Broadband Series-Fed Printed Dipole Arrays in Uniplanar Configuration

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Abstract

A novel printed antenna consisting of a series-fed dipole array and a planar-type conductor-backed coplanar waveguide-to-coplanar stripline (CBCPW-to-CPS) transition is investigated. On the basis of careful design and optimization, this antenna features a very broad bandwidth. Measured results show that the prototype antenna possesses an operating bandwidth of 100% (for the 10 dB return loss criterion), an end-fire radiation pattern with a front-to-back ratio greater than 15 dB, and cross-polarization radiation less than –16 dB across the frequency band of interest. The proposed antenna array has the advantages of uniplanar configuration, allowing it to be readily integrated with other microwave devices.

1. INTRODUCTION

The popularity of wireless services and the increasing demand for high data rate transmission have urged the development of broadband printed antennas (BPAs). Conventional BPA structures, such as aperture-stacked patch antennas and log-periodic dipole antennas introduced in [1][2], require either multilayer substrates or twisted feed lines, which increase the antenna complexity and the fabrication cost as well.

In this paper, the series-fed printed dipole array with broad bandwidth is proposed. Specifically, the printed-dipole array fed by the CBCPW-to-CPS transition proposed by Mao et al in [3] is placed on one side of the substrate. By enhancing heat sinking and strengthening mechanical support, the utilization of metallization on the backside of CPW facilitates package construction for the feed network as presented by Simons et al in [4]. Moreover, this broadband uniplanar configuration without the need of layout alignment on both sides of the substrate makes the fabrication process easier compared to the double-sided printed-strip antennas proposed by Tefiku et al [5].

A prototype of the uniplanar series-fed printed-dipole antenna is demonstrated to achieve an extremely broad bandwidth (about 100% for the 10 dB return-loss criterion), which keeping an end-fire radiation pattern with front-to-back ratio (>15dB) and cross-polarization level (<-16dB)

2. ANTENNA DESIGN AND EXPERIMENTAL RESULTS

Fig. 1 shows the schematic drawing of the proposed antennas comprising of eight printed strip dipoles and the CBCPW-to-CPS transition. The dipoles with different lengths are printed on the same side of the dielectric substrate and are connected directly through a straight CPS. The transition consisting of tapered transmission line structures can transfer the balanced-CPS to the unbalanced-CBCPW that is suitable for conventional coaxial connector. The proposed printed-dipole array is fed to the terminals of the longer element by using a direct connection between the strip dipoles. This excitation method gives the phase progression for endfire radiation and achieves the broadband characteristics. The truncated ground plane serves not only as the return path for the feed CPW, but also as the reflector of the unwanted surface wave modes for the antenna configuration as presented by Kaneda et al [6].

A prototype of the proposed antenna is fabricated on a 1.6 mm-thick substrate (ε_r= 4.4 and tanδ= 0.022). After a few optimization processes using commercial software IE3D, the structural parameters of the antenna are as follows (all in millimeters): W_1=2.3, W_2=13.5, W_3=0.86, W_4=0.5, W_5=0.25,W_g=90, S_1=S_2=0.6, $l_1 = l_2$=8, l_g=46, l_{CPS}=15, L_1=126.25, d_1=6.5, P_1=13.5, L_2=98.7, d_2=7.33, P_2=31.2, L_3=84.25, d_3=6.34, P_3=27.675, L_4=72.05, d_4=5.48, P_4=23.94, L_5=61.27, d_5=4.75, P_5=20.7, L_6=52.38, d_6=4.15, P_6=17.92, L_7=42.38, d_7=3.55, P_7=15.5, L_8=33.85, d_8=3.08, and P_8=13.4.

Fig. 2 depicts the measured and IE3D simulated return losses of the antenna array that features an operating impedance bandwidth of 100% from 1.5 to 4 GHz for the 10 dB return-loss criterion. The measured E-plane (xy-plane) and H-plane (xz-plane) radiation patterns are demonstrated in Figs. 3 and 4, respectively. These patterns are end-fire in shape with a front-to-back ratio greater than 15 dB at 1.5, 2, and 2.5 GHz. The cross-polarization less than –16 dB at the same operating frequencies is not shown here for conciseness and will be presented in the conference. The radiation mechanism of the proposed antenna is that a gradually expanding periodic structure array radiates most effectively when the array dipoles are near resonance so that with frequency in the radiating region moves along the array. Hence, the radiation bandwidth from 1.5 to 2.5 GHz is restricted to the lengths of the longest and the shortest dipole elements of the antenna array. The large variation in the radiation characteristics is observed over the operating frequency range. To increase the radiation bandwidth, more printed dipoles with longer and shorter lengths have to be added as the array elements. The measured antenna gain is about 7.09-9.1 dB between 1.75 and 2.5 GHz as shown in Fig. 5.

3. CONCLUSIONS

A novel printed antenna consisting of a series-fed dipole array and a CBCPW-to-CPS balun for broadband and endfire operation has been proposed and investigated. The measured impedance bandwidth of almost 100% is achieved. The radiation characteristics of this antenna are also measured at selected frequencies, which represent the end-fire radiation pattern with a gain of about 7.09-9.1 dB. This proposed antenna with the advantages of broad bandwidth, low cost, and easy fabrication is applicable to the ultra wideband wireless communication system.

ACKNOWLEDGEMENT

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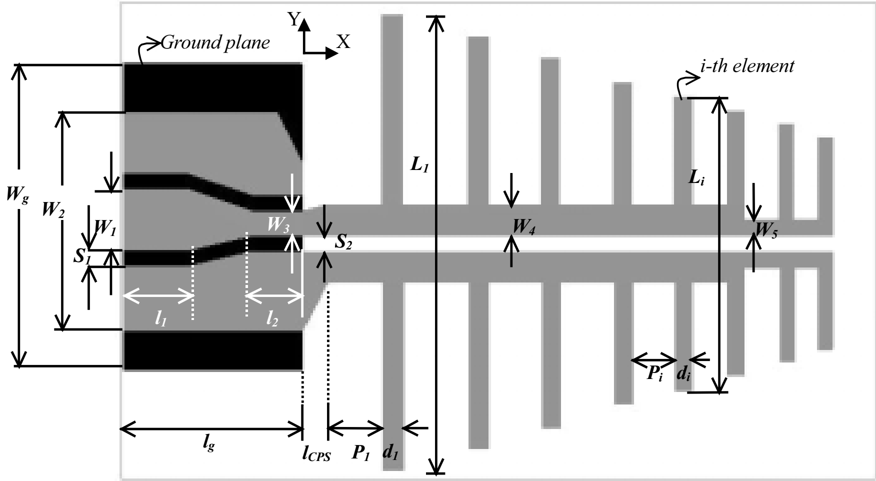

Fig 1. Schematic of the proposed series-fed printed dipole array with a CBCPW-to-CPS transition. Conductors on the top and bottom sides are depicted as shaded and black areas, respectively.

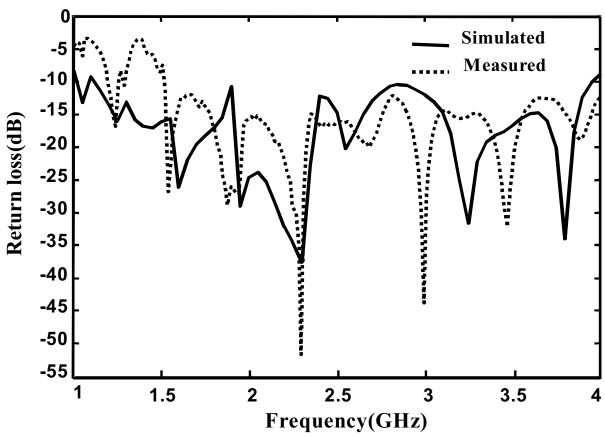

Fig 2. Measured and simulated return losses of the proposed antenna.

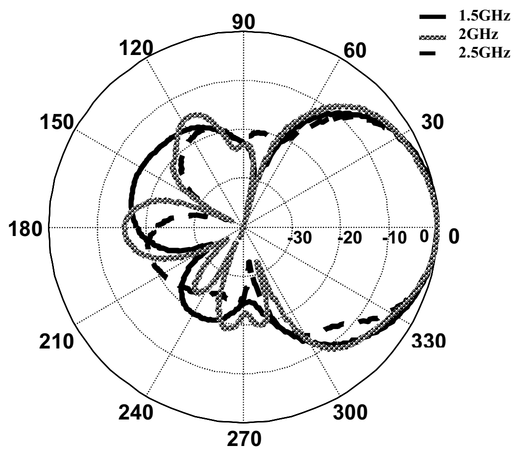

Fig 3. Measured the xy-plane co-polarized radiation pattern.

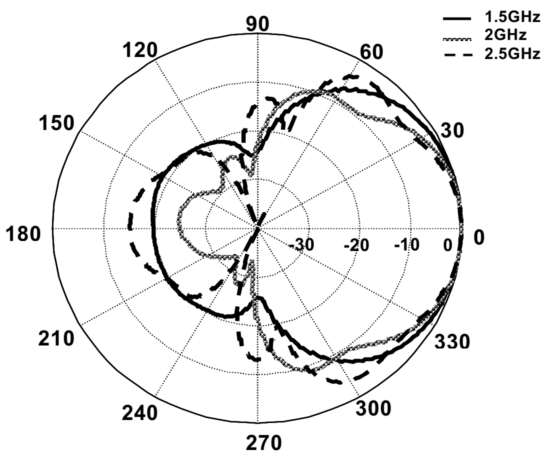

Fig 4. Measured the xz-plane co-polarized radiation pattern.

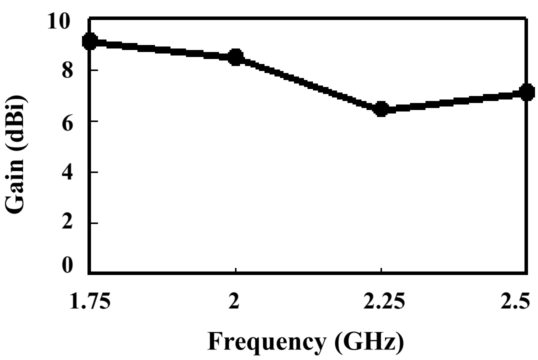

Fig 5. Measured antenna gain versus frequency.