Paper

Dual-band Multi Slot Patch Antenna for Wireless Applications

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Abstract—In this paper a novel configuration of broadband multi slot antenna for C/X bands is presented and analyzed. By cutting two diamond slots in the middle of the rectangular patch and three triangular slots in the right side of the patch, resonances can be created. Microstrip feed line is used in the down side region of the patch. Antenna characteristics were simulated using a finite element method (HFSS). According to simulations, the proposed multiple slot antennas can provide two separated impedance bandwidths of 970 MHz (about 11.96% centred at 8.11 GHz band) and 890 MHz (about 9.76% centred at 9.42 GHz band) and stable radiation patterns, promising for satellite systems.

Keywords—Ku/K band, microstrip patch antenna, multiband, satellite, slotted, triangular.

1. Introduction

Nowadays in radar and satellite communication applications, microstrip patch antennas are very popular due to their low profile, mechanically robust, relatively compact and light and possibility of dual frequency operation. They are easy and inexpensive to manufacture and can be conformable in planar and non-planar planes. Unfortunately they have some limitations, specially narrow bandwidth [1]. But presently, wider bandwidth is required for the increasing demand of modern wireless communication systems. Generally each antenna performs its function at a single frequency, so different antennas that are needed for different applications will cause a limited space problem. Researchers think that multiband antennas provide solutions to relief from this problem where single multiband antenna can operate at many frequencies for different applications. By applying fractal shape technique into antenna geometrics, multiband antenna can be constructed [2]–[6]. By using multilayer stacked patch [7] and single layer microstrip antenna [8] has been paid to little attention for achieving dual-band. In [9] dual frequency is achieved by cutting a square slot in the middle of a rectangular patch where they achieved both compactness and dual frequency operation. Dual frequency with tuneable frequency ratio can be attained by loading a pair of narrow slots parallel and close to the radiating edges of a bow tie patch [10]. Pre factual geometry and two short circuits in patch are used to achieve compact dual-band circular polarization antenna [11]. In [12], a rectangular shaped with complex slot cutting dual-band microstrip antenna for Ku band application have been proposed average gain is not good. Besides multilayer stacked patch, multi resonator, multi slot loaded antennas [13]–[17] are used for obtaining dual frequency but these structures have some disadvantages such as very complex, large, costly, thick substrate and difficult for manufacturing. On the other hand, using single feed antennas can diminish complication and high cost of the receiver front-end.

In this paper, a new broadband multi slot antenna with fractional bandwidth 11.96% and 9.76% is proposed. By arranging the geometry of the feeding structure in the below region, several resonant paths are created over the operating frequency bands. With a careful choice of the dimensions of the slots and shapes, these resonances can be merged together over the operating band and consequently the antenna can be used over a very wide bandwidth. Detail of the investigations based on simulations of the proposed antenna is described.

2. Antenna Design Architecture and Optimization

The proposed diamond and triangular slot antenna is shown in Fig. 1. The model was designed on Rogers RT/Duroid 5870 substrate with thickness 1.575 mm,

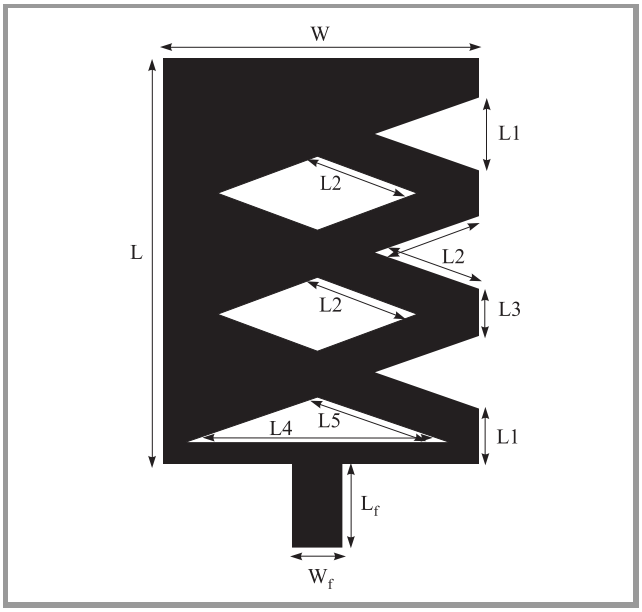

Fig. 1. Proposed antenna geometry layout.

$\varepsilon_r = 2.33$ and tan $\delta = 0.002$. The slot is etched on the patch. The length L of the slot is determined to be λg/in order to obtain a maximum power at the broadside direction. A microstrip-fed line on the bottom plane of the substrate is as a microstrip fed excitation of the slot antenna to excite the slot mode. Due to the higher impedance of the narrow slot, the width of the open circuited feed line is tuned and decreased more as before. The geometrical parameters of the multi slot antennas are presented in Table 1. During experiment, the dimensional parameters of the feed line were changed and compared in order to obverse the variation of the impedance bandwidth and the initial resonant frequency of the proposed slot antennas.

Table 1
Antenna dimensions

Parameter	Length [mm]
L	38
W	30
L1	6
L3	4
L5	11.73
L_F	10
W_F	4
L2	9.48
L4	22.71

3. Results and Discussions

The antennas were simulated using finite element based electromagnetic simulator HFSS (High-Frequency Structure Simulator). Figure 2 shows the simulated return loss against frequency for the proposed wideband dual frequency slotted antenna. It is clearly seen that simulated two resonant frequencies at 8.11 GHz and 9.42 GHz are excited with good impedance matching. The simulated lower resonant mode achieves a –10 dB impedance bandwidth of ranging from 7.84 GHz to 8.81 GHz with respect to the centre frequency at 8.11 GHz, and the upper resonant impedance bandwidth ranges from 9.18 GHz to 10.10 GHz with respect to the centre frequency at 9.42 GHz.

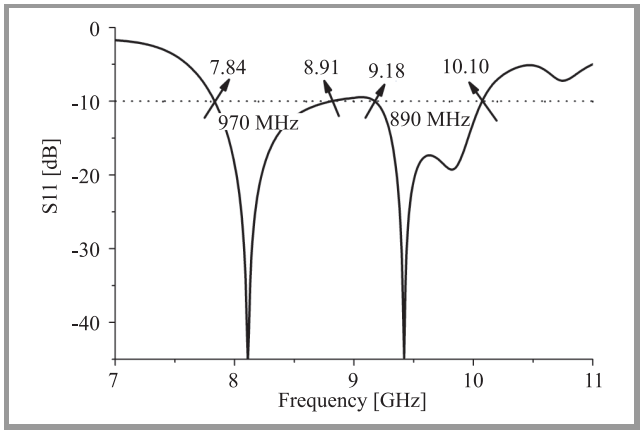

Fig. 2. Simulated return loss for the proposed dual-band antenna.

In order to achieve wide-band operation, the tuning parameters of the matching network have been studied. By adjusting the width of the 50 Ω microstrip line, we have a trade-off between impedance bandwidth and initial frequency as shown as following. Figure 3 show the smith chart and input impedance of the proposed shape antenna.

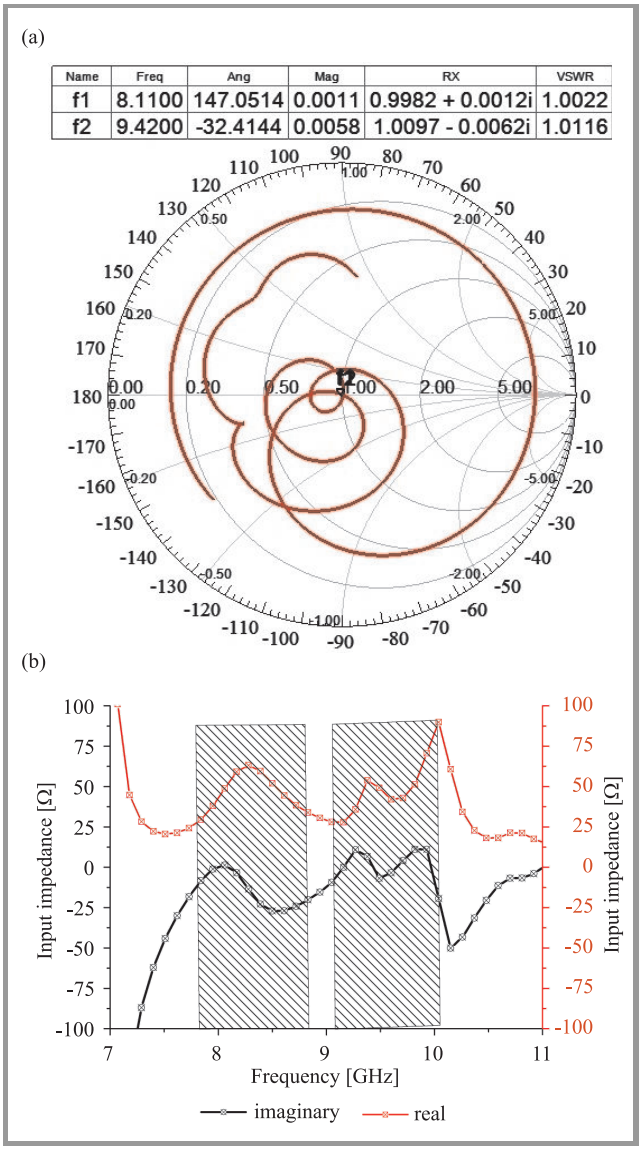

Fig. 3. Simulated (a) Smith chart and (b) input impedance for the proposed dual-band antenna.

The far-field radiation patterns for the proposed wideband dual frequency slotted antenna are also examined. Figure 4 shows the comparison between the simulated radiation

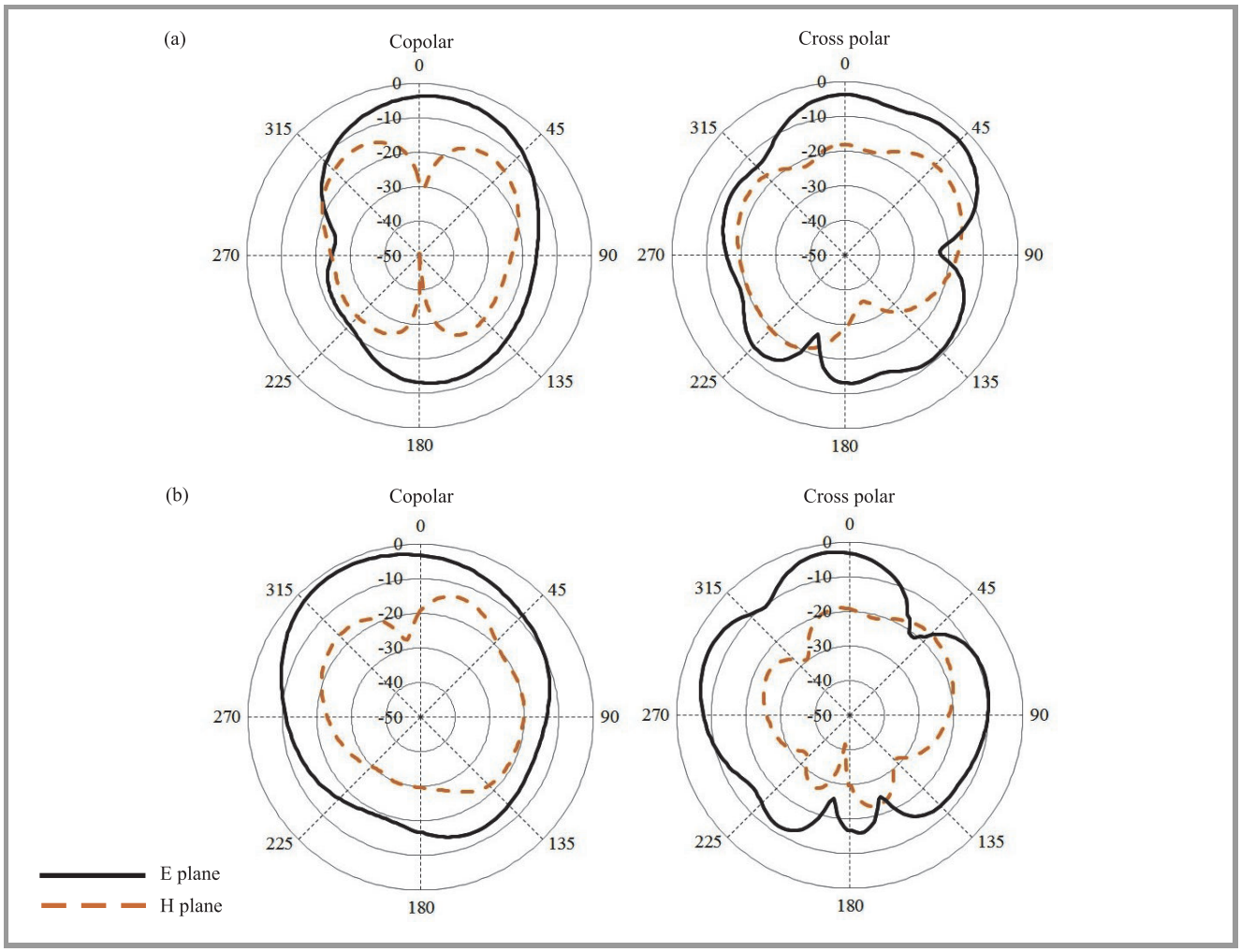

Fig. 4. E- and H-plane radiation patterns of the multi slot antenna at (a) 8.11 GHz, (b) 9.42 GHz.

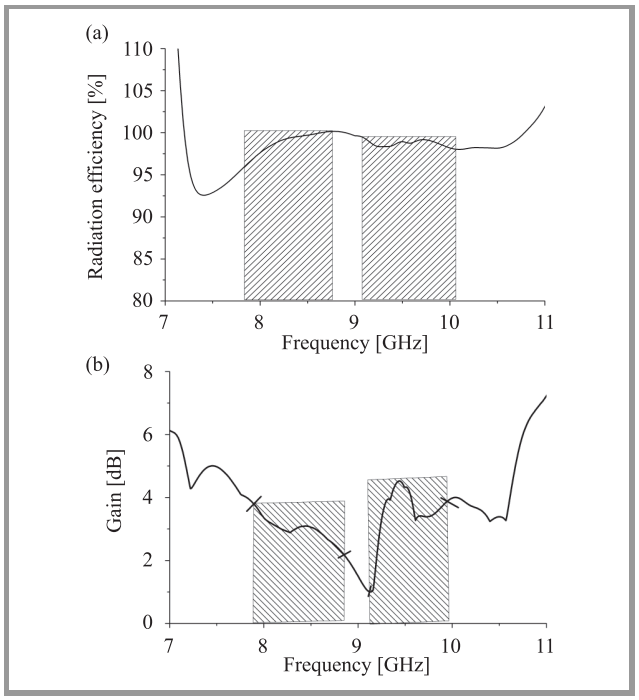

Fig. 5. Proposed antenna (a) radiation efficiency and (b) gain.

pattern including the horizontal (E plane) and vertical (H plane) polarization pattern for the antenna at lower band of 8.11 GHz and upper 9.42 GHz. Due to the much symmetry in structure of the proposed wideband dual frequency slotted antenna, rather all symmetrical radiation are seen in the horizontal and vertical planes as depicted in the plot. Typically, the radiation under the ground plane should be zero as same with the simulation radiation pattern. This is because the ground plane of the microstrip patch antenna serves as a reflector for all the radio frequency.

Figure 5 shows the radiation efficiency and gain of the proposed antenna. The average radiation efficiency and gain of the multi slots antenna are about 98.48%, 3 dB at lower band and 98.81%, 3.44 dB at higher band, respectively.

4. Conclusion

A novel design of wideband dual frequency slotted antenna which is constructed by two diamond shape slot in the middle and four triangular slot structures in the

side of the patch is presented. The simulated result such as return loss, radiation pattern, and the gain of the proposed antenna is obtained and the overall performance of the antenna still can be considered in good condition. The proposed slotted dual-band antenna has a very simple structure, which makes the design simpler and fabrications easier, and is very suitable for applications in the access points of wireless communications.

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