

Compact Frequency Reconfigurable Microstrip Antenna with Controllable Band-Notched Performance for UWB Application

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Abstract

In this paper, a new design of a frequency reconfigurable microstrip antenna by using microstrip line feeding for UWB applications is presented. The process of frequency band rejection is done through the slots on the radiation patch and ground plane of antenna. Also the antenna bandwidth has been improved by using partial Defected Ground Structure (DGS). Then by putting two switches on the ground plane slot, reconfigure ability is added to antenna. The antenna dimensions are 20×20 mm² which is very compact. Simulation results show that the designed antenna is able to cover the frequency range 3.1-10.9 GHz. Also shows a performance of frequency band rejection in the range 5.1-5.9 GHz which is related to WLAN systems.

Keyword: Reconfigurable Antenna, WLAN, Band Rejection, UWB.

INTRODUCTION

Parallel to the developments in physical layer based security for wireless networks, significant progress has been made in the design of reconfigurable antennas [1]. They can dynamically alter their radiation characteristics such as gain, polarization, radiation pattern etc. by changing its electrical or physical configuration. Various diversity techniques, including spatial diversity, pattern diversity, temporal diversity, as well as polarization diversity, are commonly used in wireless communications to improve the signal-to-noise ratio and hence the overall performance [2]. Among the large family of antennas, microstrip antennas due to the relatively simple structure, all directional pattern, their cheap price and convenient integration are very appropriate choices [3]. In recent years, along with the frequency band which is defined by the U.S. A Federal Communications Commission (FCC) for commercial communications, the interest in UWB technology has increased [4]. UWB systems due to their ability to providing high bit rate and low power consumption were considered as a desirable option for wireless communications. Several designs on UWB antennas have been reported [5]-[8]. However, due to its wide frequency spectrum of UWB systems, one of their main problems is interaction between this systems and other existing narrowband systems defined in this area, including local wireless network (WLAN) [9]. Therefore, UWB antennas with frequency band rejection characteristics are desirable to avoid the possibility of interference [10]-[17]. This has led in recent years, many methods such as using of via, electromagnetic coupling, and Using of U-shaped slot on the ground plane of antenna for creating a frequency band rejection of the microstrip antenna.

In this paper, a new design of a frequency reconfigurable microstrip slot antenna with the microstrip

feed line is presented for using UWB applications. Which is able to show a property of frequency band rejection in the range of 5.1-5.9 GHz. Make use of Defected Ground Structure (DGS) is one method of increasing bandwidth in microstrip antennas. DGS structures are created by a simple shape defect in the ground plane. Distribution of the circuit, which has covered the ground plane, is impaired by this defect and thus, it obtains in consequence of a controlled excitation and propagation electromagnetic waves in dielectric layer. In the proposed antenna a DGS structure has been used to achieve the desired impedance bandwidth. In addition, two slots which are located on the radiation patch and one slot on ground plane of antennas are used to the desired frequency band rejection. The performance of frequency band rejection is done by changing the state of switches that are on ground plane. Also by creating two symmetric incisions on the radiation patch and along the microstrip feed line proposed antenna, antenna impedance matching at the operating frequency range is improved.

ANTENNA DESIGN

The geometry structure of the proposed antenna is shown in Figure 1. The antenna was design on FR4 substrate with a 0.8 mm thickness and with a relative Permittivity of 4.4 and a loss tangent of 0.02. The exact reason of this substrate is its availability and cheapness. The proposed antenna consists of a radiation patch easily attached to a microstrip feed line 50Ω with the width of W1 and the length of L1 and a defect ground plane. W5 and L5 parameters on ground plane have a significant impact on increased antenna bandwidth. In addition, W6 and L6 parameters on ground plane and w3 and L3 on the patch play an important role in controlling the frequency of the frequency band rejection.

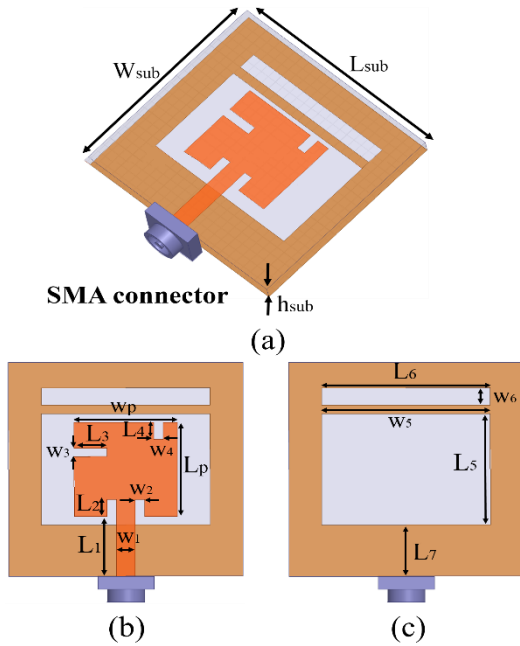


Figure 1. Geometry of proposed antenna. (a) Side view. (b) Top view.(c) bottom view

For obtaining the best operating characteristics of the antenna, the effect of changing of designing key parameters on the input reflection coefficient should be studied. Therefore, to improve antenna performance, a parametric study has been done on the design parameters. The final dimensions of designing the proposed antenna parameters are presented in Table 1. Ansoft HFSS Software is used for simulating and analyzing the proposed antenna and obtaining s parameters [18]. Also, to verify the results of the CST Microwave Studio software is employed [19].

Table 1. final dimensions of the proposed antenna

Parameter	Dimension (mm)	Parameter	Dimension (mm)
L_{sub}	20	L_5	11
W_{sub}	20	L_6	18
h_{sub}	0.8	L_7	4.5
L_p	8	w_1	1.5
w_p	8	w_2	0.5
L_1	5	w_3	0.5
L_2	1.5	w_4	1
L_3	2.5	W_5	18
L_4	1.5	W_6	2

RESULTS AND DISCUSSION

Structure of the antennas which has been examined in simulation studies is shown in Figure 2.

The designed basic microstrip patch antenna consists of a simple square $8 \times 8 \text{ mm}^2$ and a microstrip feed line with dimension $1.5 \times 5 \text{ mm}^2$ and a full ground plane with dimensions $20 \times 20 \text{ mm}^2$. The return loss of the antenna is shown in Figure 3.

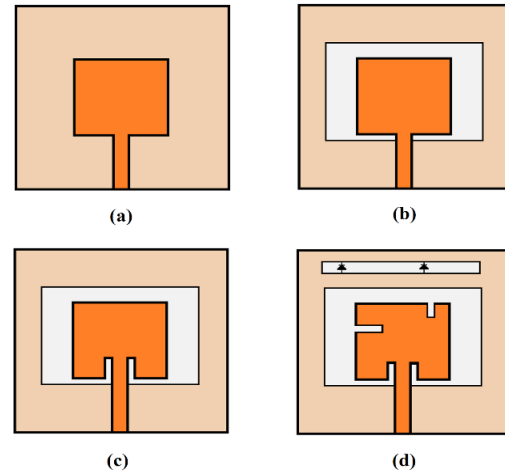


Figure 2. (a) Basic Square antenna with a full ground plane. (b) Square antenna with a DGS structure in ground plane.(c) Square antenna with a DGS structure in ground plane and two symmetric incision on the radiation patch.(d) Proposed antenna.

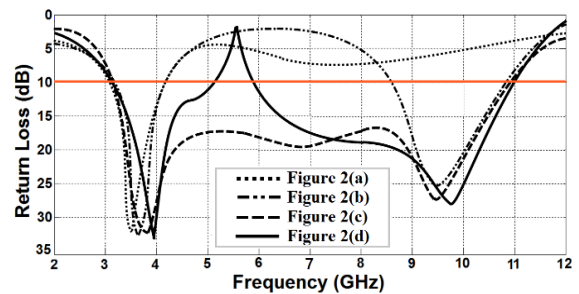


Figure 3. Simulated return loss characteristics for antennas shown in Fig. 2.

As the figure shows, the above antenna has only one resonance at 3.5 GHz frequency, and bandwidth is not appropriate. As the figure shows, the above antenna has only one resonance at 3.5 GHz frequency, and bandwidth is not appropriate. Then by designing a DGS structure we create another resonance in 9.5 GHz frequency in the range of UWB systems.

Parameter L_7 has a significant impact on improving the bandwidth of the designed antenna. For this purpose, a parametric study is done on the parameters L_7 . Figure 4 shows the return loss of the antenna for the change of L_7 parameter on the ground plane.

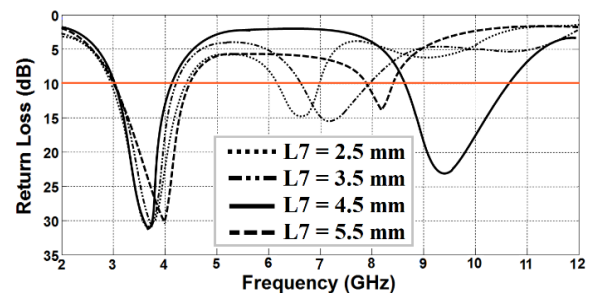


Figure 4. Simulated return loss of proposed antenna with different L_7 .

As it can be seen in Figure 3 stage (b), the antenna impedance matching in the middle band is not optimal yet.

Then by creating two symmetric incisions on the radiation patch and along the microstrip feed line of the proposed antenna, antenna impedance matching at the middle band is improved. Parameter L2 has a significant impact on antenna impedance matching designed antenna. Figure 5 shows the return loss of the antenna for the change of L2 parameter. As it can be seen by changing the amount of L2 antenna impedance matching will change and the optimum Value is L2 = 1.5 mm.

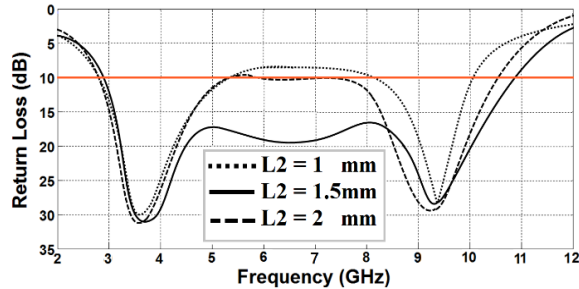


Figure 5. Simulated return loss of proposed antenna with different L2.

As it is derived from the shape, at this stage antenna bandwidth is improved and covers the entire range of UWB. In the next step, by making two slots on the radiation patch and a slot on the ground plane antenna and parametric study of the parameters w3 and L3 and w6 and L6, frequency band WLAN will be removed from the UWB frequency range. Finally by placing two switches on the slot of ground plane, frequency band of removal process can be controlled. The proposed structure has capacity to work in two different modes. When switches are on, the antenna operates in mode A. In mode A, antenna covers the Frequency Range 3.1-10.9 GHz. When switches are off, the antenna operates in mode B. In this mode WLAN frequency band will be removed.

Figure 6 shows the Simulation results return loss of proposed antenna in mode A and mod B. for verify the results of the CST Microwave Studio software and Ansoft HFSS Software are used. As it can be seen in the figure, the results obtained from both software is similar and this confirm validity of the results.

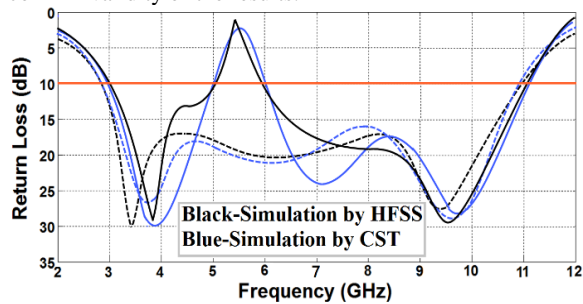


Figure 6. Return loss of proposed antenna in mode A (dash) and mode B (solid).

In spread spectrum communication, because the very short period pulses are used. And to prevent damage and distortion pulse, the Antenna should have a few group delay.

Group delay is defined as follows:

$$\text{Group delay} = - d\theta(\omega) / d\omega \quad (1)$$

Group delay of the antenna is shown in Figure 7. We'll be inferred from Figure 7 that the antenna group delay in UWB except for the removal band WLAN is less than 2 n sec.

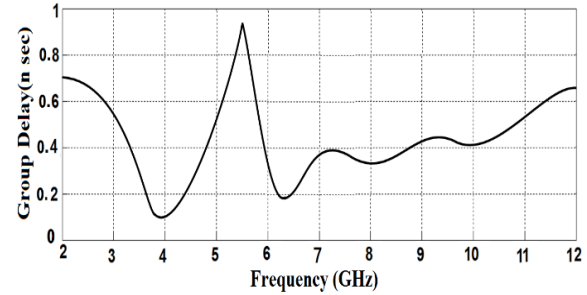


Figure 7. Group delay of the proposed antenna.

The radiation pattern of the proposed antenna in this paper is shown for two different working frequencies in the E-Plane and H-Plane in Figure 8. The radiation pattern in the H-Plane is all the directional and Uniform that this is a significant advantage for wireless systems.

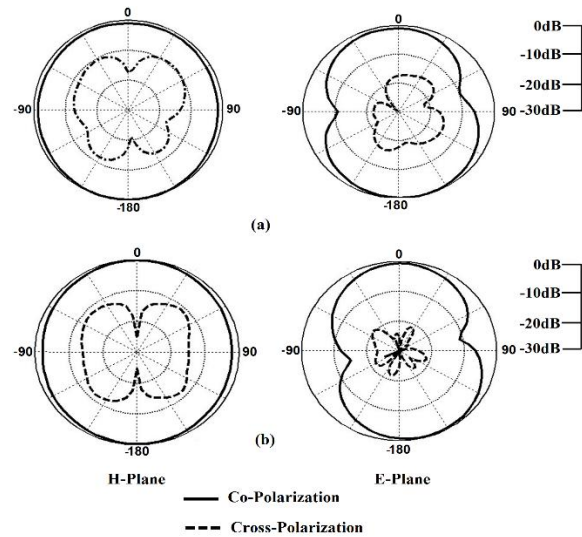


Figure 8. Simulated radiation patterns of the proposed antenna. (a) 4 GHz and (b) 9.5 GHz

Figure 9 shows the simulated gain of the proposed antenna. It is observed that Sharp gain decreases occur in 5.1–5.9 GHz bands. However, for other frequencies outside the rejected bands, the antenna gain is nearly constant in the entire UWB band.

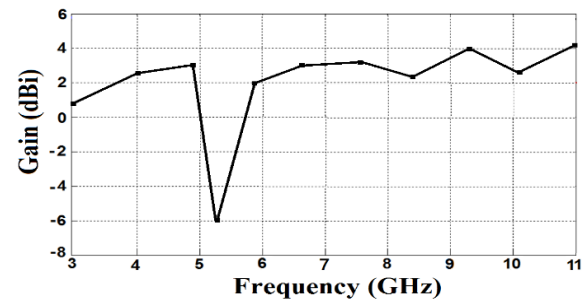


Figure 9. Simulated gain of proposed antenna.

CONCLUSION

In this paper, a frequency reconfigurable microstrip antenna with improved impedance matching for UWB systems is presented. In this structure frequency band rejection has been done by slots that are on the ground plane and radiation patch of antenna. Then by putting two switches on the ground plane slot the capability of reconfigurable frequency is added to antenna. The proposed structure has capacity to work in two different modes. When switches are on, the antenna operates in mode A. In mode A, antenna covers the Frequency Range 3.1-10.9 GHz. When switches are off, the antenna operates in mode B. In this mode WLAN frequency band will be removed. The antenna has three main features: wide band, Suitable radiation performance, and its small size. All the advantages mentioned above makes this antenna a good choice for UWB systems.

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