A TRIANGULAR PATCH ANTENNA FOR VARIOUS WIRELESS SERVICES

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Abstract

This paper proposes a miniaturized triangular patch antenna with defected ground structure showing multiband characteristics. The proposed antenna consists of a triangular patch and two parasitic patches fed by a 50Ω microstrip line. The substrate material is FR4 with ε_r=4.4. The antenna has a compact size of 39×26 mm^2. The antenna operates in three bands: WiMAX, Mobile and Fixed services band and WLAN. The antenna parameters such as return loss, VSWR, radiation patterns and gain are in good agreement with the requirements. The designing and simulation have been performed using CST (Computer Simulation Technology).

Keywords: triangular patch, defected ground structure, multiband, mobile services, parasitic patches.

1. Introduction

Numerous antennas for different purpose already exist, but the thirst of excelling in this expanse has no end. In the always growing and developing communication systems and the application areas along with the obvious requirements of small size, less weight, better performance, ease of integration and low cost, miniaturized multiband antennas are in great demand. Microstrip patch antennas are a class of miniaturized antenna with many advantages like light weight, conformability, ease of fabrication, low cost etc but there major drawback is extremely low bandwidth (<5%). Therefore, many techniques and designs have been proposed till date in the literature to improve their bandwidth, including different shape patches and probes, cutting of slots, the use of thicker substrates, and addition of parasitic patches.

Multiple resonant modes are realized through various slots of different orderly cuts onto the radiator and ground plane [1]. They allow greater tractability in antenna design as they are much easy and straight forward to implement along with the ease to adapt a geometrical shape. Some antennas are presented in [2]-[9] which employ this cutting of slots technique to achieve multiband as well as ultra wideband operation. The use of defected ground structure decreases the gain (approximately by 14%). It is so because cutting such slots in ground will make it behave as backside radiator which apparently results in radiation pattern not being omni-directional and having back lobes and reduced gain as well. Multiband characteristics are realized in [10] by using parasitic patches along with defected ground structure to enhance the bandwidth and gain characteristics.

In this paper, a triangular patch antenna along with two parasitic patches has been designed which has multiband characteristics. The defected ground structure is employed for the excitation of additional resonances to enhance the bandwidth. The proposed antenna has three resonant frequencies as 3.63GHz, 4.62GHz and 5.57GHz with the frequency range covering as 3.57-3.72GHz, 4.39-4.81GHz and 5.53-5.61GHz respectively. The three bands lay their uses for WiMAX; mobile, fixed services and fixed satellite services; and WLAN application respectively.

We organize this paper as follows. The main design guidelines are discussed in section II. Section III has various simulated results. Experimental results of prototype fabricated by photolithography process are shown in section IV. This section also presents a comparison between the simulation and experimental result. Finally, the paper is concluded in section V.

2. Antenna Structure

The multiband notch characteristics are introduced by the triangular radiator with two parasitic patches and defected ground structure. Figure 1 shows the view of radiator and defected ground of the designed antenna. The patch is placed on a FR4 substrate with a dielectric constant of 4.4. Though FR4 is not considered good for frequencies above 4GHz, it is used because of its ease of availability and low cost. The dimensions of the substrate are 39×26×1.6 mm^3. The radiating patch is fed by a 50Ω microstrip line having width of 2.9mm. Ground plane of antenna should also be taken into account because it makes a contribution to radiation as well. The antenna is designed using CST with the dimensions as shown in Figure 1 and Table I. All the dimensions are in mm.

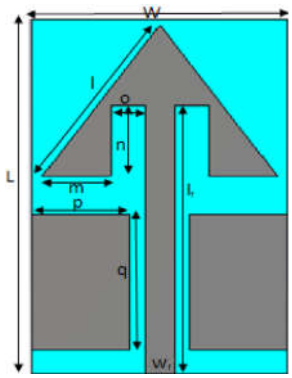


Figure 1(a). Patch

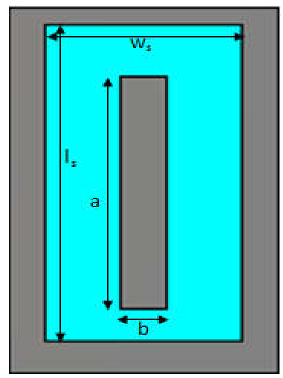


Figure 1(b). Ground

Figure 2(a). Fabricated Patch

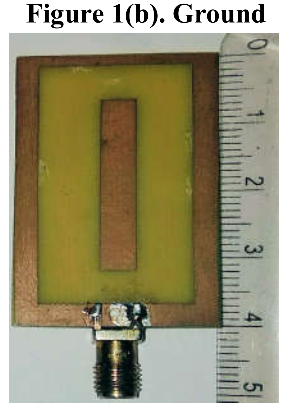


Figure 2(b). Fabricated Ground

Table I: List of Parameters

Parameters	Value (mm)
Width of substrate, *W*	26
Length of substrate, *L*	39
Length of feed, l_f	29.3
Width of feed, w_f	3
L	20.08
M	7.5
N	8
O	2.5
P	10.2
Q	13.7
l_s	34.1
w_s	22
A	25.4
B	4.6

The prototype is fabricated using standard photolithography process. The process of photolithography engrosses UV light exposure through a mask to project the illustration of a design onto the substrate. Rest of the material is then removed using a suitable solvent. The fabricated prototype, both patch view and modified ground, is shown in Figure 2.

3. Simulation Results

The slotted patch antenna is designd using Computer Simuation Technology(CST) microwave studio, 2011. CST provides study of many prameters such as VSWR, return loss, gain, smith chart, radiation patterns, field distribution and many more. These antenna parameters for the proposed antenna are also studied to measure the performance of the proposed antenna.

For perfect impedance matching, the antenna should have a characteristic impedance equal to the impedance of the source or load. Reflections are produced at the load side which travel from load to generator when the impedance of generator is not equal to that of the load. Impedance mismatching is said to occur and is measured in terms of return loss.

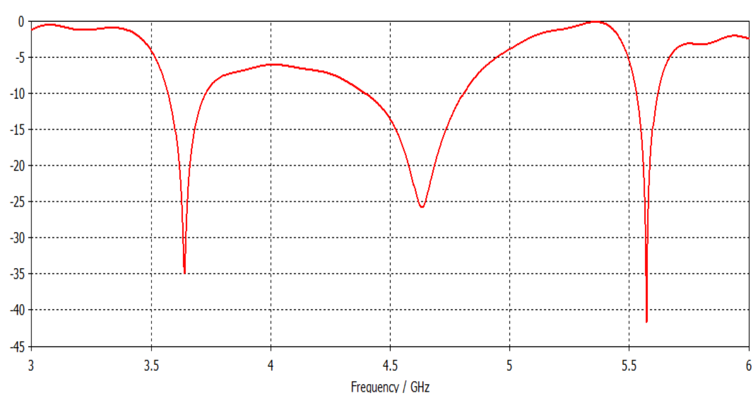


Figure 3. Return Loss of Proposed Antenna

Figure 3 shows the return loss of the antenna proposed as per the parameters shown in Figure 1 and Table I. It is resonating well in all the three frequency bands viz. 3.57-3.72GHz, 4.39-4.81GHz and 5.53-5.61GHz.

VSWR is another factor which shows the efficiency of an antenna in terms of impedance matching. Figure 4 shows that the VSWR of the proposed antenna design is well below 2 for the desired ranges of operation.

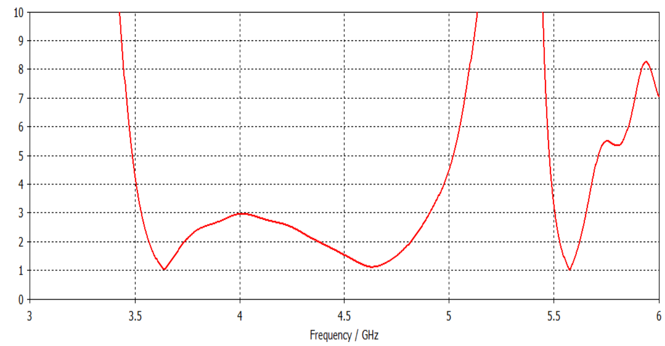
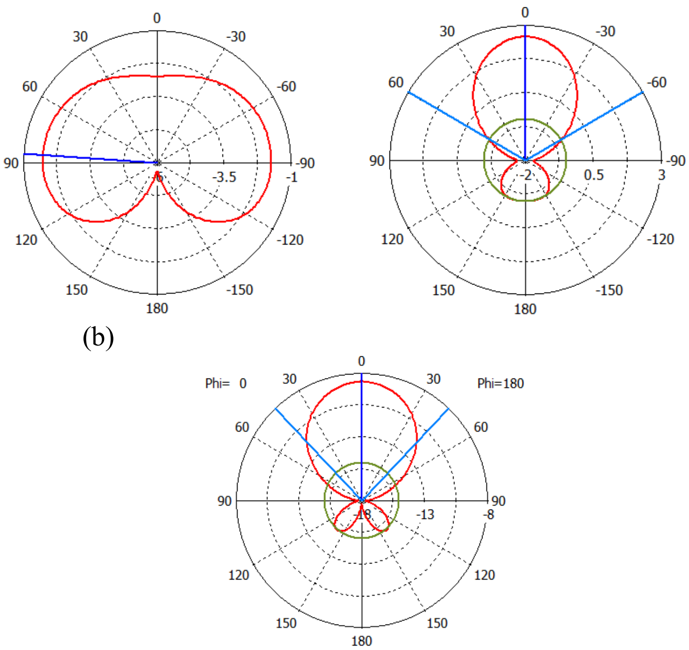


Figure 4. VSWR

Graphical representation of the radiation characteristics of antenna is the Radiation Pattern. It is the combination of E-plane and H-plane patterns. Figures 5-7 show the radiation patterns at 3.63GHz , 4.62 GHz and 5.57 GHz respectively. The H-plane patterns are omnidirectional for all the three resonating frequencies.



(a) (b)

(c)

Figure 5. E-Plane pattern for (a) 3.63GHz, (b) 4.62GHz and (c) 5.57GHz

Gain at three resonating frequencies 3.63GHz, 4.62GHz and 5.57GHz are 0.95dB, 4.12dB and 2.83dB respectively. As discussed earlier, this reduction in gain is the effect of using defected ground structure. Figure 6 displays the Gain vs. Frequency plot.

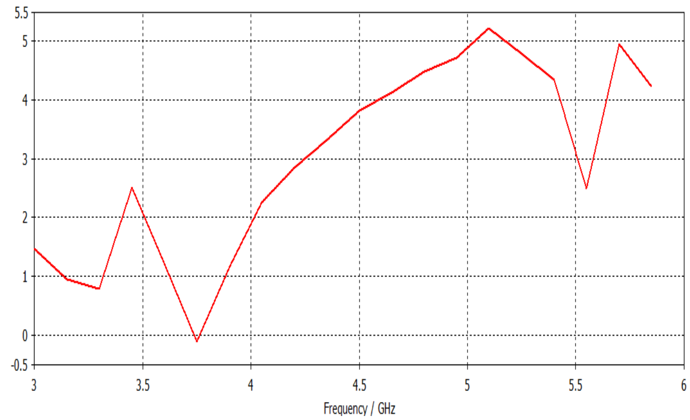


Figure 6. Gain vs. Frequency Plot

4. Experimental Results

The experimental result verification of the fabricated prototype was performed using Vector Network Analyzer (VNA); ROHDE & SCHWARZ ZVA 40. The Vector Network Analyzer is a sophisticated tool proficient of making speedy and precise measurements in frequency and time domain within a frequency range of 10MHz to 40GHz [15] and here has measured the magnitude and phase of the S-parameters, VSWR and Smith Chart. The built in signal processor scrutinize the transmitted and received data and displays the results in many plot formats. Figure 7 shows the measured return loss of octagonal ring slot patch antenna.

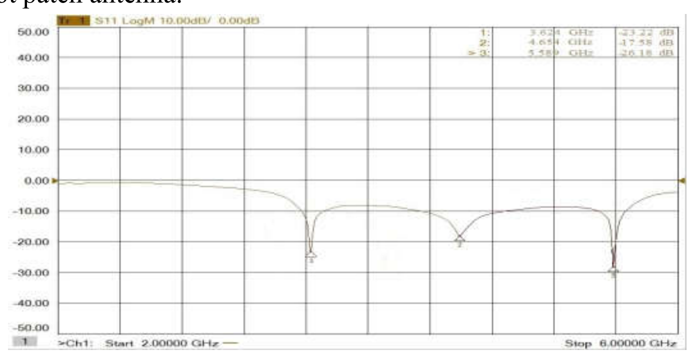


Figure 7. Experimental Return Loss

It is clearly shown that the three resonant frequencies are approximately same as the simulated results and can be considered to be in good match with the simulated results. However, this variation in the experimental results is due to the fact that practically FR4 substrate is very lossy to use above 4GHz as well as realistic environment is also very different from the one considered for simulated results. Moreover, soldering of SMA connector also induces some losses and frequency shift. So, extra care is needed to solder the connector to microstrip feed.

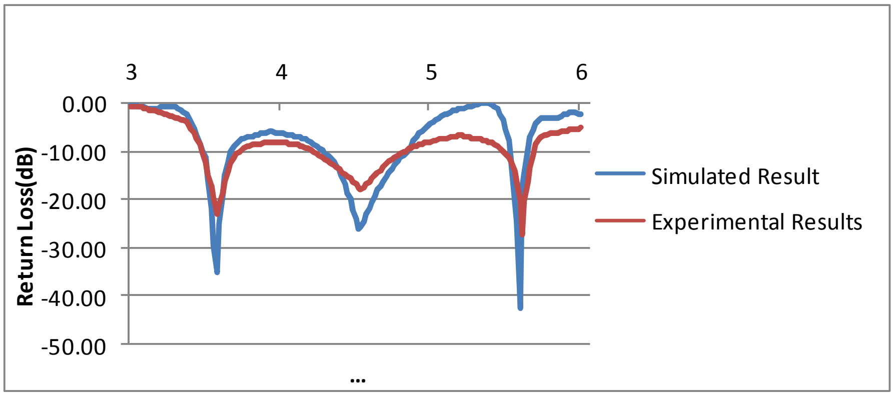


Figure 8. Comparison Between Simulated and Experimental Return Loss

A comparison between the simulated and experimental result is presented in figure 8. The measured return loss is approx -23dB as compared to the simulated value of approx -35dB at 3.63GHz. The measured return loss is approx -17dB as compared to the simulated value of approx -23dB at 4.62GHz. The measured return loss is approx -26dB as compared to the simulated value of approx -42dB at 5.57GHz. A slight frequency shift of 0.03-0.05 GHz is also observed for second and third band.

5. Conclusion

A compact multiband triangular patch antenna with parasitic patches has been presented. The use of defected ground structure and slots has excited additional resonances and an increase in bandwidth. Along with enhancing the bandwidth, use of defected ground structure has also resulted in non-omnidirectional radiation patterns and reduction in gain. The presented antenna can be used for WiMAX, various mobile and fixed services and WLAN.

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