# Design and Analysis of Modified Edge Tapered Slotted Microstrip Patch Antenna with Defected Ground Plane for Multiband Applications

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**Abstract:** The design and analysis of modified edge tapered microstrip patch antenna with defected ground plane for multiband application is presented in this paper. The FR4 epoxy material has been used to design the presented antenna with dielectric constant 4.4 and height of 1.6mm. The edge tapered antenna exhibits required parameters that depends on the coaxial feed position and size of the rectangular patch. The rectangular patch antenna consists of inverted U slots at the center of the patch and four slits of 0.6 mm width and 5 mm length at four edges of the patch. The antenna parameters such as return loss, VSWR, gain, bandwidth and radiation pattern has been optimized.

**Keywords**: HFSS, coaxial probe feed, multiband, return loss, VSWR.

## Introduction

The slotted patch antenna are widely used in wireless and wearable applications these days because of their small size and less cost[1]. The antenna without slots has maximum current distributions at center of the patch but in slotted patch radiation increases near the edges. So the idea behind cutting the slots on the patch is to increase the current distribution at the edges of the patch. The patch with cutting notches improves the parameters of the antenna. By using defects in ground plane, the gain of the antenna increases. The defected ground plane is to remove the slots from the ground structure [2]. The coaxial line feed is easy to use and the main advantage of using this feed is it can be placed at any desired location in patch in order to match the impedance [3]. The U-slots at the center of the patch are etched to in this antenna. The slotting technique is very popular to design the different type of antennas like fractal, array etc [4]. The edges of the rectangular patch tapered to achieve the circular polarization. There are lot of materials to be used for the substrate of the antenna. The FR4 epoxy with dielectric constant 4.4 is having less cost and easily available so this is mostly used as the substrate material. The truncated corner patch antenna has been proposed using EBG structure, for dual band 3.65 GHz and 5.8 GHz antenna using U Slot; the corners are truncated for achieving CP in the Lower Band [5]. The single band was achieved at frequency 2.25GHZ, The maximum gain of antenna was 4dB [6]. The probe fed antenna exhibits four resonates at 2.05 GHz, 2.45GHz, 3.54GHz and 4.23 GHz with maximum gain 6dB [7]. The designed antenna had bent fork shaped patch on the FR4 substrate with permittivity 4.4 and the shape of patch is able to reduce the degradations of radiation pattern and matching conditions [8]

## Antenna Design

The proposed antenna is designed in HFSS software. The edge tapered antenna consists of two U slots and a four slits at the edges of the patch. The FR4 material is used to design and fabricate the proposed antenna and height of the substrate is 1.6 mm. The patch is made by cutting the two inverted U slots at the center of the patch and four symmetrical slits of 0.6 mm width and 5 mm length near the four edges of the patch. Two small rectangles are integrated with 8mm width and 2.5mm length on both sides of the patch. The proposed design of the patch is shown in figure.1 (a). The L and W are the length and width of the substrate. The length of patch is $L_1$ and width of patch is $W_2$ as shown in figure 1(a).

The defected ground plane is used in proposed geometry. Four squares has been etched near the corner of the plane. The parameters of antenna are improved with the slotted ground plane. The ground plane of proposed antenna shown in figure1.(b). The defected ground plane improves the antenna parameters. The design specifications of the proposed antenna are shown in Table 1.

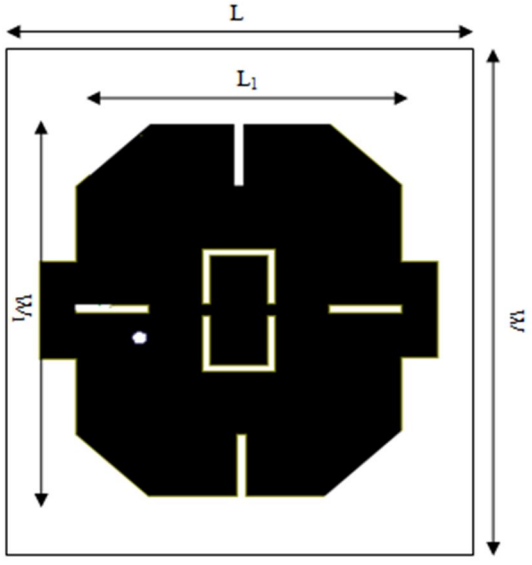



Fig.1(a). Patch of proposed antenna

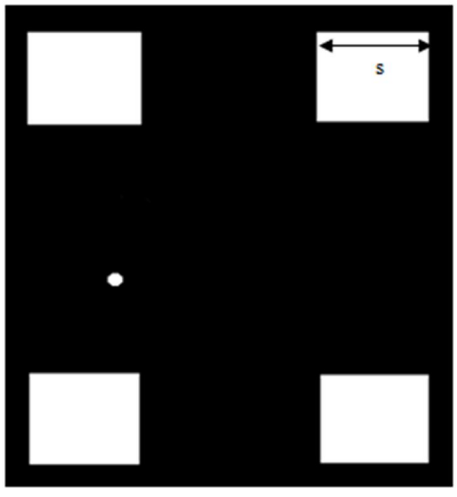



Fig.1(b). Ground plane of proposed antenna

There are five types of feeds that are used to feed the microstrip patch antenna. The coaxial probe feed is used to feed the designed antenna. The main advantage of coaxial probe feed is that can locate in any desired position of the patch in order to match the impedance.

Table 1. Antenna design specifications

| Antenna geometric Parameters | Value |
|---|---|
| Substrate length (L) | 40mm |
| Substrate width (W) | 32.2mm |
| Patch length ($L_1$) | 22.6mm |
| Patch width ($W_2$) | 30.4mm |
| Height of substrate(h ) | 1.6mm |
| Dielectric constant($\in_r$ ) | 4.4 |
| Resonant frequency( $f_r$) | 3GHz |
| Side of square slot in ground(S) | 8 mm |

## Results and Discussion

The simulation and measured results of the proposed antenna are discussed in figures below.

**Return loss**

The comparison of return loses shown below are patch without notch and patch with slots and notch. The patch with slots and notch gives better results as shown inn figure 2 (a) with red line.

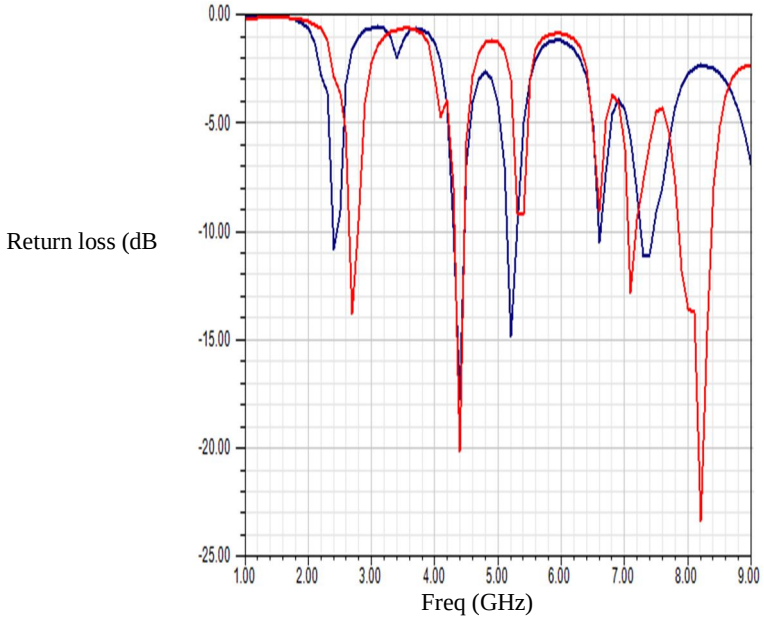



Fig.2.(a)Return loss of patch without notch and patch with slots & notch

The ground plane is make defected by cutting four square slots. The effect of cutting these squares in the ground plane is shown in figure 2 (b).

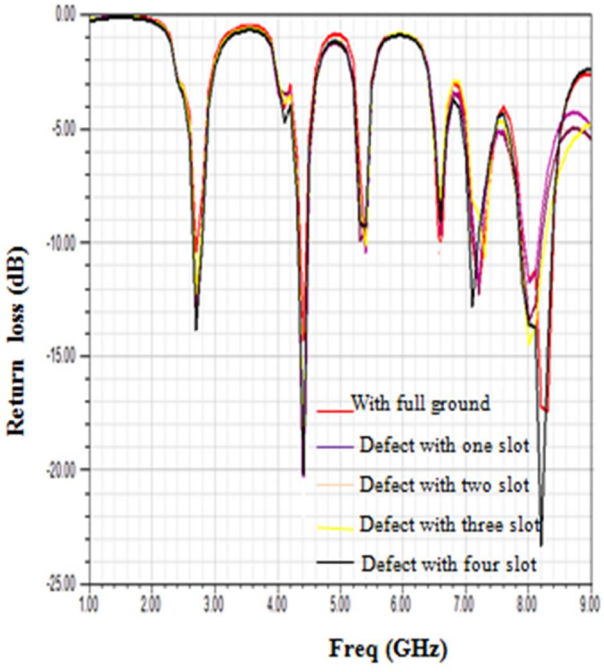



Fig.2(b) Return loss of with and without defects in ground plane

**Gain**

It is also an important parameter. The gain and directivity are equal if antenna is 100% efficient. The simulated gain of each frequency on which proposed antenna operate are shown in fig 3(a) to 3(d).

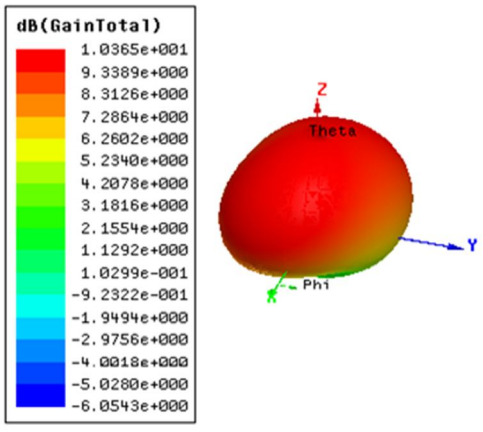



Fig. 3 (a) Simulated 3D plot of gain at frequency 2.7GHz

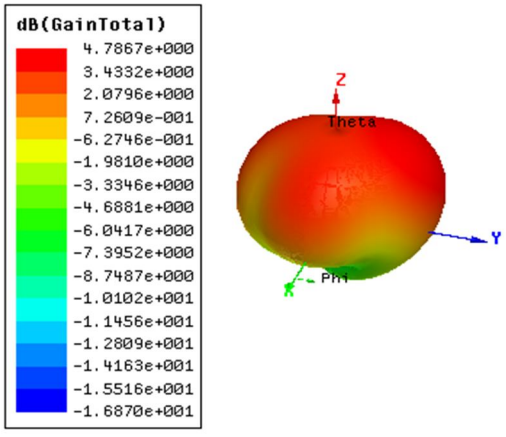



Fig. 3 (b)Simulated 3D plot of gain at frequency 4.4GHz

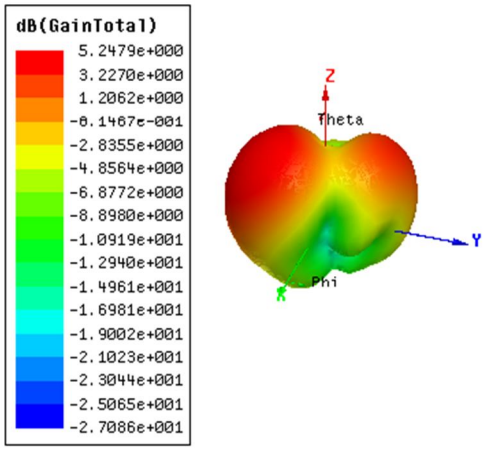



Fig. 3 (c) Simulated 3D plot of gain at frequency 7.1GHz

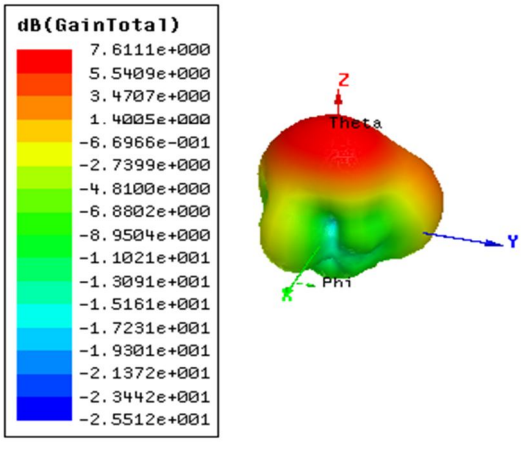
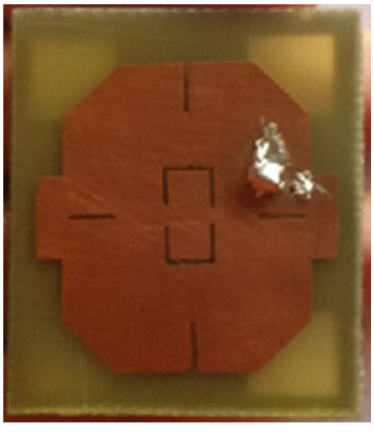



Fig. 3 (d) Simulated 3D plot of gain at frequency 8.2GHz

The optimized design parameters of the proposed antenna configuration are used for the fabrication of the antenna. The proposed antenna is fabricated with FR4 epoxy material. The fabrication of proposed antenna is shown in figure 4 (a) and 4 (b).



The designed and fabricated antenna shows good agreement. It shows a good agreement between measured and simulated results of a modified edge tapered microstrip patch antenna with defected ground plane for multiband applications. The comparison between measured and simulated results shown in figure. 5(a) and5(b).

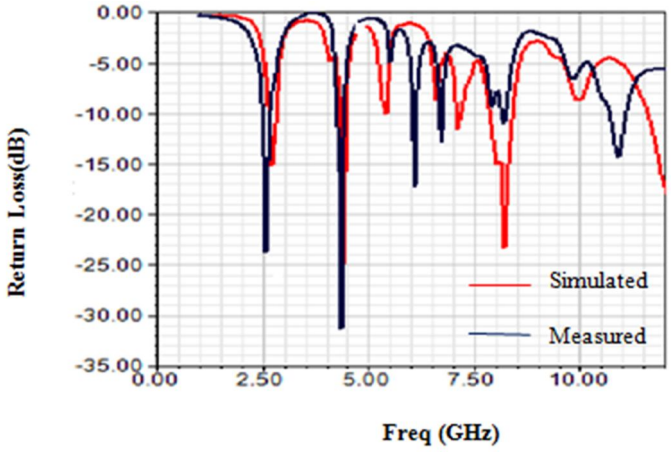



Fig .5 (a) Return loss comparison of measured and simulated results

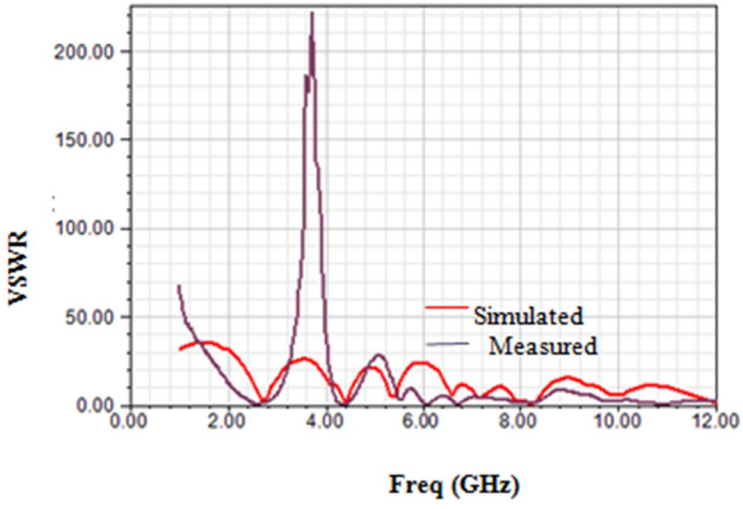



Fig.5.(b) VSWR comparison of measured and simulated results

Table 2. Comparison of simulated and measured results of proposed Modified Edge Tapered Slotted Microstrip Patch Antenna (METSMPA)

| Simulated results | | | Measured results | | |
|---|---|---|---|---|---|
| Resonant Freq (GHz) | Return loss (dB) | VSWR | Resonant Freq (GHz) | Return Loss (dB) | VSWR |
| 2.7 | -13.85 | 1.50 | 2.58 | -23.60 | 1.40 |
| 4.4 | -20.14 | 1.32 | 4.37 | -31.20 | 1.28 |
| 7.1 | -12.82 | 1.59 | 6.99 | -12.80 | 1.70 |
| 8.2 | -23.32 | 1.34 | 8.2 | -10.89 | 1.80 |

## Conclusion

The simulated and measured results are compared and are found to be good agreement with each other. The measured return loss at frequencies 2.6GHz, 4.38GHz, 6.72 and 8.23 are -23.60, -31.20, -12.80, -10.30. The VSWR of the analyzed antenna of these frequencies 1.40, 1.28, 1.70, 1.9. The designed and evaluated antenna is applicable for Direct to Home satellite TV, Mobile satellite communication.

## References

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