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# Moon Shape Microstrip Patch Antenna with Stair Case Ground

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***Abstract:*** In this paper, Moon shape microstrip patch antenna with stair case ground is presented. This antenna provides triple band that can be used for RADAR/SATELLITE/WLAN applications. The antenna is simulated using Ansys Soft HFSS simulator. The size of the antenna is 40mm*45mm*1.5mm.The antenna is printed on FR4 substrate material which has the dielectric loss tangent of 0.02 and the permittivity of 4.4. CPW feeding technique is used to feed this antenna. Stair case ground is used in this design of the antenna to improve its performance. It covers the operating frequency range of 5-10GHz and provides triple frequency bands of 5.78- 5.9GHz, 6.8-7.1GHz and 8.4-8.66GHz. The return losses of -34.3db, -32.3db and -38.4db are provided at the resonant frequencies of 5.8GHz, 7GHz and 8.5GHz respectively by this antenna. Stable omni directional as well as bidirectional radiation pattern is shown by the proposed antenna.
***Key Words**: MOON shape patch, Stair Case Ground, CPW Feeding, Triple Band*

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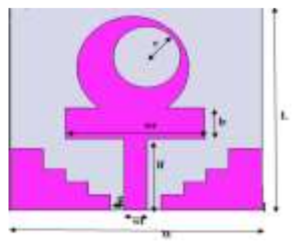
## I. INTRODUCTION

The demand in the satellite communication and wireless communication has increased in past decades. Today the world depends upon the wireless communication. The development in the WLAN is the main topic in which interest is shown from few years for the communication. So in modern era low weight, low cost, low profile antenna but maintains high performance over a large spectrum which makes the Microstrip patch antenna( MPA) designing to be focused. These are suitable to WLAN/WiMAX applications as well. The main disadvantage of the MPA is narrow band width [1]. This disadvantage can be improved by cutting the slots in the MPAs. Various slots of different shapes are cut to improve the narrow band width. The slots of rectangular, spiral and S-shapes are cut in MPAs [2-5]. They all provide the good impedance matching, stable radiation pattern and ultra wide band frequency range. To improve the impedance bandwidth triangular shape stair case ground antenna with CPW feeding is presented in [6] which also show the stable omni directional radiation pattern. Microstrip antenna is fed by three feeding techniques microstrip feeding, CPW feeding and inset feeding. CPW fed antennas of various designs are presented in [7-10]. They are used for different applications like Millimeter applications, UWB applications, Radar applications etc. The performance of the antenna is improved by using artificial magnetic conductor (AMC) reflector in [8]. The antenna of [10] shows the band notched characteristics and uses Sharp Skirt Selectivity for the UWB applications.

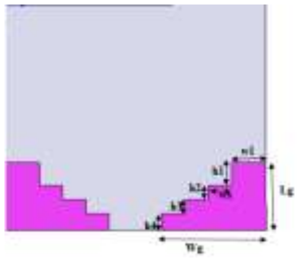
The goal of this paper is to achieve the triple band antenna by designing the Moon shape patch antenna with stair case ground. A circular slot is cut into the patch of the antenna to give its moon shape and the ground of the proposed is of stair case. The overall dimension of the antenna is 40mm*45mm*1.5mm. The design with different number of stairs in ground and different shapes of the slot in the patch is also studied to observe their effect on the performance of the antenna.

## II. DESIGN GEOMETRY

The antenna configuration is shown in fig. 1. The dimensions of the patch of the antenna and the ground of the antenna are shown in fig 1.a and fig. 1.b. The circular slot is cut into the patch of the antenna to provide it MOON shape and the rectangles of different configurations are cut from two finite ground to make it stair case ground. FR4 material of the substrate having the dielectric constant of 4.4 and loss tangent of 0.02 is used to print the antenna. The length and width of two finite grounds are 12mm*15mm*1.5mm. The radius of the circular slot cut into the patch of the antenna is 6mm. The dimensions of the patch and the stairs of the ground plane are shown in the table 1. 50Ω microstrip line is used o feed the antenna. The gap between the ground plane and the feed line is of 2.5mm.



(a) Patch of the proposed antenna



(b) Ground of the proposed antenna

Figure 1. Geometry of the moon shape microstrip patch antenna

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TABLE 1 DIMENSIONAL DESCRIPTION OF THE PROPOSED ANTENNA

| Parameters | Size in mm |
|---|---|
| L | 40 |
| W | 45 |
| Lg | 12 |
| Wg | 18 |
| Lf | 14 |
| Wf | 4 |
| h4 | 3 |
| h3 | 2.5 |
| h2 | 2.5 |
| h1 | 4 |
| w1 | 6 |
| Ws | 4 |
| Lr | 6 |
| Wr | 24.8 |
| Radius of the circular patch | 10 |
| R | 6 |
| G | 2.5 |

## III. RESULTS AND DISCUSSION

### *a) Return losses*

Fig. 2 shows the simulated results of the proposed antenna. It shows that the proposed antenna provides triple band of range 5.78- 5.9GHz, 6.8-7.1GHz and 8.4-8.66GHz. The return losses in these bands are below -10db as shown in the fig.2. The return loss achieved at differ resonance frequencies is shown in table 2. The antenna can be used for WLAN (5.78-5.9GHz)/SATELLITE (6.8-7.1GHz)/RADAR (8.4-8.66GHz) applications.

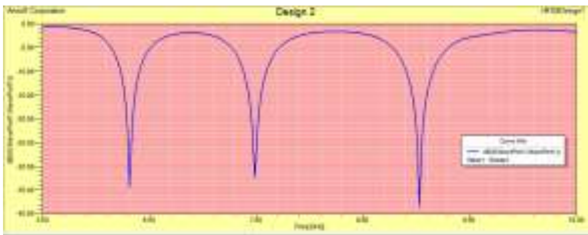



Figure 2. Simulated results of the proposed antenna

TABLE 2 RETURN LOSSES AT DIFFERENT RESONANCE FREQUENCY

| Resonant frequencies | Return losses |
|---|---|
| 5.8GHz | -34.3db |
| 7GHz | -32.3db |
| 8.5GHz | -38.4db |

### *b) VSWR*

The VSWR results due to the impedance mismatch. So it should be minimum for good impedance matching. Fig. 3 shows that the VSWR is below 2 for the operating frequency bands of 5.78- 5.9GHz, 6.8-7.1GHz and 8.4-8.66GHz which shows that this antenna provides good impedance matching in the operating frequency ranges.

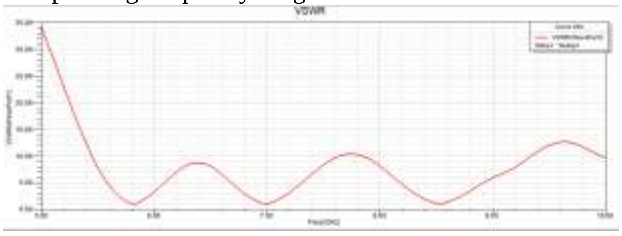
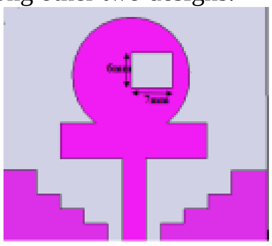


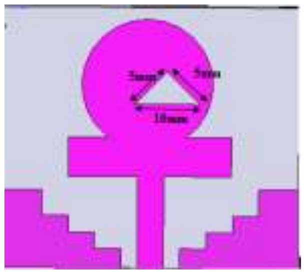

Figure 3. Simulated VSWR of proposed antenna

### *c) Effect of different shapes of the slot cut in the radiator*

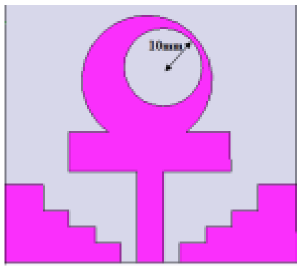
The slots are cut in the radiator to improve the performance of the antenna. Different shapes viz. Rectangular, Triangular and Circular of the slot as shown in the fig. 4(a-c) are compared to analyze their effect on the performance of the antenna. The simulated comparison result is shown in fig. 5. It shows that the return loss provided by the circular slotted antenna is best among other two designs.




(a)




(b)




(c)

Figure 4. (a) Rectangular slot in the radiator of the antenna (b) Triangular slot in the radiator of the antenna (c) Circular slot in the radiator of the antenna

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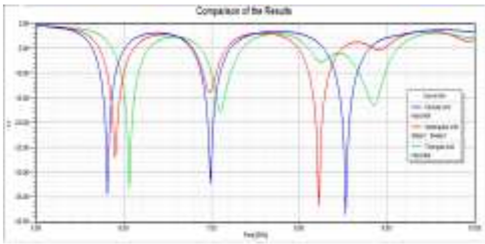


Figure 5. Comparison of the simulated results

The results show that the circular slot in the radiator of the antenna provides the best results among all other designs. The frequency bands covered by these designs are given as 5.78-5.9GHz, 6.8-7.1GHz and 8.4-8.66GHz (circular slot), 5.8-6GHz, 6.9-7.05GHz and 8.1-8.3GHz (rectangular slot) and 5.9-6.16GHz, 7-7.2GHz and 8.6-8.9GHz (triangular slot). Resonant frequencies and the return losses at resonance frequencies are shown in table 3.

TABLE 3 RETURN LOSSES AT RESONANCE FREQUENCIES OF DIFFERENT SLOT SHAPE ANTENNAS

| **Different slot shapes** | **Resonant Frequencies in (GHz)** | **Return losses at resonant frequencies in (db)** |
|---|---|---|
| Circular slot | 5.8, 7 and 8.5 | -34.3, -32.3 and -38.4 |
| Rectangular slot | 5.9, 6.9 and 8.2 | -27, -13.9 and -36.7 |
| Triangular slot | 6.06, 6.89, 8.86 | -33.3, -32.3 and -16.3 |

*d) Effect of ground geometries*

The number of stairs of the stair case ground is varied in this section to observe their effect on the performance of the antenna. The effect of the one step stair ground, two steps stair ground and three step stair ground and simple ground is compared in fig. 7. Fig. 6 (a-d) shows the geometry of all designs.

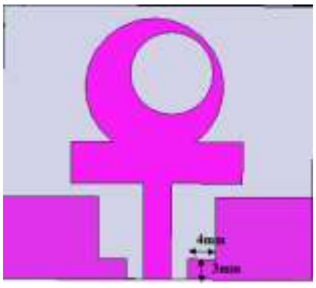


Figure 6(a) with one step

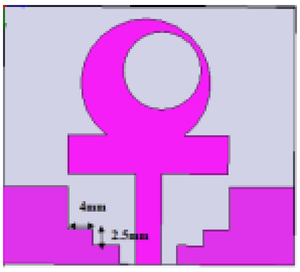


Figure 6(b) with two steps

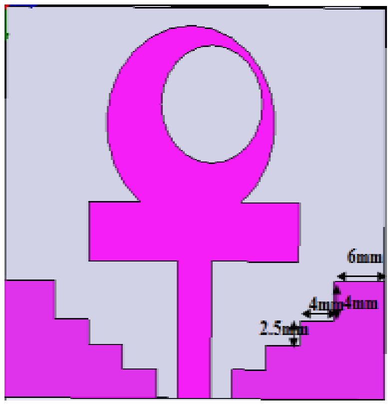


Figure 6(c) with three steps

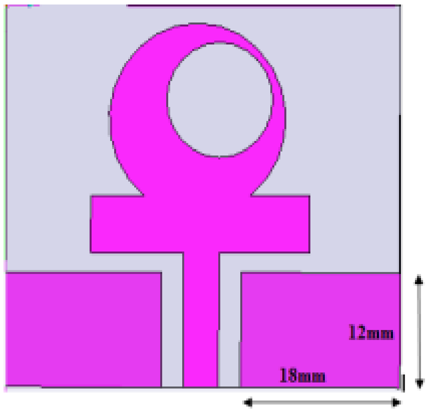


Figure 6(d) with simple ground

Figure 6. Different number of steps of stairs in the ground

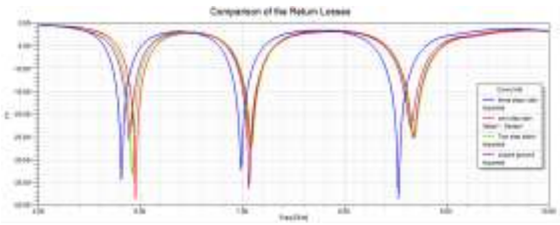


Figure 7. Comparison of the simulated results

The comparison graph of the return loss shows that the three steps stair case ground provides the best results. They have minute effect on the band width. But there is variation in the return loss which is described in the table 4.

TABLE 4 RETURN LOSSES AT RESONANCE FREQUENCIES FOR DIFFERENT GROUND GEOMETRIES

| **Different ground geometries** | **Resonant frequencies in (GHz)** | **Return loss at the resonant frequencies in (db)** |
|---|---|---|
| Simple ground | 5.9, 7 and 8.6 | -25.6, -36.4, -22.3 |
| With one step of stair | 5.9, 6.08 and 8.66 | -38.6, -27.3 and -24.5 |
| With two steps of stairs | 5.9, 7.08 and 8.67 | -33.1, -27.3 and -25.1 |
| With three steps of stairs | 5.8, 7 and 8.5 | -34.3, -32.3 and -38.4 |

*Radiation pattern*

Radiation pattern at resonance frequencies of 5.8GHz, 7GHz and 8.5GHz is shown in fig. 8. The 2-D plot is shown for the phi value of 0°, 90° and 180°.

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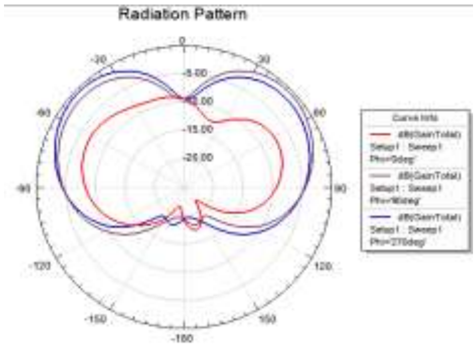
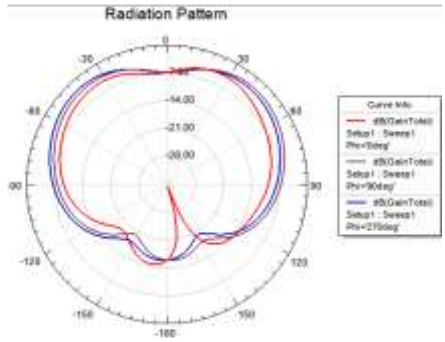
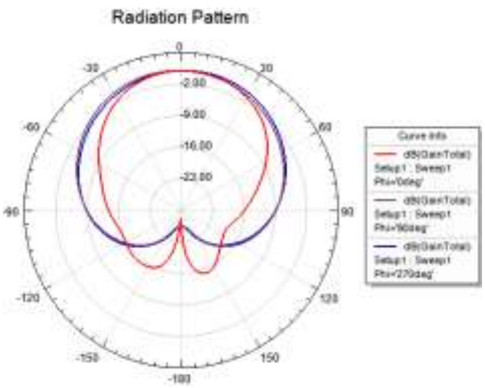



At 5.8GHz




At 7GHz

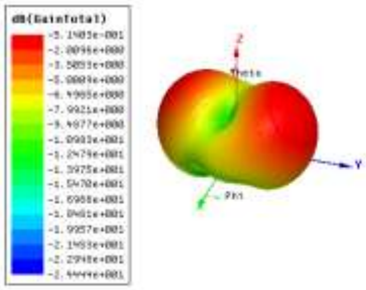



At 8.5GHz

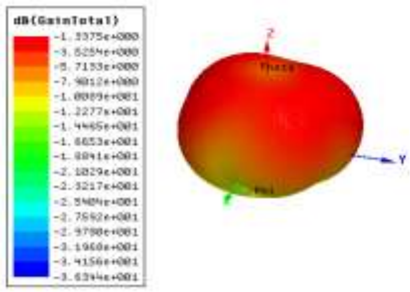
Figure 8. 2-D Polar plots at different resonance frequencies

*e) 3-D polar plot*

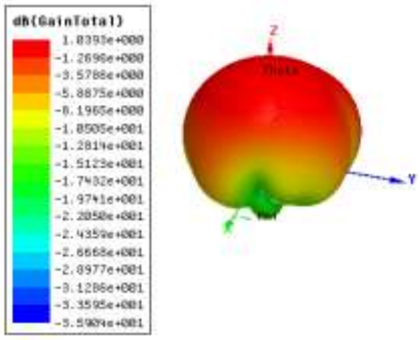
3-D polar plot for the proposed antenna is shown in fig. 9 at 5.8GHz, 7GHz and 8.5GHz. It can be said from the figures that the antenna has the bidirectional radiation pattern at 5.8GHz and omni directional radiation pattern at 7GHz and 8.5GHz. The red portion shows that the proposed antenna radiates maximum in that portion.




At 5.8GHz




At 7GHz




At 8.5GHz

Figure 9. 3-D polar plot at different resonance frequencies

## IV. CONCLUSION

In this paper, Moon shape microstrip patch antenna with stair case ground of dimension 40mm*45mm is presented. The patch of the antenna is given the shape of moon by cutting the circular slot and the ground planes are given the shapes of stairs by cutting different rectangles from it. It provides the omni directional as well as bidirectional radiation pattern. The results also show that the result loss is below -10db at the resonance frequencies of 5.8GHz, 7GHz ,8.5GHz and VSWR is less than 2 in the operating frequency bands of 5.78-5.9GHz, 6.8-7.1GHz and 8.4-8.66GHz. The proposed antenna can be used for WLAN/SATELLITE/RADAR applications.

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