COMPACT OPEN-RING MICROSTRIP ANTENNAS FED BY CAPACITIVE COUPLING

Soon-Soo Oh and Lotfollah Shafai
Dept. of Electrical and Computer Eng., University of Manitoba
15 Gillson Street, Winnipeg, Manitoba, R3T 5V6 Canada
E-mail: ssoh@ee.umanitoba.ca shafai@ee.umanitoba.ca

1. Introduction

In wireless communications, miniaturized antennas are in increasing demand and subject of constant ongoing research. One of the candidates is microstrip antenna, which has been extensively studied, due to its additional advantages of low profile and cost. Further compactness in microstrip antennas can be achieved by loading them with dielectrics, resistors and shorting pins, or selecting slot designs or meandering microstrip lines [1].

In this paper, compact open-ring microstrip antennas are presented. The proposed antenna can be thought of a folded printed dipole or a cut closed-ring microstrip antenna. Folding a narrow microstrip line can shift the resonant frequency downward, while, making its input impedance more inductive. To compensate for this inductive component, a capacitive coupling method may be utilized, which is composed of a probe-fed microstrip line coupled capacitively to the ring antenna [2], [3].

2. Design of the antennas

Three different geometries of the proposed open-ring microstrip antenna are shown in Fig. 1. They are printed on a supporting substrate with a dielectric constant of 2.5, loss tangent of 0.0019, and thickness of 0.7874 mm. A foam layer with a dielectric constant of 1.03 and thickness of 6.35 mm, is placed between the ground plate and the above dielectric substrate. The antenna shown in Fig. 1(a) has a uniform strip width of 2 mm. The capacitive loading and a high impedance of the transmission line can lower the resonant frequency of the ring [4], which is the technique adopted in Fig. 1(b). The third structure is shown in Fig. 1(c), which has a uniform strip width of 0.5 mm and its ends are bent.

The feeding strip with a width of 2mm connected to a coaxial probe is closely placed along the open-ring, as shown in Fig. 1(d). The spacing S_1 and length L_1 determine the amount of reactance, and thus, the input impedance depends heavily on them. As shown in Figs. 2(a) and (b), a parametric study for S_1 and L_1 in Fig. 1(a) was performed using the Moment Method simulator, Ansoft Designer [5]. As S_1 increases from 0.2 to 0.7 mm for a fixed L_1 = 5.5 mm, the center of impedance curve moves left and downward, which means the resistive part decreases, and the capacitance part increases. Meanwhile, increasing L_1 from 3.5 mm

ISBN: 89-86522-77-2 94460©KEES

to 7.5 mm for a fixed S1 = 0.5 mm shows an opposite effect as shown in Fig. 2(b).

3. Simulated results

The simulation for three microstrip open-ring antennas were performed and their return loss, S_{11}, are plotted in Fig. 3. Parameters of S_1, S_2, S_3, L_1, L_2, and L_3 are determined as 0.5, 0.5, 0.2, 5.5, 10, and 16.5 mm, respectively. An infinite ground plane and copper conductor were considered in the simulation models. The ring antennas of Figs. 1(a), (b), and (c) have resonant frequencies of 3.240, 2.222, and 1.708 GHz, with bandwidths of 23, 9, and 6 MHz, based on VSWR $\leq$ 2.0. Fig. 1(c) is the most compact one, with a lateral size of 0.07 free space wavelength. The interesting point to note is that, using a long line with a narrow strip width, as shown in Fig. 1(c), more decrease in the resonant frequency is achieved than the capacitive loading and higher impedance transmission line, as illustrated in Fig. 1(b), while keeping the fractional bandwidth the same.

The radiation patterns for three antennas are shown in Fig. 4. The gains for Figs. 1(a) and (b) are 5.37 dBi, and -0.52 dBi, respectively. As expected from the theory, i.e. the gain is proportional to the antenna size, the electrically smallest antenna shown in Fig. 1(c) should have a gain of -0.19 dBi. However, the results of Fig. 4(c) show a gain -8.14 dBi. The additional loss in gain is due to the ohmic loss in the thin conducting strip of the antenna. This low gain can be increased by stacking with another patch, or increasing the substrate height, which will also affect the bandwidth and the physical size.

4. Conclusions

In this paper, three compact open ring microstrip antennas, using capacitive feedings, were proposed and investigated. The effect of the capacitive feeding on microstrip patch parameters was also investigated. Simulation results showed that the resonant frequency was much lowered, which also lowered the bandwidth and gain, as expected from inherent characteristics of small antennas. Techniques for improving the bandwidth and gain will be investigated in the future studies.

References

[1] K. -L. Wong, Compact and broadband microstrip antennas, John Wiley & Sons, New York, 2002.

[2] G. Mayhew-Ridgers, J. W. Odondaal and J. Joubert, “New feeding mechanism for annular-ring microstrip antenna,” *Electron. Lett.*, vol. 36, no. 7, pp. 605–606, March 2000.

[3] G. Mayhew-Ridgers, J. W. Odendaal, and J. Joubert, “Single-layer capacitive feed for wideband probe-fed microstrip antenna elements,” *IEEE Trans. Antennas Propagat.*, vol. 51, no. 6, pp. 1405–1407, June, 2003.

[4] S. -S. Oh and Y. –S. Kim, "A compact bandpass filter using microstrip slow-wave open-loop resonators with high impedance lines," *Microwave and Optical Tech. Lett.*, pp. 185-187, Aug. 2003.

[5] Ansoft Designer 1.0, Ansoft Corp., PA, USA, 2002.

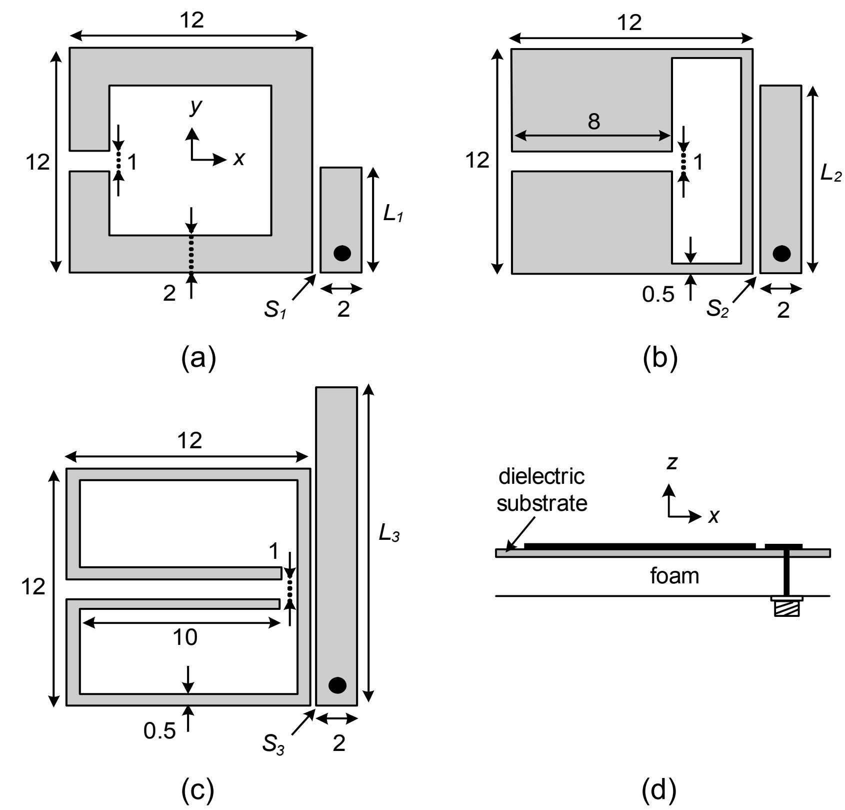


Fig. 1. Geometry of three open-ring microstrip antennas. (a), (b), and (c) Top view. (d) Side view. All dimensions are in mm.

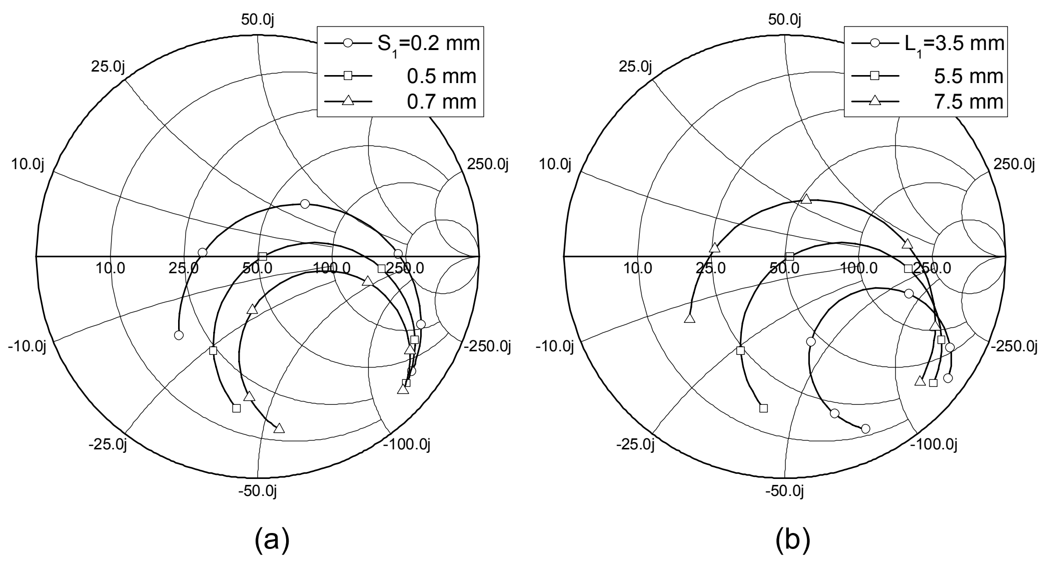


Fig. 2. Parametric study of input impedance for spacing S_1 and length L_1 shown in Fig. 1(a).

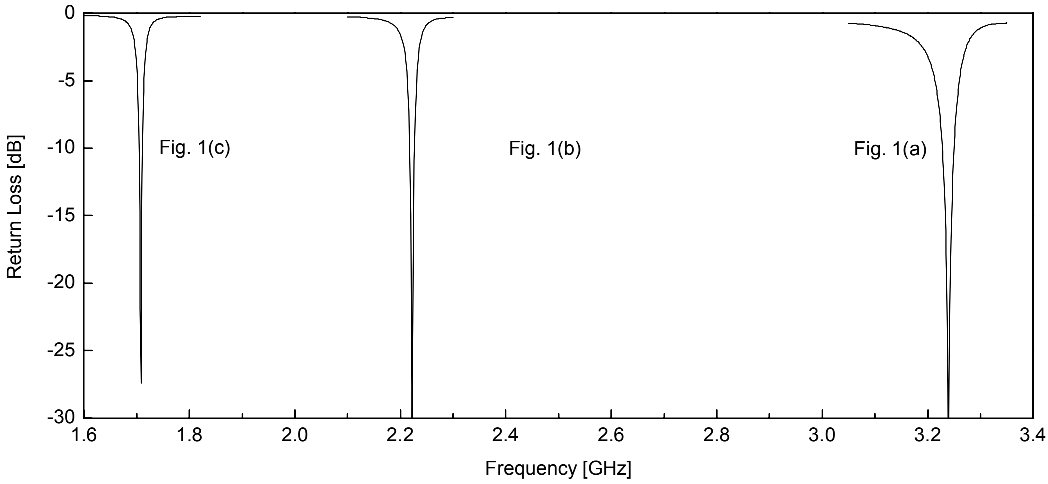
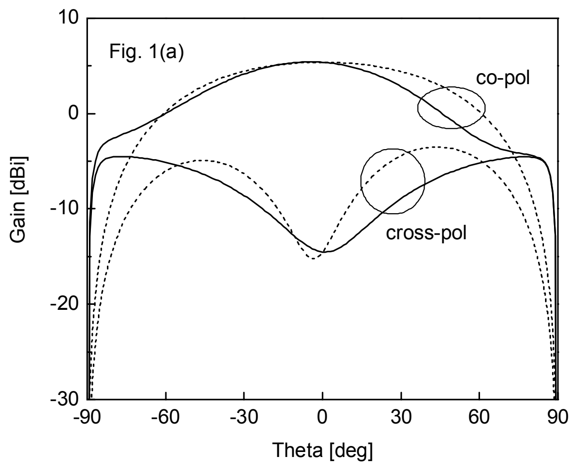
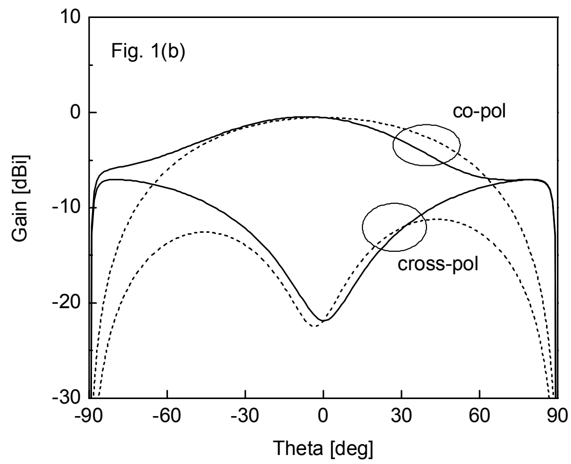


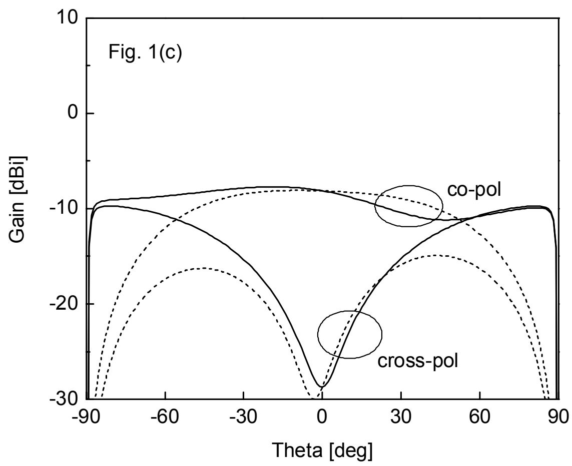
Fig.3. Return loss, S_{11}, of three open-ring microstrip antennas.



(a)



(b)



(c)

Fig. 4. Radiation patterns of three open-ring microstrip antennas. Solid lines are for E-plane (x-z plane), and broken lines are for H-plane (y-z plane).