Dual-band Cavity-backed Slot Antenna Using Series Resonator

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Abstract

A dual-band technique for a cavity-backed crossed-slot antenna is presented. A conventional cavity-backed slot antenna shows the single resonance characteristic which is determined by the lateral length of the cavity and the length of the slot. In this paper, dual-band cavity-backed slot antenna is proposed using the series resonator across the slot aperture. As the resonance of the series resonator makes the shorting path across the slot, second resonance can be introduced. The inductance and the capacitance of the series resonator which are implemented by using a straight line and a gap between two lines can be implemented using a standard printed circuit board process. The proposed technique is applied to design the dual-band cavity-backed slot antenna around 2.4 GHz for the demonstration. The simulated antenna showed the dual-band characteristics without increasing the size of the cavity.

1. Introduction

A cavity-backed slot antenna has many advantageous characteristics like planar surface and low profile and high front-to-back ratio (FTBR). The high FTBR of a cavity-backed slot antenna is achieved by using the quarter-wavelength cavity behind slot. This characteristic prevents the cavity-backed slot antenna from the effect of the material behind the cavity. Therefore, a cavity-backed slot antenna is appealing to the Body Area Network (BAN) where the antenna is backed by the lossy high dielectric constant materials.

One of the main drawbacks of a cavity-backed slot antenna is a narrow bandwidth. Bandwidth of a cavity-backed slot antenna can be enhanced by using thicker cavity or low dielectric constant material. However, these methods increase the dimensions of the cavity. Achieving the dual-band or wide-band characteristic of a cavity-backed slot antenna are comparatively difficult to other antennas like inverted-F antenna because the rectangular cavity structure.

Various techniques have been proposed for the dual-band operation of a cavity-backed slot antenna [1-4]. In [1], the fictitious resonant microstrip feed is used for the wide-band cavity-backed slot antenna. The length and the position of the microstrip feed line are adjusted for the second fictitious resonant frequency [2]. In [3], two slots for different resonance frequency are placed on the cavity. The resonance frequency of each resonance can be changed by adjusting each slot length. However, this technique may increase the dimensions of the cavity. In [4], small via connecting the top and bottom plate of the cavity is inserted above the slot. As the via makes another current path, the dual resonance is obtained. The resonance frequency of the second resonance caused by placing the via can be controlled by moving the position of the via.

In this paper, a dual-band technique for a cavity-backed crossed-slot antenna is presented. The proposed technique makes second resonance by introducing the shorting current path through the series resonator. The inductive and capacitive elements of the series resonator are implemented by using straight line and gap capacitance. The simulated results showed that the dual-band half cavity-backed slot antenna can be designed without increasing the size of the cavity.

2. Antenna Structure

The structure of the proposed dual-band half cavity-backed crossed-slot antenna is illustrated in Fig. 1. Because of the symmetric field distribution of the cavity-backed slot antenna, the half cavity is used for antenna miniaturization. The proposed structure is similar to that of a conventional half cavity-backed crossed-slot antenna except a series resonator across the slot. The series resonator across the slot is connected in parallel with the last part of the slot. In the proposed structure, the straight line and the gap between two lines are used for the implementation of a series resonator. These elements can be simply fabricated with a standard printed circuit board process. By adjusting the length of the line and the gap distance between two lines, the resonance frequency of the series resonator can be controlled.

The proposed antenna is fed by a coaxial cable at the bottom of the cavity. The center pin and the outer conductor of the coaxial cable are connected to the top and bottom plate of the cavity, respectively. The feeding position can be adjusted for the 50 ohm antenna impedance. The operating frequency of proposed antenna is set to 2.4 GHz and the series resonator is placed across the slot. The proposed antenna is simulated on the 1.57 mm height Duroid 5880 substrate. All antenna parameter values are described in Fig. 1. The simulation is conducted using CST Microwave studio.

3. Simulation Results

The z-directional E-field distribution inside the cavity at each resonance is plotted in Fig. 2. Around the first resonance frequency where the slot is about half-wavelength and the series resonator operates as the capacitor, the E-field distribution was similar to that of the conventional cavity-backed slot antenna. The E-field at each side of the slot were opposite direction, exciting the y-directional E-field across the slot. At the second resonance, the impedance of the resonating series resonator was much lower compared to that of the last part of the slot. As a results, the most of the current flows through the series resonator. The effective length of the slot is shortened causing the second resonance at the higher frequency.

The simulated reflection coefficient of the proposed antenna is plotted at Fig. 3. The simulated antenna showed dual-band characteristics. The -10 dB bandwidth were 2.22-2.28 GHz, 3.407 – 3.433 GHz at each resonance. The resonance frequency of first resonance was decreased from 2.4 GHz to 2.25 GHz because of the capacitance of the series resonator. The resonance frequency at each resonance can be adjusted by changing the structure of the series resonator.

The radiation efficiency at 2.25 GHz, and 3.42 GHz was simulated to be 93.6 % and 73.7 %, respectively. The radiation efficiency at the second resonance was lower than first resonance because of the power loss along the series resonator.

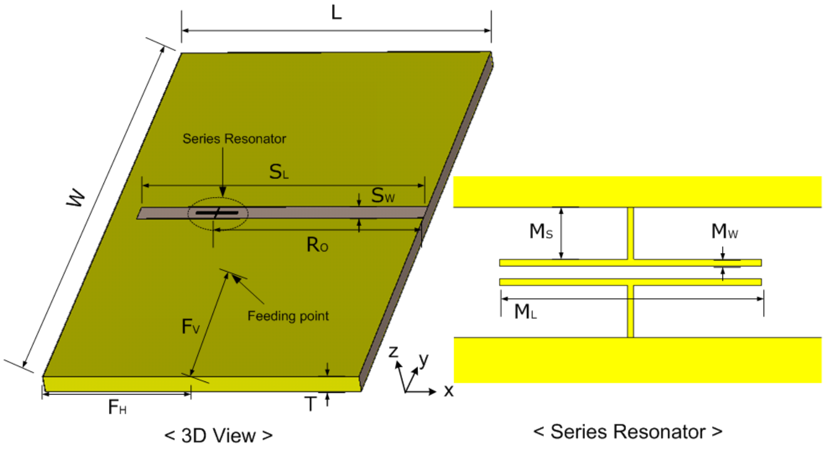

Figure 1. Geometry of the proposed dual-band half cavity-backed slot antenna(dimensions of the simulated antenna, W = 55, L = 30, S_w = 2, S_L = 27.5, R_O = 20, F_H = 15, F_v = 17.5 M_S = 0.85, M_W = 0.1, M_L = 5, T = 1.57, all in the unit of mm).

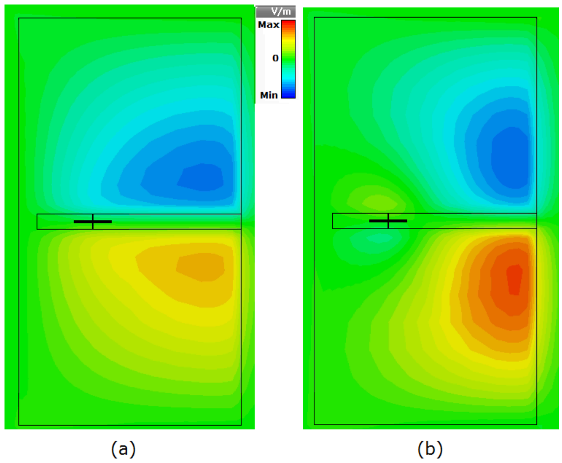

Figure 2. Z-directional E-field distribution inside the cavity at each resonance (a) 2.25 GHz (b) 3.45 GHz

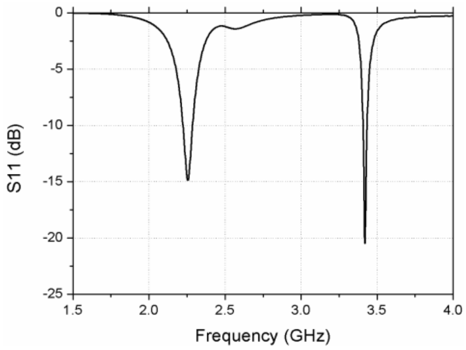

Figure 3. Simulated antenna reflection coefficient.

The radiation patterns of the simulated antenna is plotted in Fig. 4. The peak gain was higher at 2.25 GHz because of the losses in series resonator.

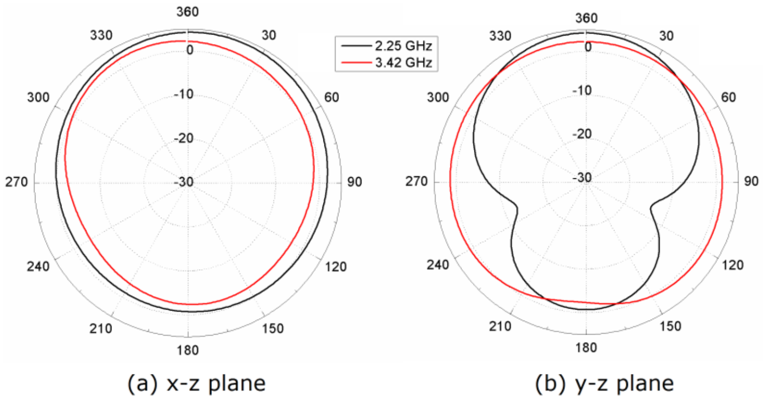

Figure 4. The simulated radiation patterns of the proposed antenna

4. Conclusions

A dual-band technique for a cavity-backed crossed-slot antenna is presented. By inserting the distributed series inductance and capacitance across the slot, the dual-band characteristic is achieved. The proposed structure is compatible with a standard printed circuit board process. Using the proposed technique, a dual-band cavity-backed slot antenna can be designed without increasing the antenna dimensions

5. Acknowledgement

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6. References

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