# A Metamaterial Inspired, Slotted Multiband Patch Antenna with Reconfigurability

**Banuprakash. R, Hariprasad. S.A**

***Abstract*: In this letter the antenna is designed for achieving the multiband frequency configuration with the dimension of 26*26*1.6 mm3 with the use of substrate of dielectric constant of 4.4. It is capable of operating at the frequency of 3.9 GHz,5.8GHz and 6.7GHz, with a gain of 2.9dB,4.6dB,-1.5dB respectively. By using the method like DGS, Slots and SSRR structure, the design is able to generate and operate at the above mentioned frequencies. Furthermore by placing a metallic switch on the rectangular shaped slot the proposed antenna can also be used as reconfigurable antenna to produce different frequency.***

***Index Terms*: Slots, DGS, Reconfigurability, HFSS.**

## I. INTRODUCTION

In recent years the rapid development of the antenna has led to the increased demand of multiband microstrip antenna[6]. This has changed the approach of antenna design in completely diverse way[2]. Antenna is a passive device which converts electrical energy into Radio Frequency energy and couple it to free space for transmission. Since the antenna is an elementary device for wireless communication setup the microstrip multiband antenna has given a new manner to accomplish this objective.

The performance of an antenna depends on the design parameters like dielectric constant, height of the substrate, frequency etc. There is an immense need of packed size and light weight antenna's which can be effectively bound together in present day communication systems. The micro strip patch antenna have been broadly utilized in elite satellite and remote specialized gadgets because of their low cost, compact shape, lightweight, simplicity of creation and similarity of combination with circuit technology. However, low transmission capacity, low power handling limit, low gain and directivity are the real disadvantages of patch antenna. Therefore, the challenge in microstrip antenna design is to increase the bandwidth and gain.

To attain good gain and bandwidth, at low frequency bands in handheld and portable wireless devices antenna size plays a dynamic role. For flexibility to various situations in wireless remote sensing and radar systems, antenna with numerous working frequencies is must [2] and patch antennas can be designed by engraving a portion of metal on ground plane either in periodic or non-periodic mode called as Defective Ground Structure (DGS). A break in the current distribution created by the slots make a positive influence on input impedance to generate supplementary resonant frequencies [5].

For better compatibility and to satisfy the developing needs of different portable electric devices, many wideband, ultra wideband and multiband antennas have been designed. In any case, multiband antennas are a preferred choice over other wide band and ultra wide band antennas as they ease the effects of electromagnetic impedance and pulse distortion. [1]. Overall, multiband resonant modes can be achieved by altering patch or ground plane. This can be achieved by adding multi-diverged strips and carved slots [3].

### A. Reconfigurability of the Antenna

The progression in wireless communication technologies composed with the upward need of reconfigurable property of antenna for users has motivated the demand for smaller and multi-functional wireless antennas in communication device. Reconfigurable antennas have been proposed to fix a vital issue of employing the restricted spectrum effectively on the communication applications [4]..

## II. ANTENNA GEOMETRY AND RESULTS

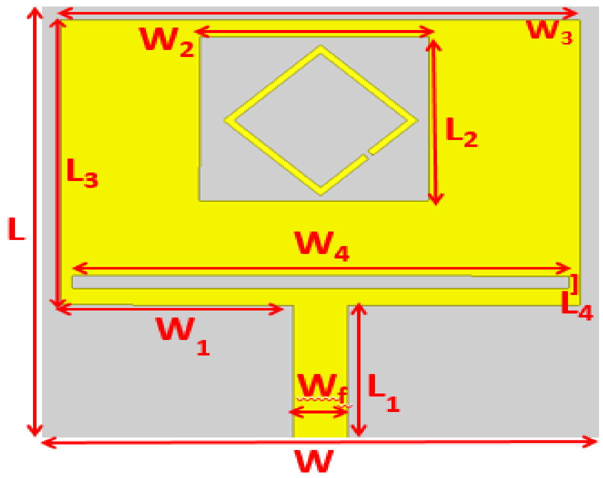


Fig1.Front View

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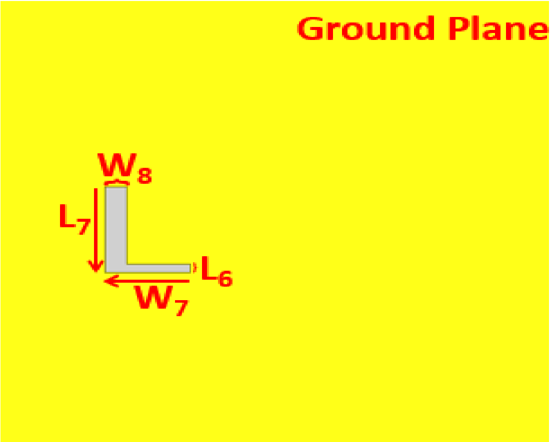



Fig.2. Back view

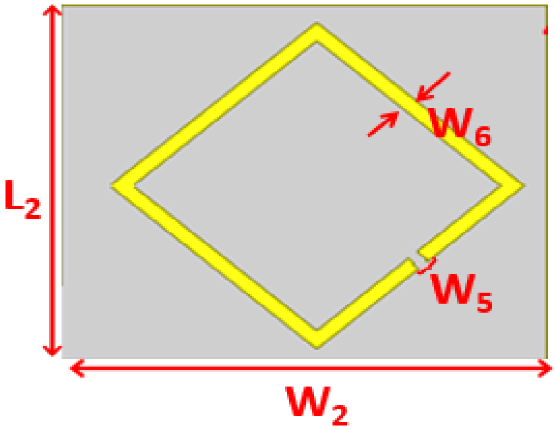
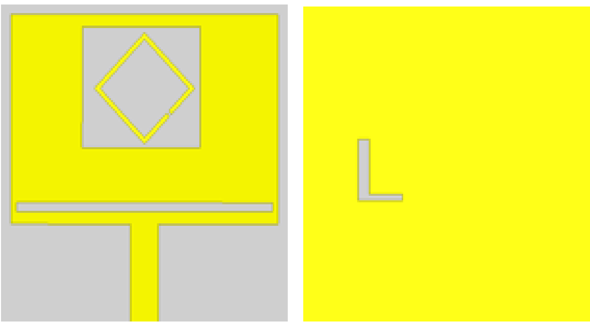



Fig. 3. SSRR structure

The measurements of the design are listed below:

| | |
|---|---|
| W = 26 mm | L = 26 mm |
| W1 = 10.75 mm | L1 = 8 mm |
| W2 = 10.6 mm | L2 = 9.8 mm |
| W3 = 24 mm | L3 = 17 mm |
| W4 = 23 mm | L4 = 0.45 mm |
| W7 = 4 mm | L6 = 0.5 mm |
| W8 = 1 mm | L7 = 5mm |

The above mentioned structure is obtained after the repeated iterations. The different steps which led to the final design and corresponding results are as follows



Patch Ground

Fig.4a) The proposed design

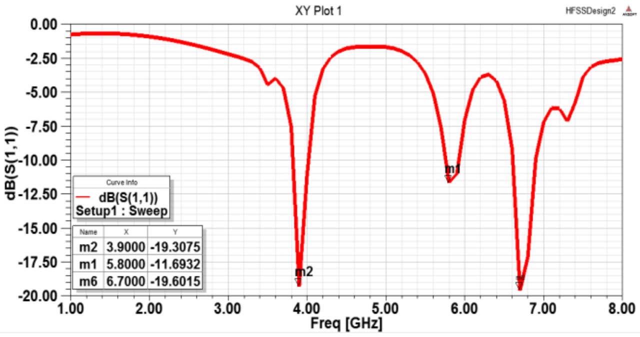



Fig. 4b). Plot of return loss for proposed antenna

And the initial designs which led to the proposed antenna are as follows

**Step1:**

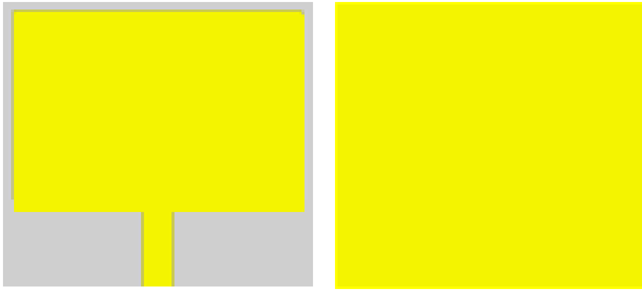


Fig5.a) Patch Ground

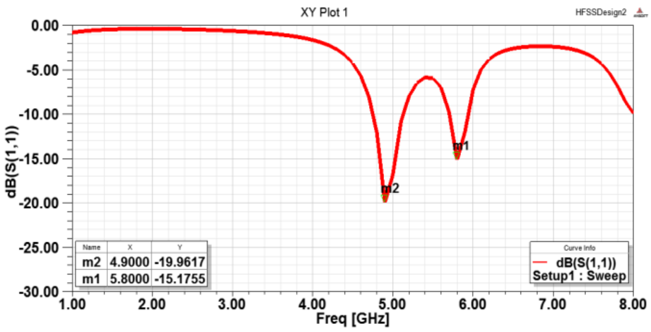
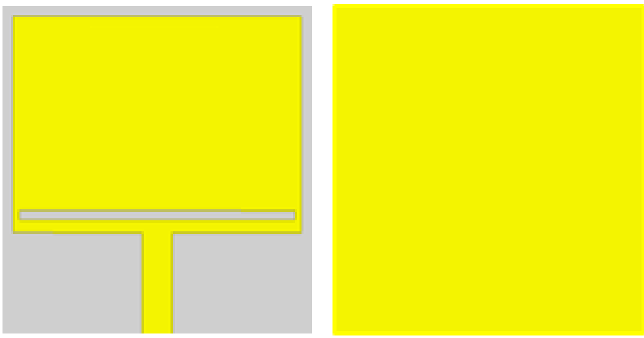



Fig.5.b) Frequency Vs Return loss

Fig.5(a,b). Initial design and the corresponding result

**Step 2:**



Patch Ground

Fig6.a) Design with slot

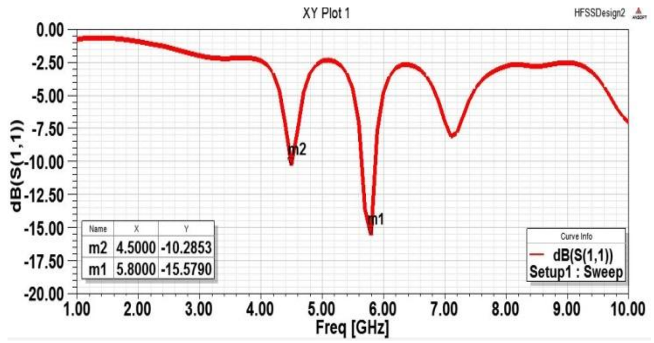
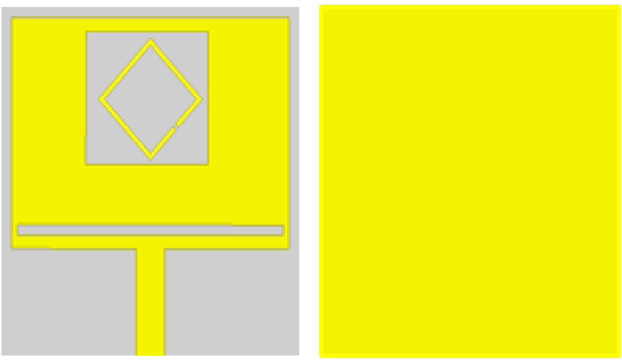



**Fig.6 b)** Return loss

**Step 3:**



Patch Ground

Fig.7 a) Patch with Square Split Ring Resonator

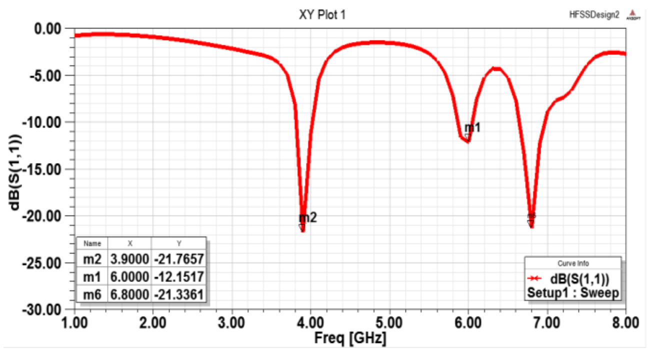



Fig.7 b) Return loss

The above mentioned steps have given the corresponding return loss values and hence giving the operating frequencies. From the above mentioned design steps and the corresponding results it shoes that initially the simple microstrip patch antenna is able to generate 4.9GHz and 5.8GHz frequencies but after the insertion of rectangular slot near the feed the antenna produced 4.5GHz and 5.8 GHz. Then to produce another frequency the use of SSRR structure is incorporated and the antenna is simulated to get the result. The antenna was then able to generate 3.9 GHz,6GHz and 6.8GHz.

To obtain a better gain an L slot is presented in ground plane hence leading to the defective ground structure (DGS). It produced the final set if frequencies of 3.9GHz, 5.8GHz and 6.7GHz with good gain.

**The plot of gain for above mentioned frequencies are as follows**

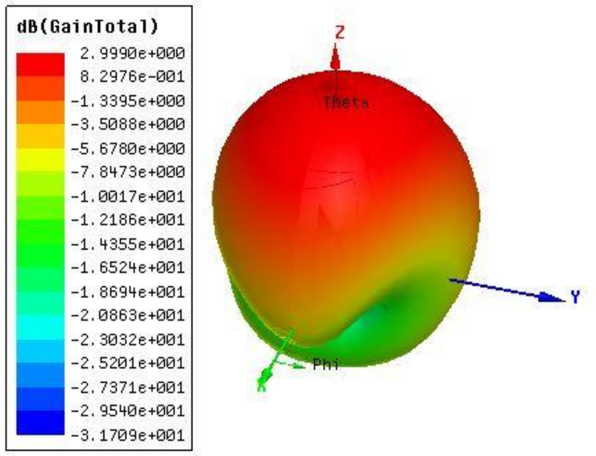



Fig.8a): For 3.9GHz

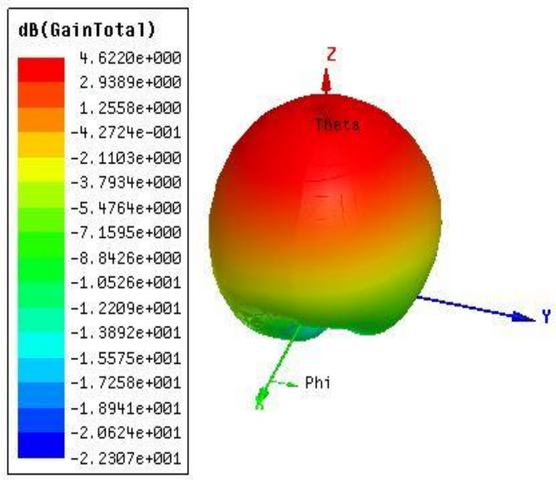



Fig. 8b): At 5.8GHz

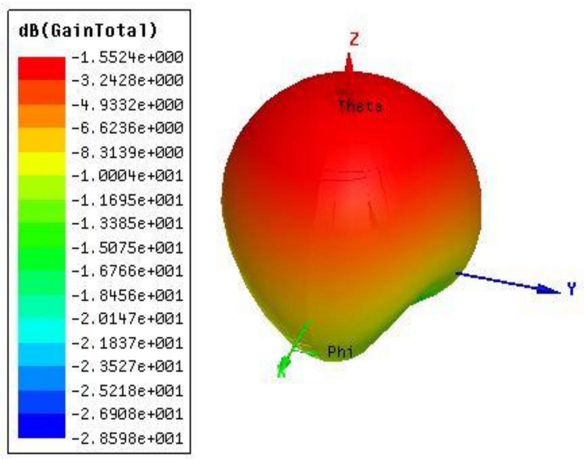



Fig. 8c): For 6.7GHz

From the above figures it is clear that the proposed antenna produces a gain of 2.99dB for 3.9GHz, 4.62dB for 5.8GHz and -1.55dB for 6.7GHz respectively.

## Radiation patterns of the proposed structure :

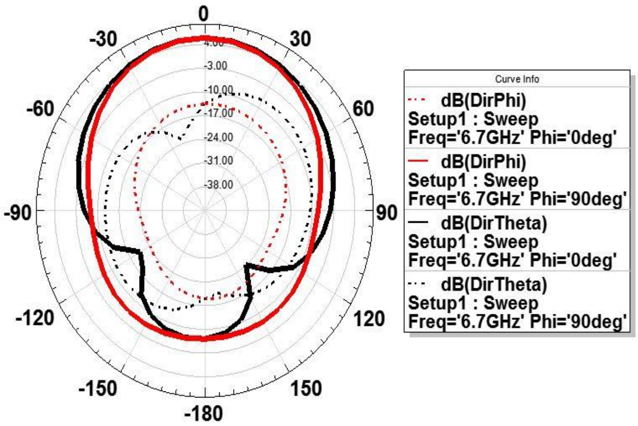



Fig.9a): For 3.9GHz

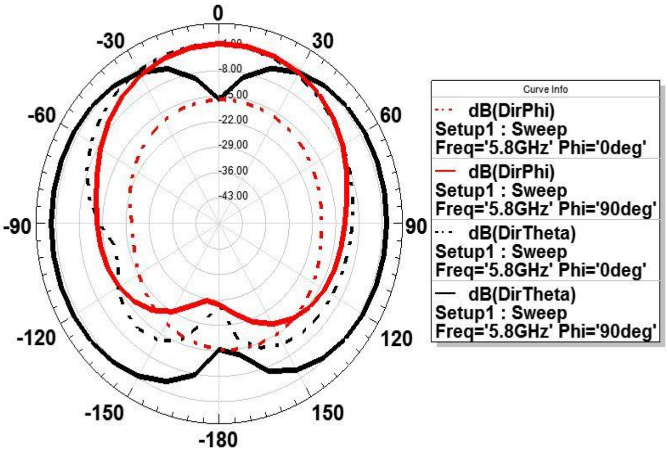



Fig.9b): For 5.8GHz

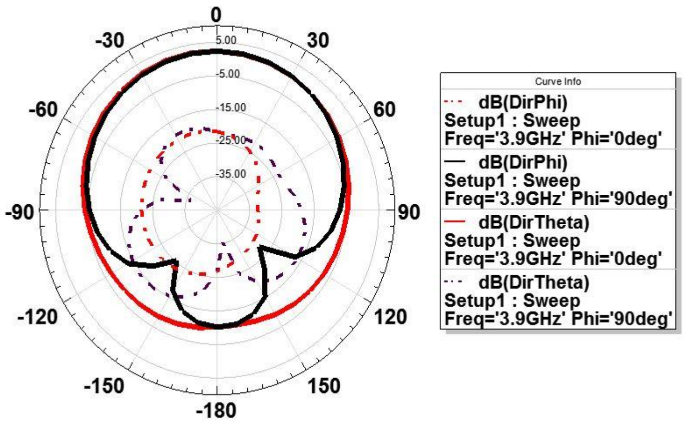



Fig.9c): For 3.9GHz

The above figures illustrate the radiation plot for the obtained frequencies.

**Frequency Reconfigurability:**

The antenna can be reconfigured to 6 GHz by placing a simple metal switch in the slot as shown in Fig 10.

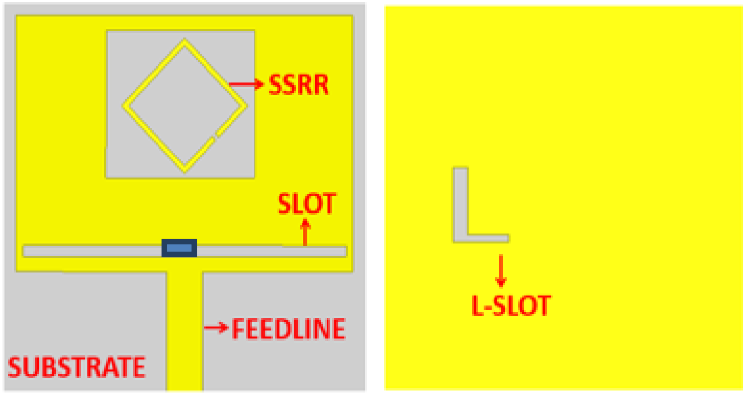



Fig.10: Antenna structure with a metal switch

The above mentioned reconfigurable antenna produces the following result

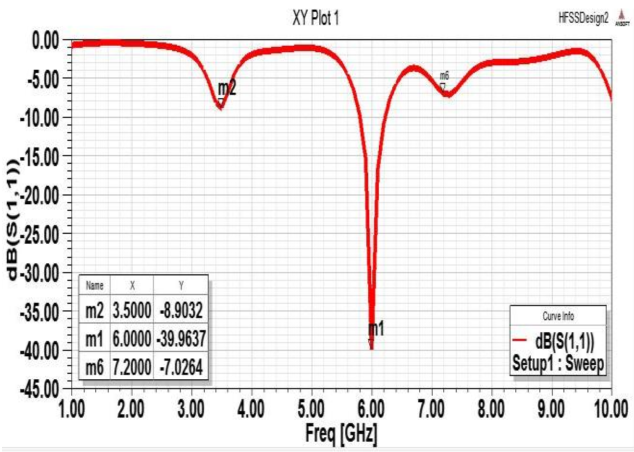



Fig.11: Return loss plot for the reconfigured antenna

**Comparison table for result obtained in each step:**

| Step | Frequency GHz | $S_{11}$ in dB | Applications |
|---|---|---|---|
| #1 | 4.9<br>5.8 | -19.9<br>-15.1 | • C-band<br>• Wi-Max |
| #2 | 4.5<br>5.8 | -10<br>-15 | • C-band<br>• WLAN |
| #3 | 3.9<br>6.0<br>6.8 | -21<br>-12<br>-21 | • Wi-Max<br>• Lower satellite band<br>• Satellite Television |
| #4<br>Proposed design | 3.9<br>5.8<br>6.7 | -19<br>-11<br>-19 | • Middle Wi-Max<br>• Upper Wi-Max<br>• Satellite Television |

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**Comparison of the proposed antenna:**

| Ref. no. | Year | Total area ($mm^2$) | Operating bands (GHz) | Reconfigurability |
|---|---|---|---|---|
| [1] | 2015 | 50x50 | 2.54/3.55/ 5.7 | NO |
| [2] | 2017 | 40x40 | 3.04/3.83/4.83/ 5.76 | NO |
| [3] | 2016 | 38x38 | 2.4/3.5/5.8 1.52/1.6/1.5 | NO |
| [5] | 2015 | 56x44 | 3.1/5.52/7.3/9. 7 | NO |
| Proposed Antenna | | 26x26 | 3.9/5.8/6.7 | YES |

## III. CONCLUSION

The increasing demand for the antenna for multiband frequencies is increasing exponentially. In an effort to get a solution the above antenna is proposed with multiband frequency operation characteristics. The proposed antenna operates at 3.9GHz,5.8GHz and 6.7GHz with return loss of -21.7dB,-12.1dB and -21.3 dB respectively. It has produced a gain of 2.9dB,4.6dB and -1.5dB accordingly. The same antenna with the help of electric switches like metal switch can be modified to produce 6 GHz and made as a reconfigurable antenna. Hence the proposed antenna not only offers multiband frequency operation capability it also offers reconfigurability.

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