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Design and Characteristics Investigation of Multiband Microstrip Patch Antenna for Wireless Application

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Abstract: *This paper presents design and characteristics investigation of a low-profile compact microstrip patch antenna for multiband application. The antenna with a novel structure is designed on FR4 substrate having dielectric constant 4.4. The proposed antenna consists of a patch with four narrow slits and ground plane to generate six bands of frequency at 1.34, 1.99, 2.98, 3.27, 3.56 and 3.86GHz for different wireless systems. The design is simulated using Ansoft HFSS software. For verification of simulation results a prototype antenna is fabricated and tested. Both simulated and measured results are shown to illustrate the performance of the proposed antenna design.*

Keywords: *Multiband antenna, Stripline-feed, Return loss, VSWR.*

1. Introduction

Wireless technology has undergone different phases of development ever since its inception. Over the years there have been different standards of this technology that evolved out of the demands. Nowadays, there are more and more interests in research on multi-functional systems in the wireless communication [1]. This multi functionality provides users the options of connecting different kinds of wireless services for different purposes at different times.

Rapid developments in the wireless communication require novel antenna designs which can be used for multifunctional systems, which means that the antenna should have more than one frequency band. Microstrip antennas have a variety of configurations and have been the topic of what is currently the most active field in antenna research and development. These antennas have increasingly wide range of applications in mobile as well as satellite communication systems due to their great advantages [2]. As revealed in many literatures [3-4] microstrip patch antennas are proposed for multiband operations. E-shaped fractal design [5], multiband PIFA [6], U-slots on stacked patch [7] are proposed to obtain multiband behavior of patch antennas.

In this paper a novel design of single layer, linefeed, rectangular patch antenna with multiband capability is presented. This antenna can operate at six frequency bands between 1.0 to 4.0 GHz. Good return loss, VSWR and radiation pattern characteristics are obtained. Simulated and measured results are presented to validate the usefulness of the proposed antenna structure for Multiband applications.

2. Proposed Design

The structure of stripline-feed proposed microstrip patch antenna is shown in Figure 1, which is printed on an FR4 substrate of thickness 1.6 mm and permittivity 4.4. The antenna structure consists of a rectangular radiating patch; a ground plane and a 50 ohm feed line. Four narrow slits are taken out from the patch. The antenna is occupying an area of 46.81X36.56 mm^2 on one side of substrate and an area of 57X57 mm^2 for the ground plane on the other side.

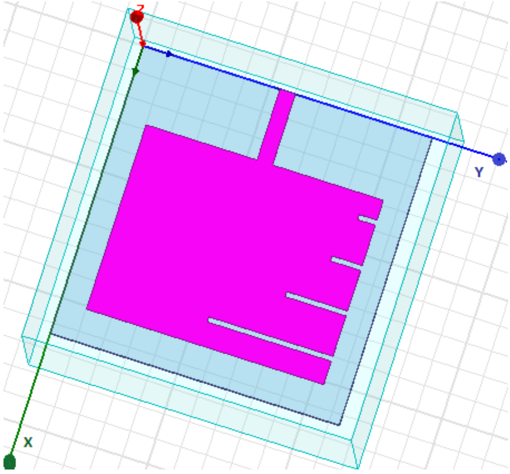

Figure 1. *3D structure of Multiband Antenna including ground plane*

3. CHARACTERISTICS INVESTIGATION

3.1 Return Loss

Return loss is a measure of the reflected energy from a transmitted signal. It is a logarithmic ratio measured in dB (decibel) that compares the power reflected by the antenna to the power that is fed into the antenna from the transmission line. Larger the value of return loss less is the energy reflected. For good impedance matching resonant frequency must lie below -10 dB.

3.2 VSWR

VSWR stands for Voltage Standing Wave Ratio. The parameter VSWR is a measure that numerically describes how well the antenna is impedance matched to the radio or transmission line it is connected to. Smaller the VSWR better the antenna matched to the transmission line and more power is delivered to the antenna. For the perfect matching VSWR = 1, there is no reflection and return loss. In the real system it is very hard to achieve a perfect match, so it is defined that have VSWR < 2 is still good matching system [8].

3.3 Radiation Pattern

Radiation pattern is graphical representation of the relative field strength transmitted from or received by the antenna. It is measurement of radiation around the antenna. Antenna radiation patterns are taken at one frequency, one polarization and one plane cut. The patterns are usually presented in polar or rectilinear form with a dB strength scale [9]. Figure 2 shows radiation pattern for φ= 0^o, 90^o, 180^o, 270^o and 360^o.

3.4 Band Width

Bandwidth is defined as the range between upper cut of frequency at 10 dB and lower cut of frequency at 10 dB [9].

$$BW=f_H-f_L$$

Band width indicates range of frequency for which an antenna provides satisfactory operation. Proposed design has six bands of operations with narrow bandwidths.

3.5 Half Power Beamwidth

The Half Power Beamwidth (HPBW) is the angular separation in which the magnitude of the radiation pattern decreases by 50% (or -3 dB) from the peak of the main beam [9]. Figure 2 shows elevation pattern for φ= 0^o, 90^o, 180^o, 270^o and 360^o. From this figure it is clear that HPBW is 100 degrees.

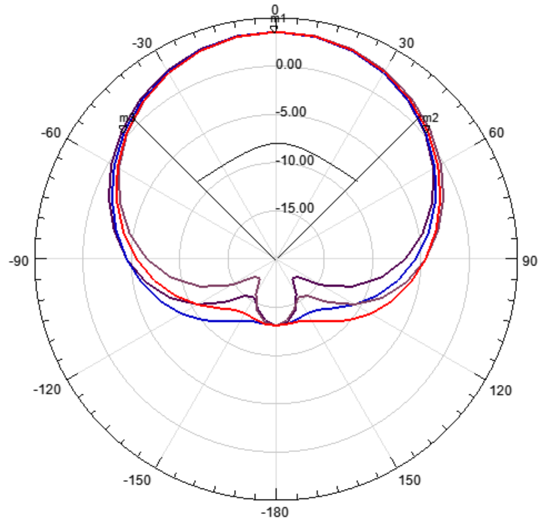

Figure 2. *Beam width*

3.6 Directivity

Directivity of an antenna is a measure of the concentration of the radiated power in a particular direction. Figure 5 indicates the directivity plot of the proposed antenna.

4. Results & Discussion

To validate the above characteristics, the proposed structure is simulated using Ansoft HFSS (High Frequency Structure Simulator) software. Also a prototype of the proposed antenna is fabricated and tested. Figures [3-8] show simulated and tested results.

4.1 Simulated Results

Figure 3 shows simulated S parameter Vs frequency plot of the proposed antenna. From this return loss plot it is clear that the antenna is having six bands of operations. The value of return loss are -13.94dB,-22.78dB, -21.02dB, -15.70dB, -24.64dB and -11.17dB at 1.34GHz, 1.99GHz, 2.98GHz, 3.27GHz, 3.56GHz and 3.86GHz frequency respectively. S11 parameter obtained at all these frequencies has values less than -10dB.

Figure 4 shows simulated VSWR curve of the antenna. The graph indicates that for all six frequencies VSWR is less than 2.

Figure 5 and 6 present directivity plot and radiation pattern of proposed antenna respectively. Maximum achieved directivity is 3.5597dB.

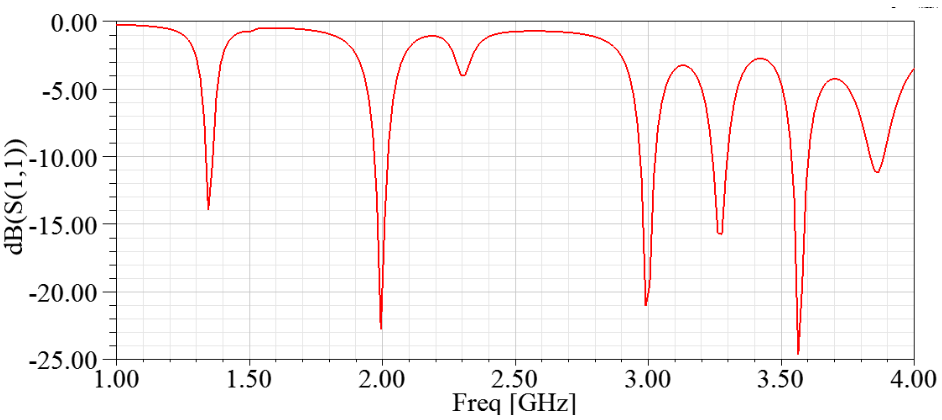

Figure 3. *S parameter Vs Frequency plot*

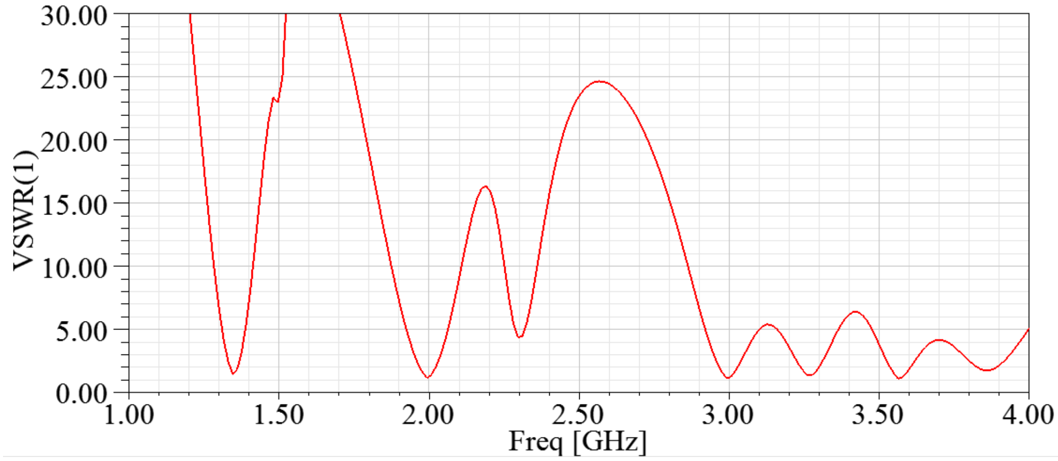

Figure 4. *VSWR Vs Frequency plot*

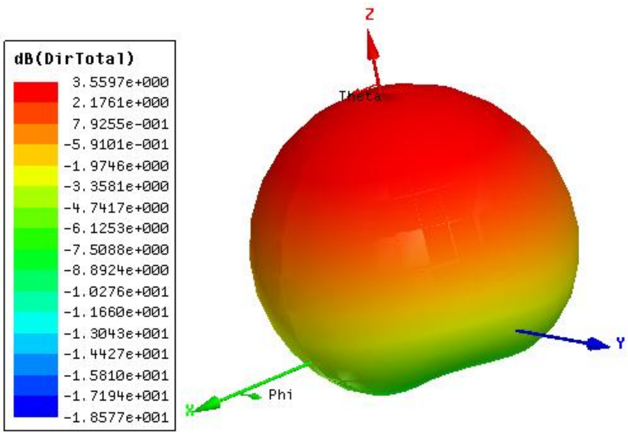

Figure 5. *Directivity plot*

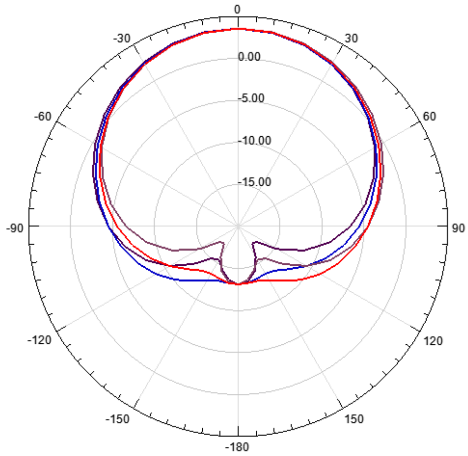

Figure 6. *Radiation Pattern*

4.2 Tested Results

The proposed antenna with optimal design, as shown in Figure 7, is built and tested. The following plots (Figure 7, 8) represent the tested results of the antenna.

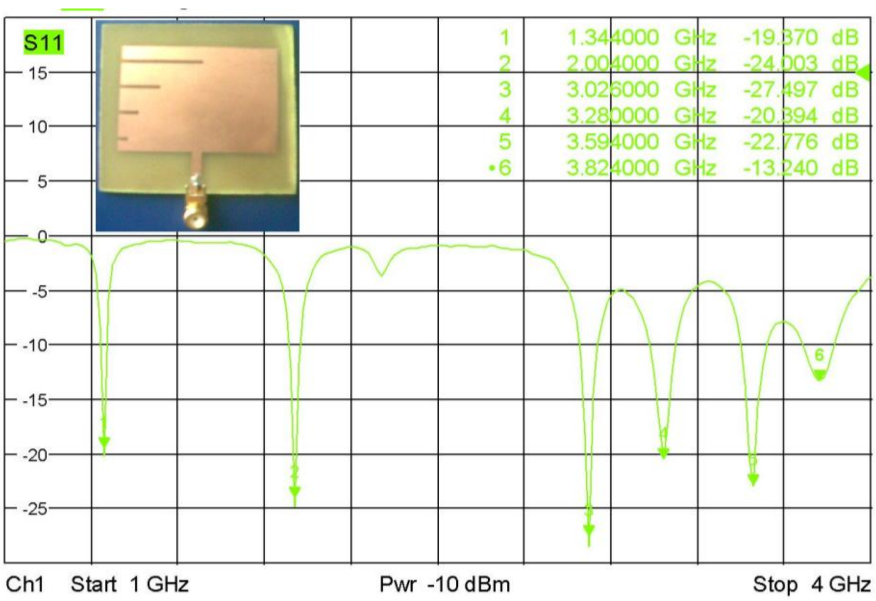

Figure 7. *Tested S parameter Vs Frequency plot*

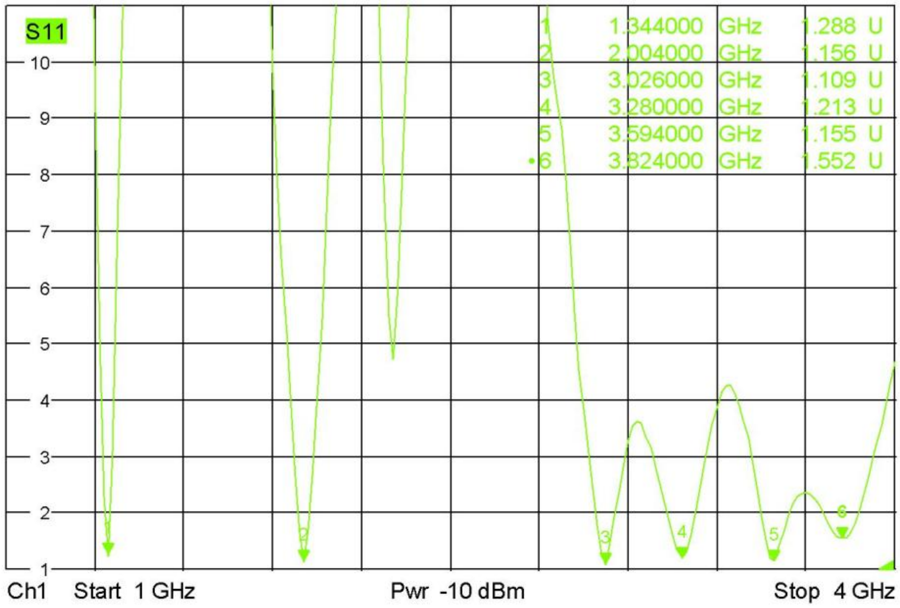

Figure 8. *Tested VSWR Vs Frequency plot*

Table 1 summarizes values of Return loss and VSWR for both simulated and tested results. From this table it is clear that proposed antenna has six resonating frequencies. Simulated and Tested results are nearly same.

Table 1. *Comparison between Simulated and Tested Results*

Frequency	Return loss (in dB)		VSWR	
	Simulated	Tested	Simulated	Tested
1.34GHz	-13.94dB	-19.37 dB	1.50	1.28
1.99GHz	-22.78dB	-24.0 dB	1.16	1.15
2.98GHz	-21.02dB	-27.49 dB	1.19	1.10
3.27GHz	-15.70dB	-20.89 dB	1.39	1.21
3.56GHz	-24.64dB	-22.77 dB	1.12	1.15
3.86GHz	-11.17dB	-13.24 dB	1.78	1.55

5. Conclusion

In this paper design of multiband microstrip patch antenna for wireless system has been proposed and implemented. Simulated and measured results show that the antenna can operate between 1 and 4 GHz at multiple frequencies. It is a low-profile antenna which is easy in fabrication. The measured and simulated results are in good agreement. This proposed antennas has return loss less than -10dB and VSWR <1.8 for all frequencies. Radiation patterns are Omni-directional. This antenna is highly suitable for L and S band applications. It can be used for WLAN, Wi-MAX, WLL and other wireless applications.

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