Double Rectangular Grooves Microstrip Antenna With The Dual L-shape Tuning Stubs Supporting Tri-Band Frequencies

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Abstract

This research proposes the microstrip patch antenna which consists of the tuning L-shape slits and the double rectangular grooves structure for supporting tri-band frequencies on 2.44, 3.55, and 5.8 GHz. The antenna prototype produces high gain and compact size which is around 11.6 % less than the conventional one. The proposed antenna is the bi-direction pattern for supporting the standards of IEEE 802.11b/g, 802.16e and 802.16d

Keywords : Microstrip Slit Rectangular Groove

1. Introduction

Standards of the wireless communication technology have been assigned to support frequencies in microwave bands such as mobile, computer and education systems. So, IEEE is the reference standard of wireless communication for researchers. However, wireless antennas become very popular and favourite. Generally, wireless antennas are designed to specific frequency band [1-5], or dual-band [6-12] which their structures are not compact size. So that, many researchers have tried to develop the wireless antennas which are capable of communication in wide range frequencies bands [13-14], but they were required higher power consumption. Thus, the tri-band antenna is proposed for supporting in the range of standard frequencies such as IEEE 802.11b/g, 802.16e and 802.16d

So, this paper presents the development of the dual band microstrip antenna with trapezoid stub by using the double rectangular grooves and L-shaped slots for generating the third band.

2. Antenna Design

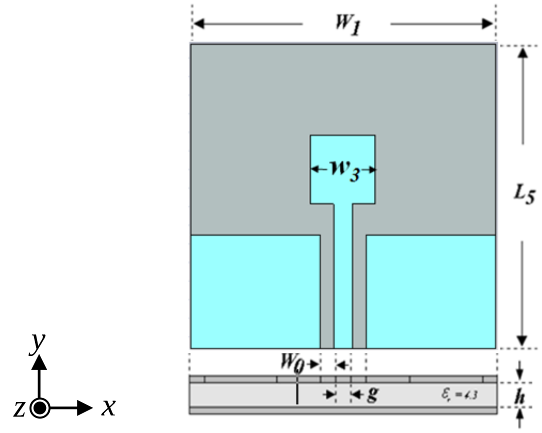
In the previous research, microstrip antenna in [13] is the dual-band antenna using the tuning trapezoid stubs and L-shape slits for supporting the wireless communication system including techniques as described in [6-9]. The antenna is fabricated on the PCB FR4 with its dielectric constant, ε_r, = 4.3, and its thickness, h is 0.764 mm, respectively. The electromagnetic software CST is used for analysis and implementation. However, the antenna feed line is 50 ohm.

Figure 1(a) shows the layout of the conventional antenna and its parameters which have been already optimized for producing the good return loss (S_{11}), as well as the best efficiency, but the characteristic response generated only two-frequency ranges at 2.44, and 5.78 GHz. So that to obtain the third band, there are three main steps for parameters varying, W_2, W_4, and L_4 as shown in figure 1(b). First, the top rectangular patch groove width, W_2 is varied. It can be noticed that the return loss is below -10 dB when W_2 = 14, 16, 18 and 20 mm, respectively. But when W_2 = 16 mm, the antenna can produce dual-band at 2.68 and 3.63 GHz as shown in figure 2(a).

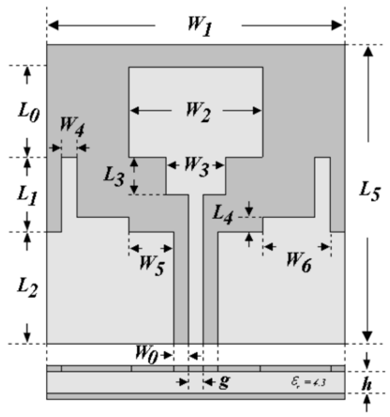
Next, figure 2(b) shows the frequency responses when W_4 is varied. W_4 is the width of I-shaped slot which is laid on the both side of the patch antenna with the optimized length L_1 of 10 mm. It can be found that when W_4 is varied at 2, 3, 4 and 5 mm, the bandwidth of the first band is changed, too. Besides, the third band of around 5.8 GHz is also produced. At the desired frequencies the compatible value of W_4 is equal to 2 mm.

Finally, according to the frequency bands of the standard requirements, the I-shape slots are adapted to be L-shaped slots with the technique in [6-9]. The lengths of L-shaped slots, L_4, are varied at 2, 3, 4, and 5 mm. Figure 2(c) shows the frequency responses when L_4 is changed. It is found that when L_4 is varied, the centre frequencies of the third band are also varied. The suitable value of L_4 is around 2 mm because it creates the required frequencies that are 2.44, 3.55, and 5.8 GHz.

The optimized dimensions have been determined as following: L_0 = 12 mm, L_1 = 10 mm, L_2 = 15 mm, L_3 = 5 mm, L_4 = 2 mm, L_5 = 40 mm, W_4 = 2 mm, W_1 = 40 mm, W_2 = 16 mm, W_3 = 8 mm, W_5 = 6 mm, and W_6 = 9 mm, respectively. The total dimension is equal to 40×40 mm^2.

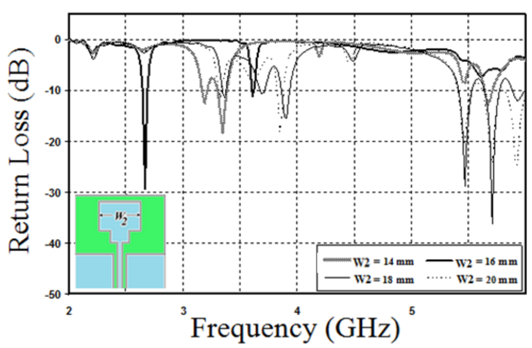


(a)

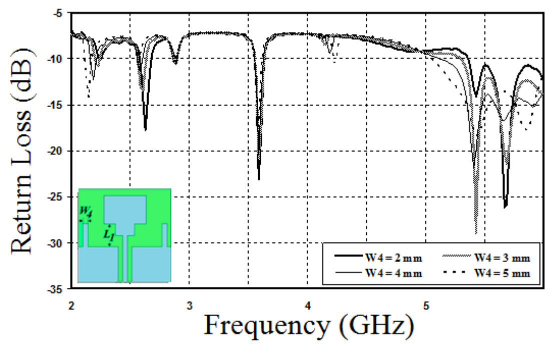


(b)

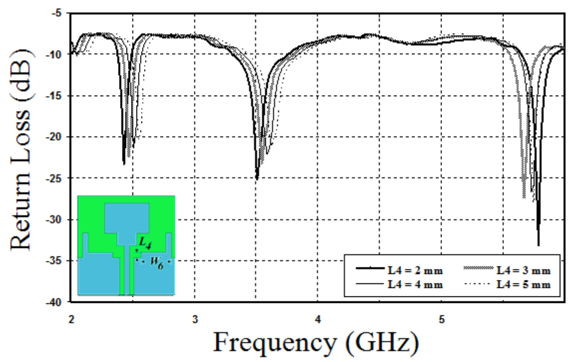
Figure 1: Layout of (a) The Conventional Antenna (b) The Proposed Antenna



(a)



(b)

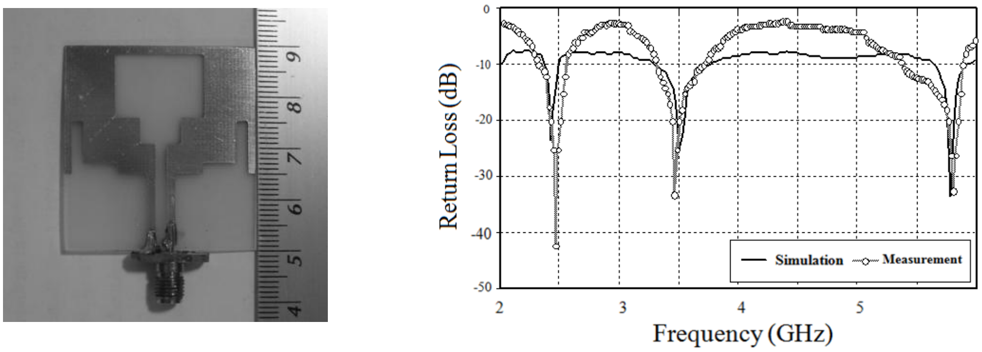


(c)

Figure 2: The Frequency Response (S_{11}) when (a) W_2, (b) W_4 and (c) L_4 are varied.

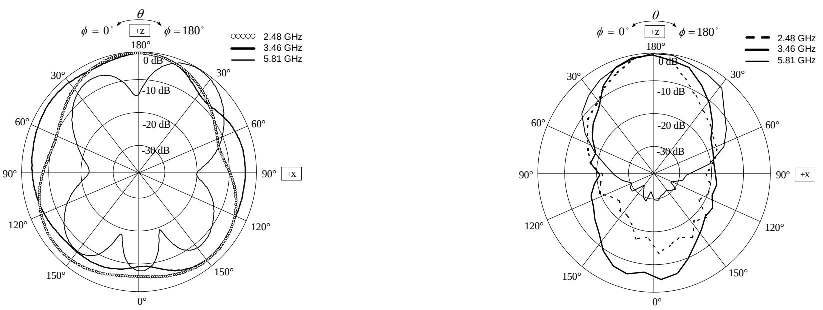
3. Fabrication and Measurement

Figure 3(a) shows the photograph of the double rectangular grooves microstrip antenna with the dual L-shape tuning stubs. The network analyser is used to measure the return loss for explaining the responding result of frequency. Figure 3(b) shows the comparison of the simulated and measured return loss. It can be seen that the frequency responses are just right very well and can be conformed the IEEE 802.11b/g and 802.16a. The gain of the proposed antenna is 5.21 dBi in the range of 2.4- 2.48 GHz, 5.38 dBi of 3.4 – 3.69 GHz, and 7.89 dBi of 5.7-5.9 GHz as shown in fugure 4 and 5.



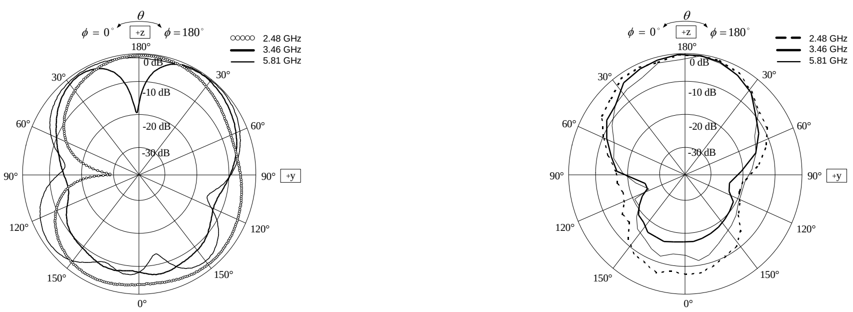
(a) (b)

Figure 3: (a) The Photograph of The Proposed Antenna (b) The Comparison of the Return Loss of the Simulation and the Measurement.



(a) (b)

Figure 4: The Radiation Pattern at the Frequencies of 2.48, 3.45, and 5.81 GHz on E-Plane (a) Simulation (b) Measurement.



(a) (b)

Figure 5: The Radiation Pattern at the Frequencies of 2.48, 3.45, and 5.81 GHz on H-Plane (a) Simulation (b) Measurement.

Conclusion

This research presents the microstrip antenna for tri-band frequencies. Because of the prototype antenna, it is found that the resonances of the frequency at 2.30 – 2.52 GHz are 9.12 %, 12.57 % of the frequency at 3.28 – 3.72 GHz and 9.57 % at 5.37 – 5.91 GHz when compared with the standard antenna. The proposed antenna size (40×40 mm^2) is 11.60 % less than that of the previous research.

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