STACKED U SLOT MICROSTRIP PATCH ANTENNA FOR BANDWIDTH ENHANCEMENT

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Abstract

In this modern wireless communication, the demand for microstrip patch antennas with larger bandwidth has been increased. These antennas are suitable for broadband wireless communication because of their advantages like low profile, ease of fabrication, easiness in the design of dual frequency and dual polarization antennas etc. But conventional Microstrip patch antennas have two major limitations that are low gain and narrow bandwidth (3-6%) of central frequency. This can be eliminated by using different enhancement techniques. In this paper, stacked multi layered configuration and patch geometry modifications like slots on the patch are used for bandwidth enhancement. The software used for the simulation and analysis is CST microwave studio suite which is user friendly software. S_{11} parameter, axial ratio, VSWR, directivity and gain are used for the analysis of designed structure. Axial ratio less than 3 dB shows that the antenna is circularly polarized. This proposed antenna is suitable for WiMax, Wi-Fi, Bluetooth, RFID etc.

Keywords: *Broadband, Stacked Configuration, Patch Antenna, Circular Polarization, Slots, CST Microwave Studio Suite*

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1. INTRODUCTION

Microstrip antenna technology was introduced in late 1950s but its actual development starts only in 1970s. Nowadays microstrip antenna plays an important role in wireless communication. Microstrip patch antennas are preferred than any other antennas for modern wireless communication like cellular phones, WLAN, Bluetooth etc. It is used in these communications due to low size, low profile, low cost and moreover it is easy to fabricate. But it has some limitations of narrow bandwidth, low gain and low efficiency.

A new design technique of microstrip patch antenna with circular polarization for bandwidth enhancement is presented in this paper. Stacked configuration along with patch geometry modifications are used here to enhance the bandwidth. For stacked geometry, the patch radiators are employed one over the other. Therefore two or more resonant patches can share a common aperture area. Main advantage of this geometry is that it does not increase the surface area of the element. It can be utilized in array geometries without the danger of creating grating lobes.

2. LITERATURE SURVEY

Various techniques are used in design of microstrip antennas. Different bandwidth enhancement techniques includes patch geometry modification, EBG structures, defected ground plane models, multi layered configuration, multi resonator structures and impedance matching networks. A rectangular microstrip patch antenna is designed with a probe feed and partial ground plane [1]. At center frequency, the design antenna exhibits a good impedance matching of approximately 50 ohms. Reconfigurable antennas can be used to enhance the bandwidth. It is suitable for terrestrial and satellite links [2]. With this reconfigurable antenna, multiple functions at multiple frequency bands with a single aperture is possible. The reconfigurable stacked square microstrip patch antenna supports a right hand circular polarization with a good axial ratio which is suitable for satellite communication system. Frequency Selective Surface (FSS) superstrate layer on the return loss of a probe-fed microstrip antenna can improve the bandwidth of an antenna. Suitable use of the superstrate layer leads to produce separate resonance frequencies and therefore wide bandwidth [3]. Also the directivity could be achieved by using the superstrate layer that has been made by the FSS layer with square loop elements. Another effective method to overcome the limited bandwidth is to add another patch in front of the basic patch. Resulting structure is called dual patch microstrip antenna [4].

Two configurations of parasitic geometry are coplanar and stacked geometries. In coplanar, number of patches arranged coplanar on the dielectric substrate and they are coupled to main patch [5]. Here only one patch has been excited. For stacked geometry, the patch radiators are placed one over the other with intervening dielectric layers. It helps two or more resonant patches to share a common aperture area.

3. DESIGN

The first step of designing the patch is to choose an appropriate dielectric substrate material. The major electrical properties that considered are dielectric constant ε_r and loss tangent tan δ. Thickness of the substrate should be chosen as large as possible to maximize bandwidth and efficiency, but not so large as to risk surface wave excitation [6-7].

Three essential parameters required for the design are:
Frequency of operation (f_o): - 2.43 GHz
Dielectric constant of substrate (ε_r): - 10.2
Thickness of substrate (h): - 1.5 mm
The design equations for calculating dimensions of patch and substrate are shown below [8]:-

$$W = \frac{c}{2 f_r}\sqrt{\frac{2}{\varepsilon_r + 1}} \tag{1}$$

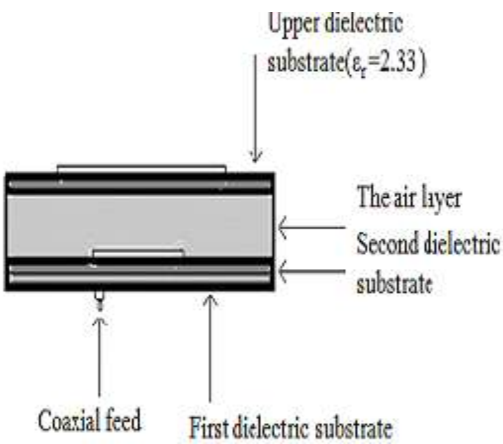
$$L_{eff} = \frac{c_0}{2 f_r \sqrt{\varepsilon_{reff}}} \tag{2}$$

$$\varepsilon_{reff} = \frac{(\varepsilon_r + 1)}{2}\frac{(\varepsilon_r - 1)}{2}\left(1 + 12 \times \frac{h}{W}\right)^{-1/2} \tag{3}$$

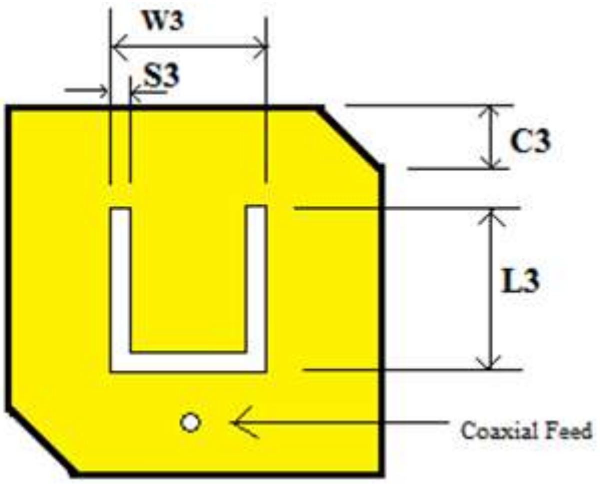
$$\frac{\Delta L}{h} = 0.412 \times \frac{(\varepsilon_{reff} + 0.3)}{(\varepsilon_{reff} - 0.258)}\frac{\left(\frac{W}{h} + 0.264\right)}{\left(\frac{W}{h} + 0.8\right)} \tag{4}$$

$$L_{eff} = L + 2 \times \Delta L \tag{5}$$

The design structure of the proposed antenna is shown in fig.1. The antenna was implemented on a three layer substrate. First and second layer substrates are higher dielectric substrates with a dielectric constant 10.2 and upper substrate is with a dielectric constant 2.33. Rogers RO3010 is used for lower layer substrates and Rogers RT5870 is used for upper layer substrate.



(a)



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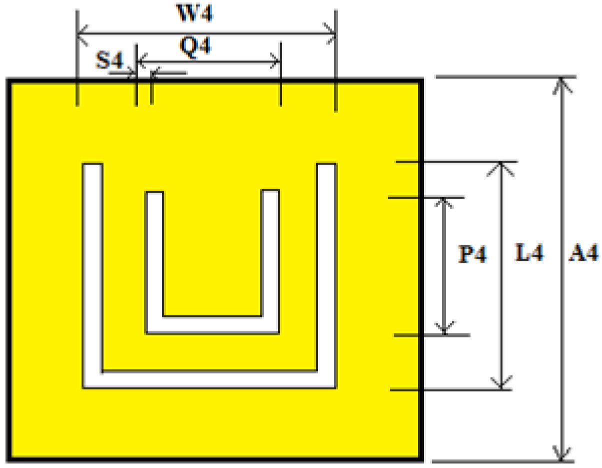

(c)

Fig -1: (a) Side view of the proposed antenna (b) Lower patch design (c) Upper patch design

In this proposed design coaxial feeding is used as the feeding technique. It consists of a coaxial connector and an outer body or flange. The inner conductive pin of coaxial connector is soldered to the patch and outer is soldered to the bottom ground plane. Coaxial feed is widely used as a feeding method because it can be placed at any desired location in the patch to get the optimum results. The additional air layer between the second and third dielectric substrates will improves the gain effectively.

1.1 Design Specifications of Lower Patch

The lower patch was implemented on second dielectric substrate. Cutting a symmetrical U-slot with equal arms in the lower square patch with truncated corners will provide an axial ratio bandwidth of about 4 %. Circularly polarized radiation is generated by the truncated corners. It will be proved that the U slot circularly polarized patch antenna on high dielectric substrate has the attractiveness of small size and good axial ratio bandwidth. The specifications of the lower patch design are shown in table 1.

Table -1: Dimensions of Lower Patch

Parameters	Value
Dielectric substrate	Rogers RO3010
Dielectric constant (ε_r)	10.2
Substrate thickness (h)	1.5 mm
A3	16.5 mm
L3	16.8 mm
C3	6.26 mm
S3	0.6 mm
W3	12.6 mm
Feed position (x direction)	2.63 mm
Feed position (y direction)	8.4 mm

Classical U-slot patch antenna's pattern bandwidth is very narrow but by using a stacked configuration this drawback can be overcome.

1.2 Design Specifications of Upper Patch

Upper patch is implemented on the third dielectric substrate RT5870. The antenna consists of a U slot loaded fed patch, stacked with dual U slot loaded rectangular patch to generate the required frequency range. Design specifications are given in table 2 below:-

Table -2: Dimensions of Upper Patch

Parameters	**Value**
Dielectric substrate	Rogers RT5870
Dielectric constant (ε_r)	2.33
Substrate thickness (h)	1 mm
A4	32.5 mm
L4	13 mm
S4	0.7 mm
W4	14 mm
P4	7 mm
Q4	4 mm

4. RESULTS AND DISCUSSION

From simulated results, the realized gain obtained is 6.9 dB. Fig.2 shows the simulated return loss plot. Impedance bandwidth (S11 < -10 dB) of 570 MHz (2.316GHz-2.886GHz) centered around 2.43 GHz with S11=-34.58 dB is obtained. Axial ratio at 2.43 GHz obtained is less than 3dB. This implies that stacked microstrip patch antenna of fig.1 is circularly polarized. The right hand circular polarization radiation pattern of proposed antenna is shown in fig.3. The directivity and VSWR are 7.12 dB and 1.03 respectively.

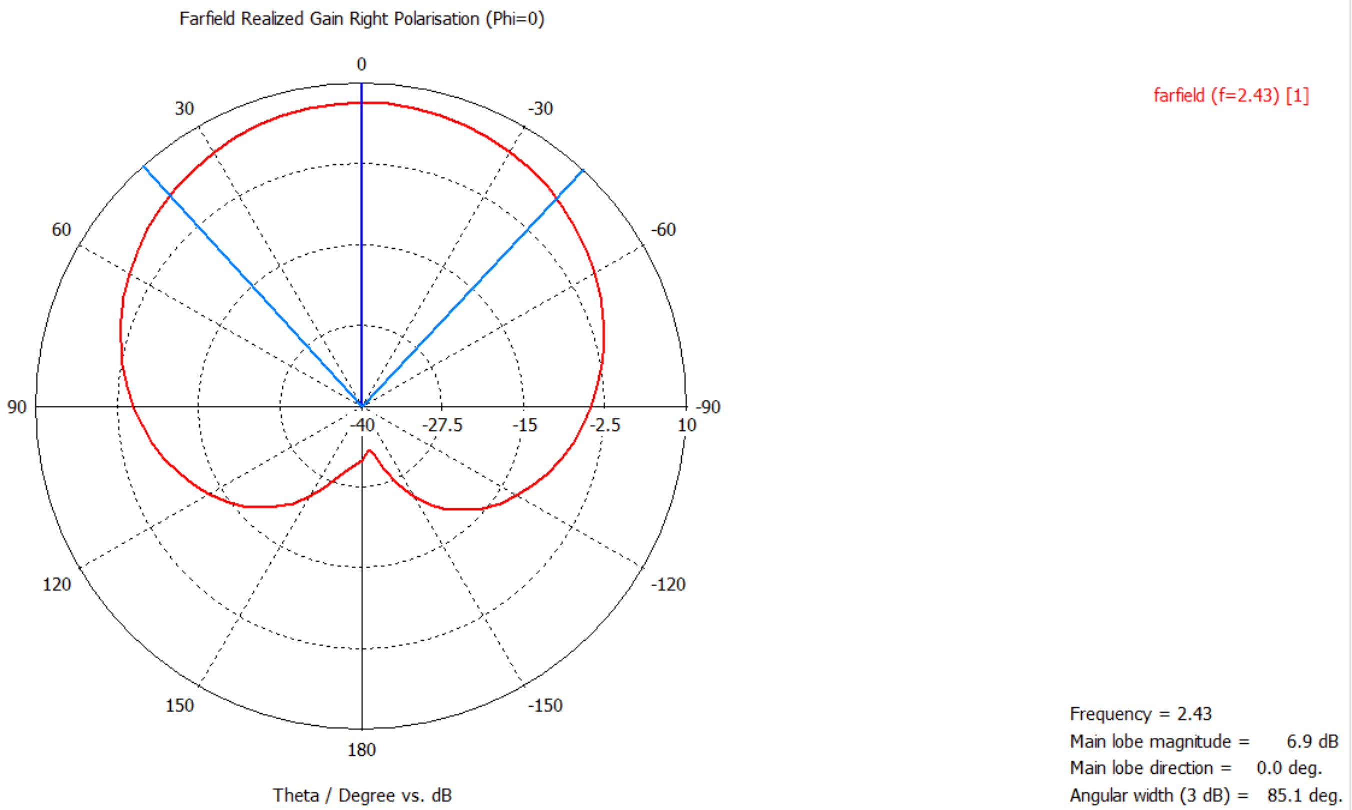

Fig -2: Simulated return loss of proposed antenna in CST Microwave studio

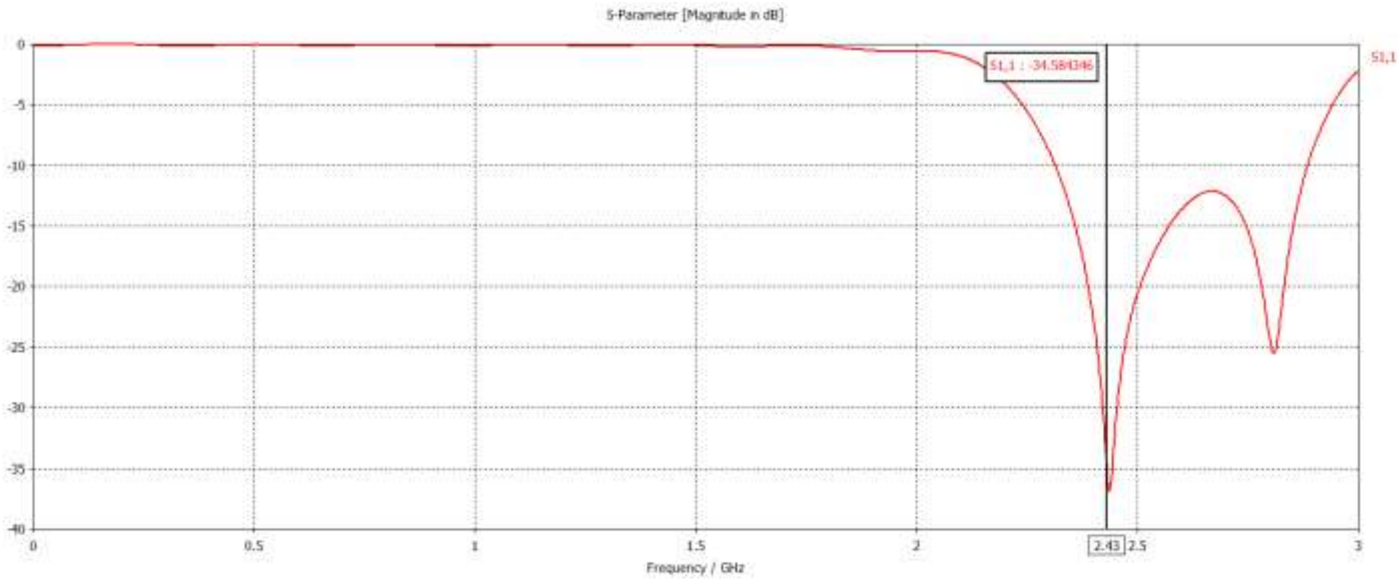

Fig -3: Right polarization pattern (polar) of stacked microstrip patch antenna

5. CONCLUSION

A new microstrip patch antenna in stacked configuration is designed for broadband applications. The limitations of microstrip patch antenna like narrow bandwidth and low gain are eliminated with suitable structures. The proposed structure is designed using CST microwave studio suite software. The main advantage of U slot patch antenna is that it produces broadband characteristics with a single and simple topology. Also a gain of 6.9dB is obtained at 2.43 GHz. The return loss obtained at this frequency is below -10 dB which shows that there is good matching at frequency points. Axial ratio and VSWR values are also good for the structure. This shows that the antenna is good enough to be used for the broadband wireless applications.

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