have also plotted the return loss in the figure for a T-dipole [4] which has the same overall dimensions (76 mm

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× 42 mm). It is seen that the bandwidth of the T-dipole is ~30%, much less than the bandwidth (~40%) of the printed dipole with adjusted integrated balun.

The measured gain varies from 8 to 6 dBi, about 2 dB higher than the printed Yagi-Uda dipole [5]. The radiation patterns measured and simulated at 2.1 GHz are compared in Fig. 3 and good agreement is observed for the co-polarized component. The measured level of the cross-polarized component is less than 20 dB, comparable to the printed Yagi-Uda dipole. There is no significant change for the radiation patterns in the frequency range 1.7-2.5 GHz.

III. ANTENNA ARRAY

To demonstrate the potential applications of the printed dipole with adjusted integrated balun, we have designed an eight-element linear array for wireless base station communications. The antenna elements were slightly modified to take into account the mutual coupling among these elements. It was found that the mutual coupling tends to shift down the operating frequency of the printed dipole from 1.7-2.5 GHz to 1.5-2.3 GHz and the impedance matching became worse at the lower frequency. The operating frequency shift down is reasonable because the neighboring elements of an antenna tend to effectively increase the size of the antenna. We scaled down the length and the overall height of the printed dipole from 76 mm to 70 mm for the length and 42 mm to 40 mm for the overall height. The position of the feed point was adjusted from H_m=15 mm to H_m =14 mm and the length of the open stub was shortened from L_m=15.5 mm to L_m=12.5 mm. The antenna array is fed by a corporate feed network. The 50-Ω microstrip lines from neighboring elements are joined at a T-junction and transformed through a 35-Ω quarter-wave transformer back to a single 50-Ω line. The antenna array and the feed network were fabricated on the same RO4230 board and cut out afterward. The antenna array is mounted on the center of a reflector plate with dimensions of 900 mm × 160 mm while the feed network is placed on the plate and fed by an SMA connector from the backside of the reflector. The reflector plate has a pair of side walls to reduce the backside radiation. A prototype of the assembled antenna array is displayed in Fig. 4. The measured and simulated results for return loss of the antenna array are presented in Fig. 5 and shows reasonable agreement. The measured bandwidth is about 40% and covers the design frequency 1.7-2.5 GHz. The gain of the array has an almost constant value of 16 dBi over the design frequency, useful for broadband wireless applications. The constant gain is due to the fact that the array factor increases with frequency while the gain of the antenna element decreases as frequency increases. The radiation patterns simulated and measured at 2.1 GHz are shown in Fig. 6 and good agreement is obtained. The cross-polarized component is less than 20 dB. The sidelobe level is less than 14 dB and the backside level is less than 35 dB due to the effect of the side walls. The antenna array should be found applications in base stations for wireless communications with the requirements for almost frequency-independent gain and broadband matching (~40%).

IV. CONCLUSION

A printed dipole with an adjusted integrated balun is developed. It is found that this topology can directly match to a 50-Ω feed and has a bandwidth of more than 40%. The broadband impedance matching can be achieved simply by adjusting the position of the feed point of the integrated balun. With the proposed adjustable integrated balun, an eight-element linear antenna array has been developed, which has an almost constant gain of ~16 dBi over the frequency range from 1.7 to 2.5 GHz and thus may find applications in base stations for 2G, 3G, and 4G wireless communications

Acknowledgement

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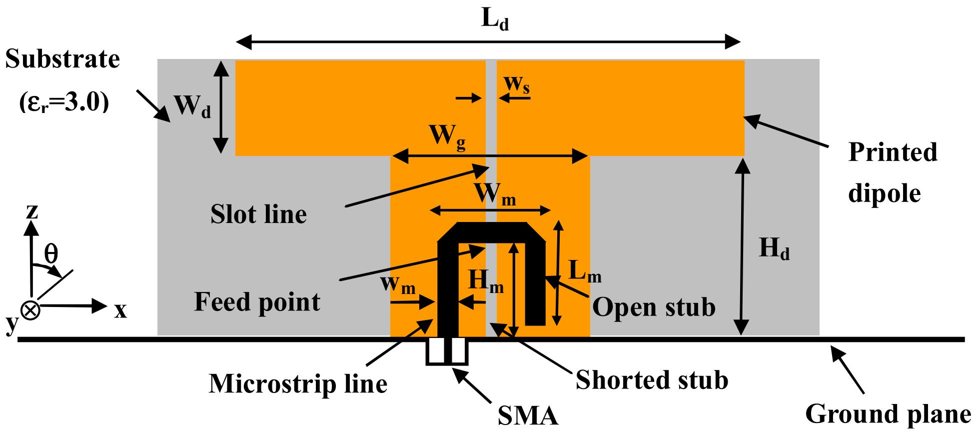

Fig. 1. Geometry of a printed dipole with adjusted integrated balun. (Geometrical parameters: L_d=76 mm, W_m=16 mm, W_d=15 mm, H_m=15 mm, H_d=27 mm, w_s=1.0 mm, W_g=30 mm, w_m=2.5 mm, L_m=5.5 mm, t=1.0 mm)

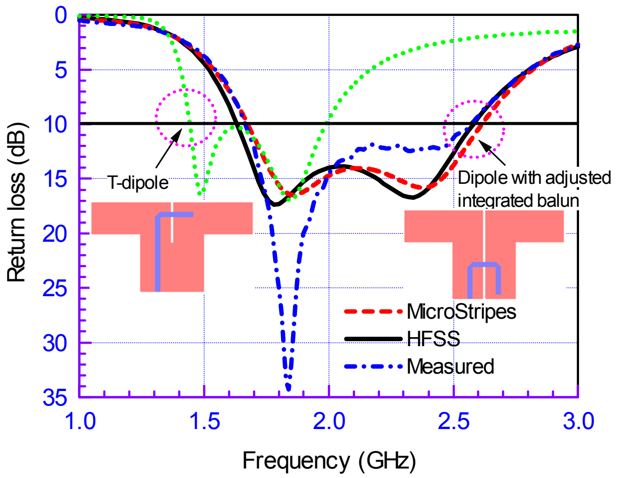

Fig. 2. Simulated and measured results for return loss of the printed dipole with adjusted integrated balun and comparison with a T-dipole.

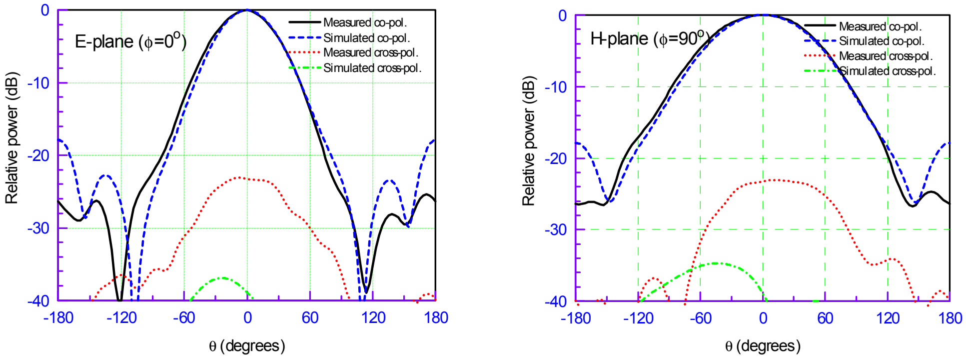

Fig. 3. Radiation patterns of the printed dipole with adjusted integrated balun simulated and measured at 2.1 GHz.

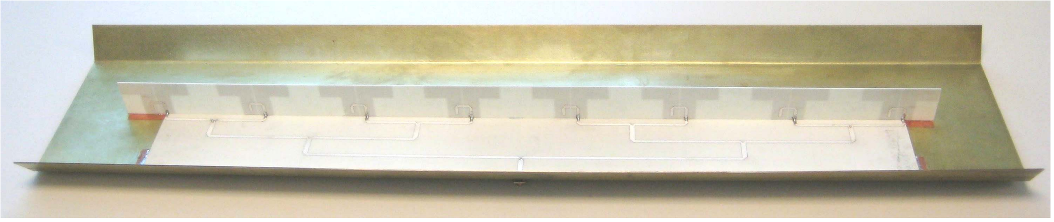

Fig. 4. Eight-element linear array of the printed dipole with adjusted integrated balun.

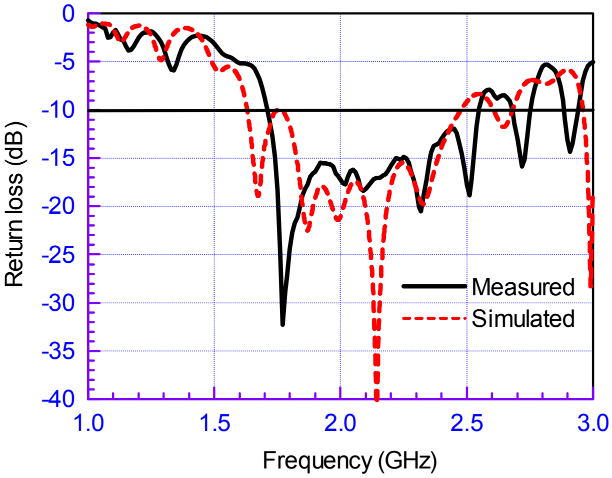

Fig. 5. Simulated and measured results for return loss of the eight-element linear array.

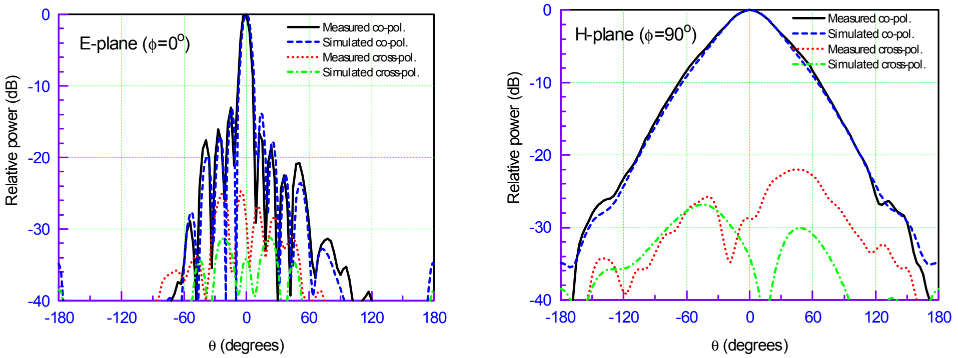

Fig. 6. Radiation patterns of the eight-element linear array simulated and measured at 2.1 GHz.