A Cavity-Backed Broadband Circularly Polarized Slot/Strip Loop Antenna with a Simple Feeding Structure

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Abstract: A cavity-backed loop antenna with a simple feeding structure is proposed for broadband circularly polarized (CP) radiation. The proposed antenna configuration consists of a slot loop and a strip loop. The slot loop radiates a CP wave at a lower frequency while the strip loop produces CP radiation at a higher frequency. A combination of the two frequencies leads to a bandwidth enhancement. The slot/strip loop antenna is fed by a single straight microstrip line. It is demonstrated that the cavity-backed slot/strip loop antenna can achieve an axial ratio (≤3 dB) bandwidth of 20% with good impedance matching.

I. INTRODUCTION

Cavity-backed slot antennas have two major advantages over cavity-backed wire antennas, such as dipole, helix, and spiral [1]. First, a slot antenna can be flush mounted on a metal surface; therefore, it is suitable for applications in mobile communication and radar systems of high-speed vehicles or aircraft [2]. Second, slot antennas can be easily fed by a microstrip line which is fabricated on the same substrate with the slot and is placed between the cavity and the ground plane of the microstrip line, thus avoiding the undesirable radiation from the feeding network. This is particularly important for applications in antenna arrays. Many types of slot configurations have been developed for producing circularly polarized (CP) radiation, such as annual slot [3], dual-spiral slot [4], rectangular slot [5], and cloverleaf slot [6]. However, these slot antennas have a narrow axial ratio (AR) bandwidth (usually <5% for AR≤3 dB). Archimedean spirals offer a much wider bandwidth, but it is limited by the presence of the cavity. One way to remedy this limitation is to use absorbers inside the cavity or to terminate the spiral slot with tapered resistive loading [7], [8], thus reducing the power efficiency. Recently, a bandwidth-enhanced (~15% for AR≤3 dB) cavity-backed slot antenna has been presented in [9], but it requires a complicated feeding network. In this paper, we propose a broadband cavity-backed loop antenna with a simple feeding structure. The proposed antenna configuration consists of a slot loop and a strip loop. The slot loop radiates a CP wave at a lower frequency while the strip loop produces CP radiation at a higher frequency. A combination of the two frequencies leads to a bandwidth enhancement. The slot/strip loop is fed by a simple microstrip line which can achieve good impedance matching.

II. ANTENNA STRUCTURE

The configuration of a rectangular cavity-backed CP slot/strip loop antenna is shown in Fig. 1. The slot/strip loop can be considered as a combination of a slot loop and a strip loop, as illustrated in Fig. 2. The slot loop radiates a CP wave at a lower frequency while the strip loop produces CP radiation at a higher frequency. Note that the length of the slot loop is longer than that of the strip loop. A combination of the two frequencies leads to a bandwidth improvement. The slot/strip loop is fed by a microstrip feeding line which consists of three sections: an open stub, a coupling stub, and a 50-ohms microstrip line. By adjusting the length of the open stub and the width of the coupling stub, a good impedance matching can be achieved. The cavity-backed CP loop antenna was designed using *Micro-Stripes 6.5.* A prototype (see its photo in Fig. 3) was built for a C-band operation. Both of the slot/strip loop and the feeding line were printed on a 0.254-mm (10 mils) RT/duroid 5880 substrate (ε_r=2.2).

III. RESULTS

Fig. 4 shows the simulated AR results for the cavity-backed slot loop, strip loop, and the slot/strip loop. The slot loop has a minimum value (in dB) for AR at a lower frequency (about 5.8 GHz) while the strip loop produces a minimum AR at a higher frequency (about 6.8 GHz). Note that the bandwidths of these two loops are very narrow (<5% for AR≤3 dB). However, a combination of the slot loop and the strip loop, i.e., a slot/strip loop, results in a much wider bandwidth (about 20% for AR≤3 dB). The simulated results for AR and gain of the slot/strip loop are compared with measured results in Fig. 5, which confirms the bandwidth enhancement. The gain of the cavity-backed slot/strip loop antenna is around 9 dBi. The simulated and measured results for return loss (RL) are plotted in Fig. 6. The bandwidth for RL≤-10 dB is found to be about 22%. The radiation patterns measured at 5.7 GHz and 6.7 GH are compared with the simulated results in Fig. 7. Good agreement is observed for the co-polarization (i.e., the left-hand circular polarization, LHCP) over the main beam. The cross-polarization (i.e., the right-hand circular polarization, RHCP) is less than -15 dB.

IV. CONCLUSION

A cavity-backed slot/strip loop antenna is proposed for a broadband CP operation. The slot/strip loop is a combination of a slot loop and a strip loop. The slot loop radiates a CP wave at a lower frequency while the strip loop produces CP radiation at a higher frequency. A combination of the two frequencies leads to a bandwidth enhancement. The slot/strip loop can be fed by a simple microstrip line. It is confirmed that the slot/strip loop antenna can achieve a bandwidth of 20% for AR≤3 dB and RL≤-10 dB.

Acknowledgement

The authors wish to acknowledge the support of Georgia Electronic Design Center and the NSF Packaging Research Center.

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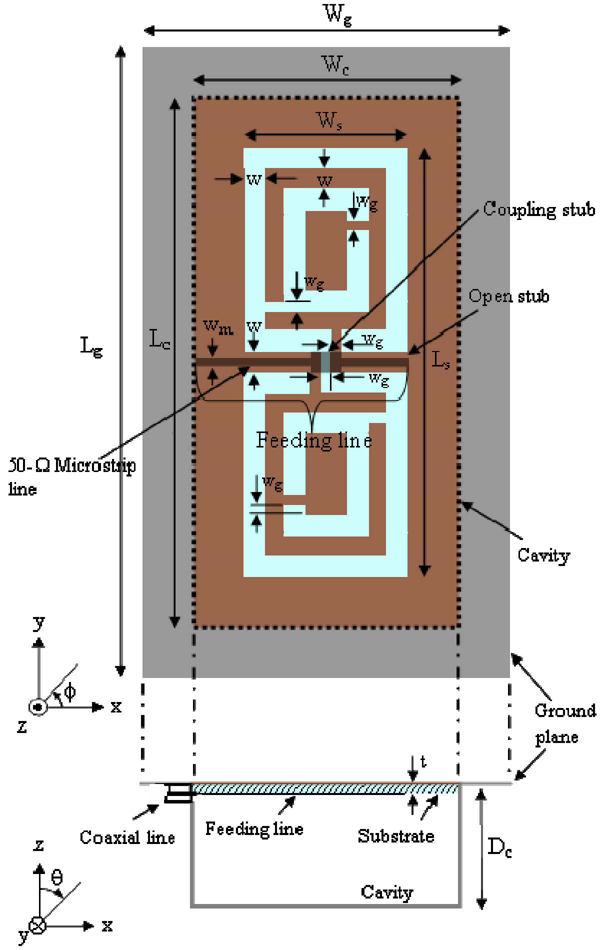


Fig. 1. Configuration of a cavity-backed broadband CP slot/strip loop antenna. (W_g=36 mm, L_g=62 mm, W_c=26 mm, L_c=52 mm, W_s=16 mm, L_s=42 mm, w=2 mm, w_g=1 mm, w_m=0.78 mm, D_c=12 mm, t=0.254 mm)

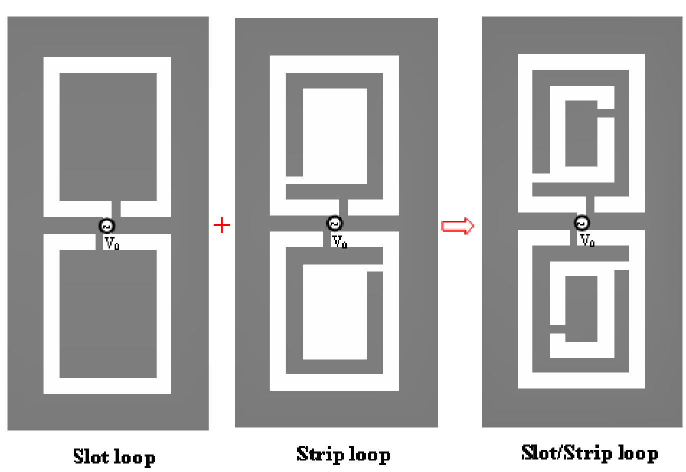


Fig. 2. Slot/strip loop as a combination of a slot loop and a strip.

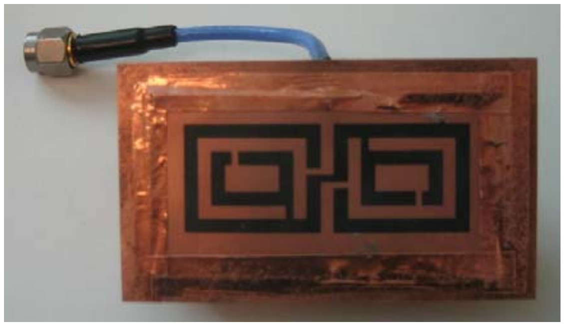


Fig. 3. A photo of the prototype of a cavity-backed slot/strip loop antenna.

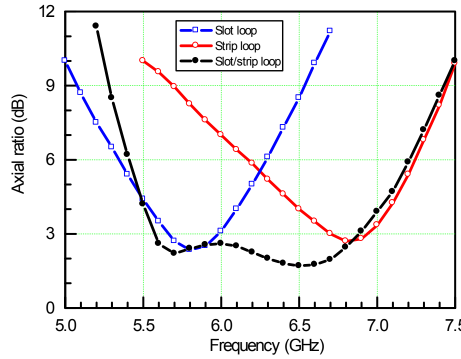


Fig. 4. Comparison of axial ration among a slot loop, a strip loop, and a slot/strip loop.

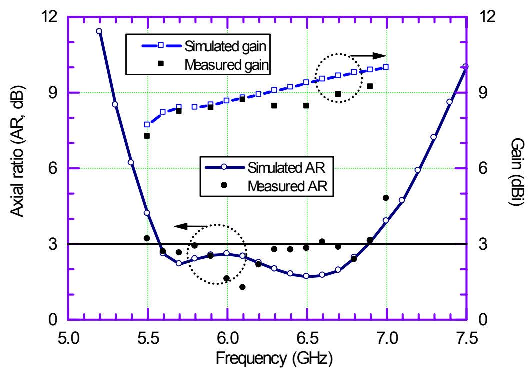


Fig. 5. Simulated and measured results for axial ration and gain of the slot/strip loop.

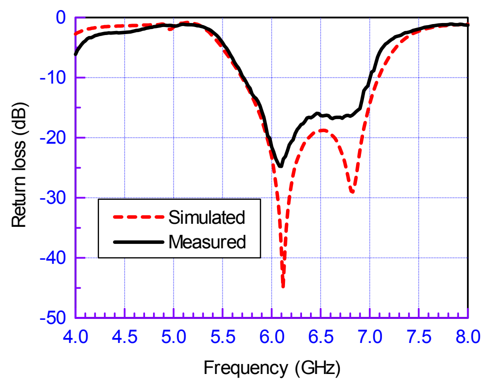
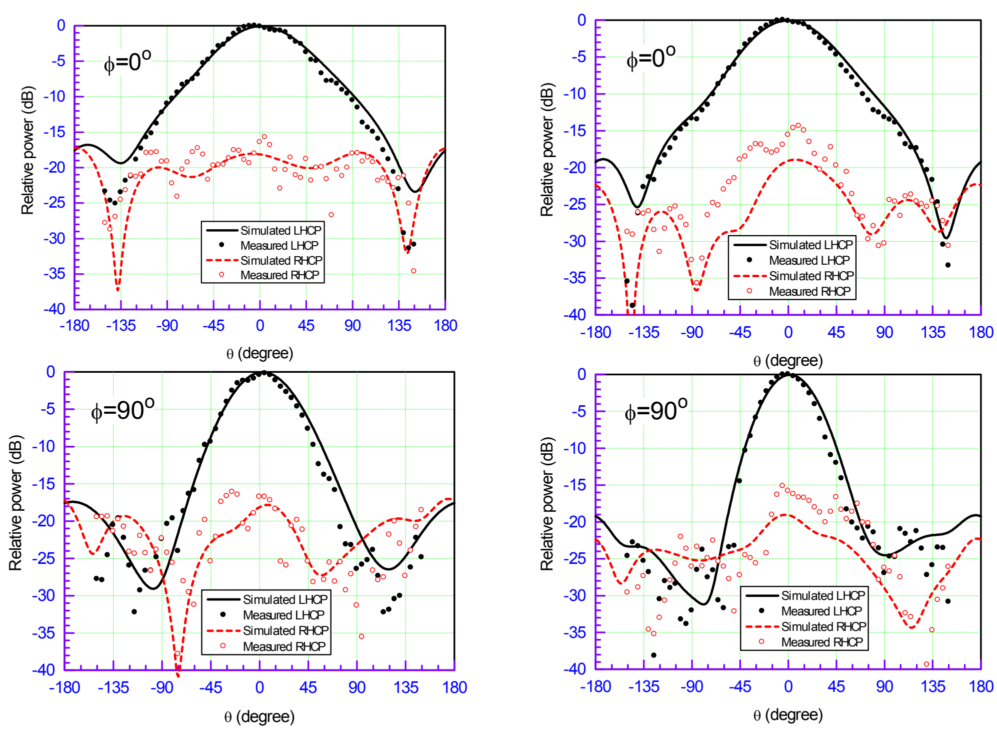


Fig. 6. Return loss of the slot/strip loop antenna.



(a) 5.7 GHz (b) 6.7 GHz

Fig. 7. Radiation patterns of the slot/strip loop antenna.