Broadband Microstrip Patch Antenna using Slot

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ABSTRACT
A broadband high gain microstrip patch antenna using slot is proposed. The Antenna has low profile with enhanced bandwidth and gain. The slot use on the patch's surface affects the radiation characteristics of proposed antenna. The antenna operating frequency range is 4.4 - 6.4 GHz with VSWR less than 2. By using slot on rectangular patch with coaxial probe feed a wide bandwidth is achieved. The IE3D simulation result shows that the proposed antenna has 37% impedance bandwidth. The return loss of -38.82 dB, Gain of 3.8 dBi, Efficiency of about 80% and VSWR of 1.023 is achieved at 5.36 GHz.

Keywords
Low profile, coaxial probe feed, wide bandwidth, slot, return loss.

1. INTRODUCTION
Antennas are key components of any wireless system. The microstrip patch antennas are used in the various fields such as in the medical applications, satellites [10] and of course even in the military systems just like in the rockets, aircrafts missiles etc The microstrip patch antennas are well known for their performance and their robust design, fabrication and their extent usage. The advantages of Microstrip patch antenna can be increase to overcome their demerits such as narrow bandwidth, gain, return loss, efficiency etc. The usage of the Microstrip antennas is spreading widely in all the fields and areas and now they are booming in the commercial aspects due to their low cost [3] of the substrate material and the fabrication. The performance of microstrip patch antennas can be increase by using different techniques like changing feed point, height of dielectric. Slot size, dielectric constant etc. It is well known that the major drawback of a microstrip antenna is its narrow bandwidth [2]. One of the popular techniques for broadening the patch antenna bandwidth is to incorporate U-slot on its surface [1]. In this communication [4] a microstrip patch antenna using dual U-slot with broad bandwidth (>37%) is proposed. The slot on patch's surface affects the radiation characteristics of antenna [1]. The proposed antenna is simulated by using IE3D simulator.

2. ANTENNA GEOMETRY FORMULAS AND DESIGN

2.1 Design Formulas
Microstrip patch antenna consists of a radiating patch on one side of a dielectric substrate which has a ground plane on the other side [7]. So by using transmission line model mathematical analysis of proposed antenna is done. The fringing fields act to extend the effective length of the patch**.** Thus, the length of patch is slightly less than the effective length of patch due to fringing effect.

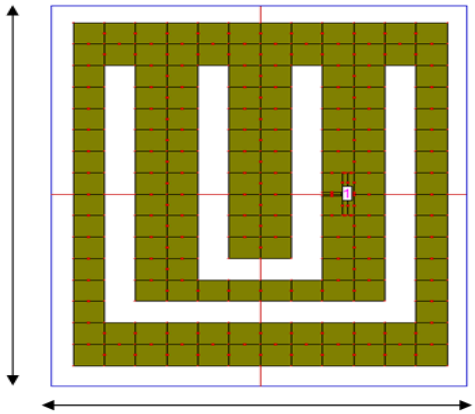

Fig.1. Structure of proposed antenna

The electric field lines in the antenna mostly move in the substrate and even a bit out of the substrate in to the air so the value of ε_{reff} is slightly less than that of ε_r [12]. The effective dielectric constant is given as

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left[1+12\frac{h}{w}\right]^{-1/2}$$

The change in length is calculated as:

$$\Delta L = 0.412h\,\frac{(\varepsilon_{reff}+0.30)\left(\frac{W}{h}+0.264\right)}{(\varepsilon_{reff}-0.258)\left(\frac{W}{h}+0.8\right)}$$

The width of proposed antenna can be calculated by using effective dielectric constant and wave length = C/f_0 as

$$W = \frac{C}{2fo\sqrt{\frac{\varepsilon_{reff}+1}{2}}}$$

The effective length (L_{eff}) and actual length (L) of proposed antenna is calculated as

$$L_{eff} = \frac{C}{2fo\sqrt{\varepsilon_{reff}}} \;\&\; L = L_{eff} - 2\Delta L$$

2.2 Antenna Geometry
The proposed antenna geometry is shown in fig. 2,where a coaxial feed rectangular patch is printed over [1] Glass epoxy FR4 substrate of thickness h=1.5 mm, permittivity ε_r=4.3,and tangent loss is 0.019. Two U-slots are cut on the patch's surface separated by GND plane $L_g \times W_g$ = 26.6 × 32 mm. The GND plane and patch is separated by substrate. The size of proposed antenna is calculated by using formulas described above. The dimensions of Antenna that give a broadband impedance bandwidth are shown in fig. 2.

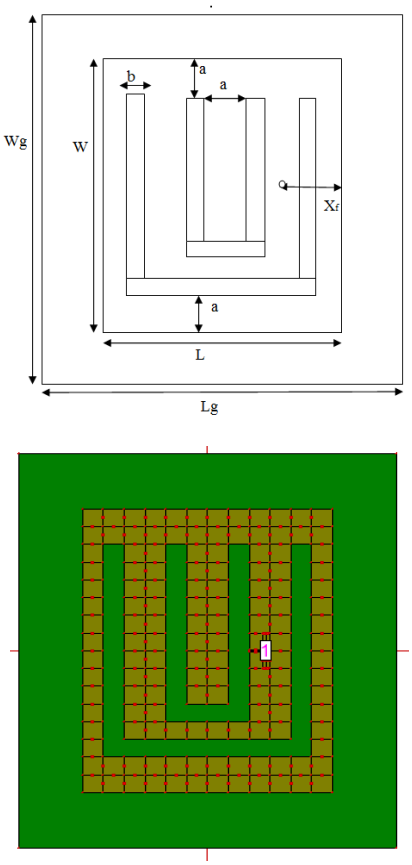

Fig.2. Geometry of proposed antenna (Top view)

Table 1: Dimensions of proposed microstrip patch antenna

Parameter	L_g	W_g	L	W	a	b	X_f
Unit(mm)	26.6	32	17.6	23	3	1.5	4.8

2.3 Parametric Study

The parameters which are responsible for antenna performance are chosen for parametric study. These parameters are length of patch (L), width of patch (W), dielectric constant (ε_r) and slot size. Patch length and slot length are responsible for electric length, whereas W changes patch impedance. Slot size and location shows current distribution on patch's surface [1]. To study the antenna performance parametric study is carried out using IE3D simulation software. The simulation results shows that by changing the parameter of microstrip patch antenna the performance of antenna can be improve. After simulation impedance bandwidth > 37% and return loss -38.82 is achieved at 5.36 GHz.

3. SIMULATION RESULTS AND DISCUSSION

The results of proposed antenna designed on FR4 substrates using coaxial feed technique, simulated and measured by using IE3D simulator are shown in Fig 3.From the figure it is shown that broadening the antenna bandwidth because of using slots on patch's surface. According to the simulated results, slot technique increases impedance bandwidth of antenna. The bandwidth of proposed antenna is 37% (4.4 GHz – 6.4 GHz) is achieved. The return loss is -38.82 dB at 5.36 GHz and -37.18 at 4.75 GHz achieved. Return loss represents the amount of power which is reflected back to source and should be as small as possible. Fig.3 shows the simulated S_{11} plot of proposed antenna. The bandwidth of antenna is calculated at -10 dB of S_{11} plot which represents the usable frequency with reasonable performance.

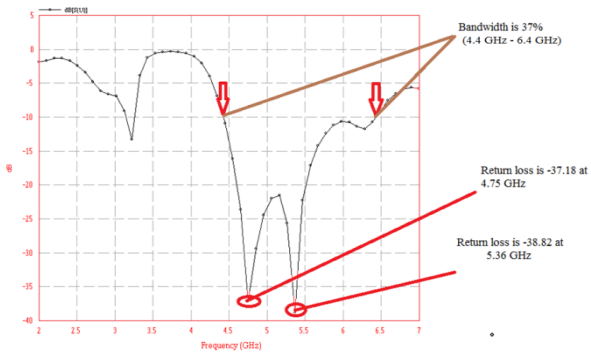

Fig.3. Simulated return loss of proposed antenna.

The simulated result of proposed antenna shows that the VSWR (fig.4) is minimum (1.023) and directivity which is the maximum directional gain of antenna is 4.2 dBi at 5.36 GHz frequency (fig.5). The Smith chart (Fig.6) shows the normalized impedance of proposed antenna. Fig.10 shows the magnitude of Z-parameter which is about 50 ohm at 5.36 GHz frequency. The antenna and radiation efficiency 80% achieved after simulation of proposed antenna is shown in Fig.7. The measured radiation pattern E-total is shown in fig.8 and polar plot of E-total is shown in fig.9. Polarization of radiation represents the property of electromagnetic wave describing the electric field vector as the time varying direction.

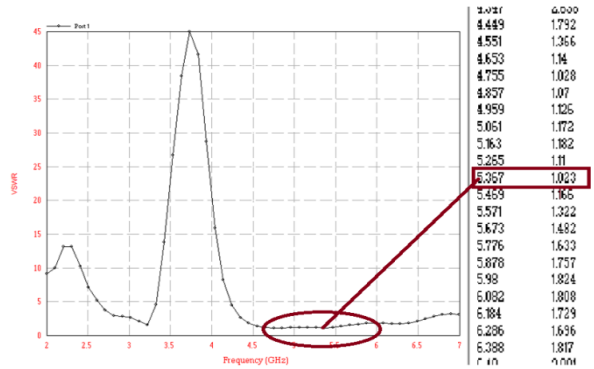

Fig.4. VSWR of proposed antenna

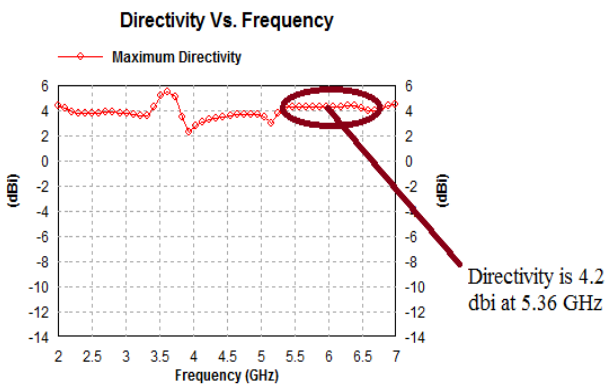

Fig.5. Directivity of proposed antenna.

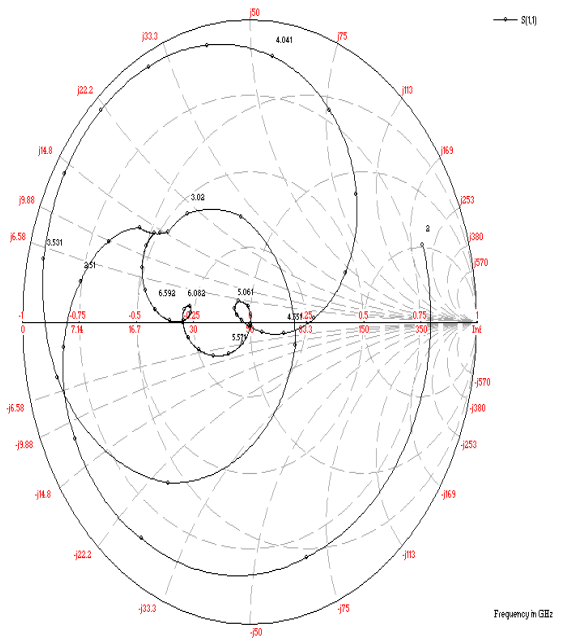

Fig.6. Smith chart of proposed antenna.

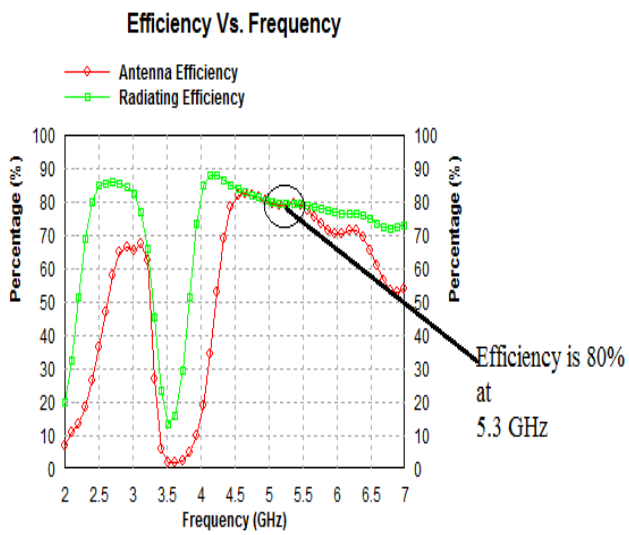

Fig.7. Antenna and radiation efficiency of propose antenna.

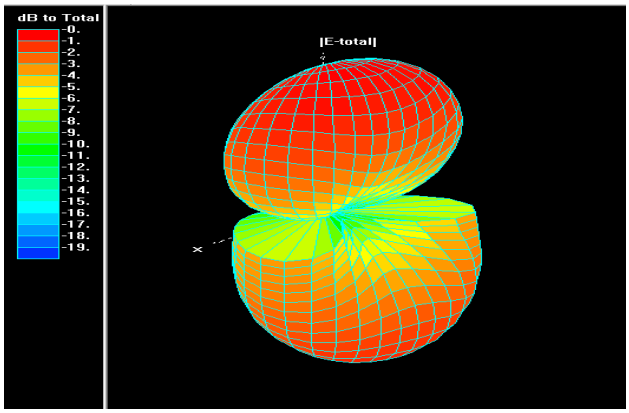

Fig.8. E-total of proposed antenna

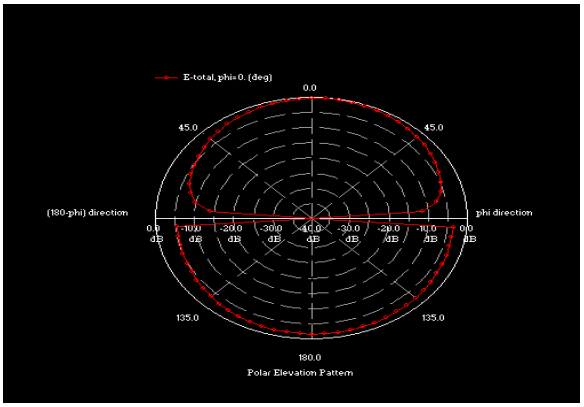

Fig.9. Polar plot of E-total of proposed antenna

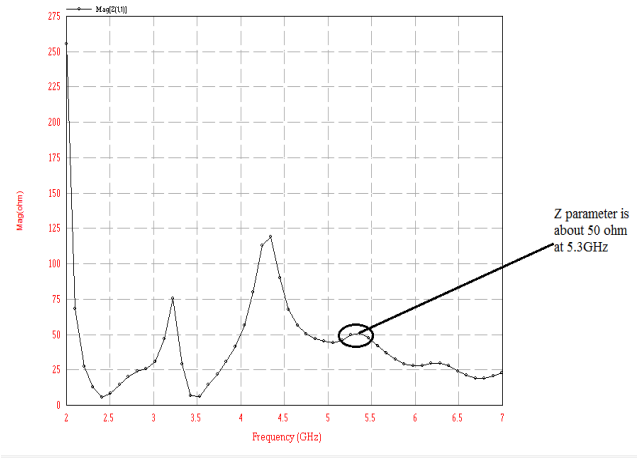

Fig.10. Magnitude of Z-parameter of proposed antenna

4. CONCLUSION

Broadband microstrip patch antenna using dual U-slot with low profile has been proposed and analysis of results has been done by using IE3D simulator. The results of proposed antenna shows that by using proper slot size on patch's surface the performance of antenna can be improve. The proposed antenna has 37% impedance bandwidth (4.4 GHz – 6.4 GHz) achieved in C-band. The return loss -38.82 dB and VSWR 1.023 achieved at 5.36 GHz. The proposed antenna efficiency 80% and directivity 4.2 is measured as the result of simulation at 5.36 GHz. The proposed antenna is desirable candidate for satellite communication and wireless telephone network.

5. REFERENCES

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