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# Design of Elliptical Patch Antenna with Single & Double U-Slot for Wireless Applications: A Comparative Approach

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***ABSTRACT:*** *A novel approach in the field of wireless communication industry continues to drive the requirements for small, compatible, and affordable multiband antennas. To overcome the challenges of multi-frequency operation a new scheme of multiband is proposed. So, in this we are taking elliptical probe-fed antenna with double U-shaped slot in order to increase the bandwidth to an extent. The presented antennas are suitable for multiband wireless communication systems.*

***Keywords:*** *Microstrip patch antenna, multiband, U-shaped slot, elliptical patch antenna.*

## I. INTRODUCTION

Now a day's wireless communication devices needed more and more frequency bands because of increasing wireless service requirements. Due to this specification the demand for multiband antenna design is increasing continuously. Multiband antennas have derived rapidly increasing attention in modern wireless communication systems in which the downward compatibility and the roaming capability among multi-standards are demanded. For example, The global system for mobile communication (GSM), The wireless local area networks (WLAN), The general packet radio services (GPRS), The universal mobile telecommunication systems (UMTS) are generally a dual band or multiband wireless standards communication devices. Microstrip patch antennas consist basically of three layers, a metallic layer with the antenna element pattern, a dielectric substrate and another metallic layer as the ground plane. These antennas are relatively easy to manufacture because of their simple planar configuration and the compact structure. They are light in weight and have the capability to be integrated with other microwave circuits. It has a radiating patch on one side of a dielectric substrate which has a ground plane on the other side. The patch is generally made of conducting material such as copper or gold and can take any possible shape.

Microstrip patch antennas are increasing in popularity for use in wireless applications due to their low-profile structure. They have a very high antenna quality factor (Q). To design the multiband antenna we have different feeding techniques in which we are using coaxial cable or probe feed technique. The coaxial feed or probe feed is a very common technique used for feeding microstrip patch antennas. The inner conductor of the coaxial connector extends through the dielectric and is soldered to the radiating patch, while the outer conductor is connected to the ground plane. The main advantage of this type of feeding scheme is that the feed can be placed at any desired location inside the patch in order to match with its input impedance. It is easy to fabricate. However, its main disadvantage is that it provides narrow bandwidth and is difficult to model since a hole has to be drilled in the substrate and the connector protrudes outside the ground plane, thus not making it completely planar for thick substrates.

Since the dimension of the patch is treated a circular loop, the actual radius of the patch is given by (Balanis, 1982)

$$a = \frac{F}{\left\{1 + \frac{2h}{\pi \in_r F}\left[\ln\left(\frac{\pi F}{2h}\right) + 1.7726\right]\right\}^{1/2}}$$

Where,

$$F = \frac{8.791 \times 10^9}{f_r \sqrt{\in_r}}$$

Above does not take into consideration the fringing effect. Since fringing makes the patch electrically larger, the effective radius of patch is used and is given by (Balanis, 1982).

$$a_e = a\left\{1 + \frac{2h}{\pi \in_r a}\left[\ln\left(\frac{\pi a}{2h}\right) + 1.7726\right]\right\}^{1/2}$$

Hence, the resonant frequency for the dominant $TM_{110}$ should be modified by using above equation and expressed as
.

$$(f_{rc}) = \frac{1.8412\vartheta_0}{2\pi a\sqrt{\epsilon_r}}$$

where $v_0$ is the free space speed of light.

## II. ANTENNA DESIGN & ANALYSES

Here, antenna is designed using a HFSS (High Frequency Structural Simulator), it is one of several commercial tools used for antenna design. The multi-band elliptical patch antenna is designed to operate at particular frequency bands. The antenna consists of elliptical patch with U-shaped slot by coaxial or probe fed. U-shaped slot is used to increase the Bandwidth. The antenna is printed on the FR4 epoxy substrate with dielectric constant ($\varepsilon_r$) =4.4, thickness of 0.8mm.
The designing of antenna is done by following steps.

***Design Requirements:***
Input Impedance =100 Ω
Resonant Frequency of the Antenna=10GHz
Relative permittivity of the substrate = 4.4
Dielectric loss tangent =0.02

**Procedure:**
1) **Designing the Microstrip patch**
a) Draw the substrate dimensions 3cm x 3cmx 62mm.
b) Draw the elliptical patch and trace on the top face of the substrate. The elliptical patch has Dimensions
Radius-0.525cm
Along x axis: 1.93cm
Along y axis: 1.93cm
Material used: FR-4 Epoxy
c) Draw an Air box on starting from the bottom of the substrate with the same length and width .The height of the air box can be any value. Here the dimensions are taken to be 3cm x 3cmx 1.9cm.
d) Draw an Air box below the substrate of dimensions 3cm x 3cmx 1.9cm.
e) We need to define a wave port .To do so draw a circle on the XY plane of dimensions such that it covers the trace. Make sure you select the XY Plane from the menu before drawing

2) **Assigning Materials**
a) Select the substrate to assign material
b) Assign a User defined material with a relative permittivity of 4.4 and dielectric loss tangent of 0.02 to the substrate.

3) **Assigning Boundaries and Excitations**
a) Select the bottom face of the substrate and Assign the Perfect E boundary to it.
b) Assign the Radiation boundary to the top and bottom air boxes.

4) **Making "U" slit around probe**
a) $1^{st}$ u slit of length 0.4cm and breadth 0.6cm
b) $2^{nd}$ u slit of length 0.25cm and breadth 0.25cm

Here as we are observing the comparison between the elliptical patch with single U-slot and double U-slot. So we are comparing return loss, 3D gain plot, 2D gain plot and Radiation pattern. Designs of both single and double U-slot are shown below.

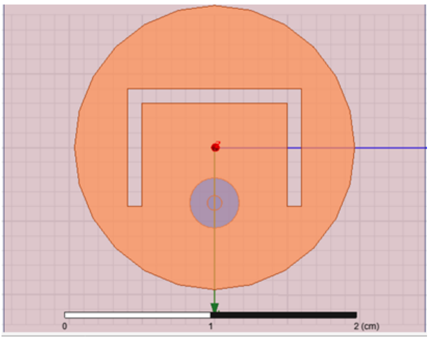


Fig. 1. Design of elliptical patch antenna with single U-slot

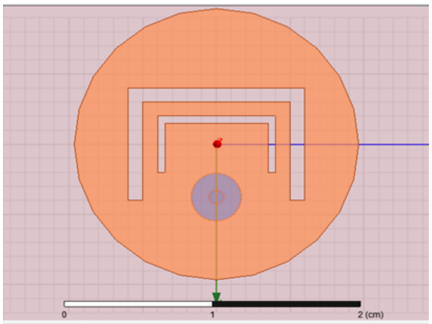


Fig. 2. Shows the design of elliptical patch antenna with double U-slot

The model of the HFSS will be in this form with the x,y and z co-ordinates, the rectangular shape is the substrate in which the antenna is designed, and the elliptical antenna is fed with coaxial cable on that double U-slit is placed and the optimization is done. This is the closer view of the design process given in following figure (2).

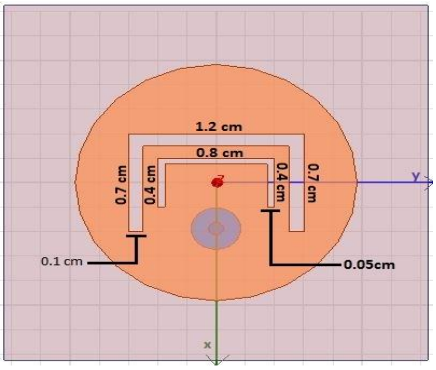


Fig. 3. Represents the closer view

## III. RESULTS & DISCUSSION

In the design process after the simulation, we will get Return loss, Input impedance (S11 parameters), 3D total gain, 2D gain total. So we are showing a comparison between the single U-slot and double U-shaped slot.

| Parameters | Single U-Slot | Double U-Slot |
|---|---|---|
| Operating Frequency | 10GHz | 10GHz |
| Return loss | 6.30GHz at -11 dB | 4.6 to 6.25 GHz. |
| Substrate material | FR4 Epoxy | FR4 Epoxy |
| Feed material | Teflon(tm) | Teflon(tm) |

Table 1. Comparison between single U-slot and double U-slot

Below figures are the results of elliptical patch antenna with single U-slot.

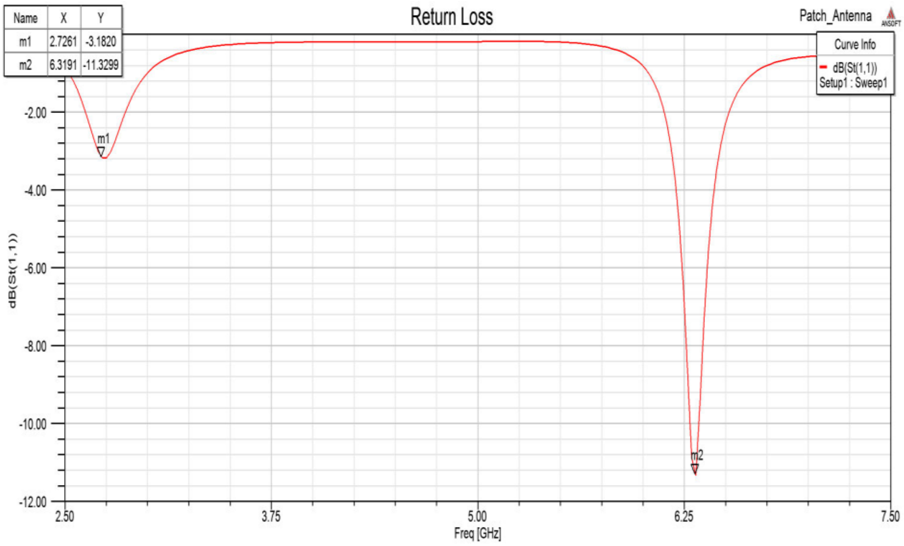


Fig.4. Represents Return loss

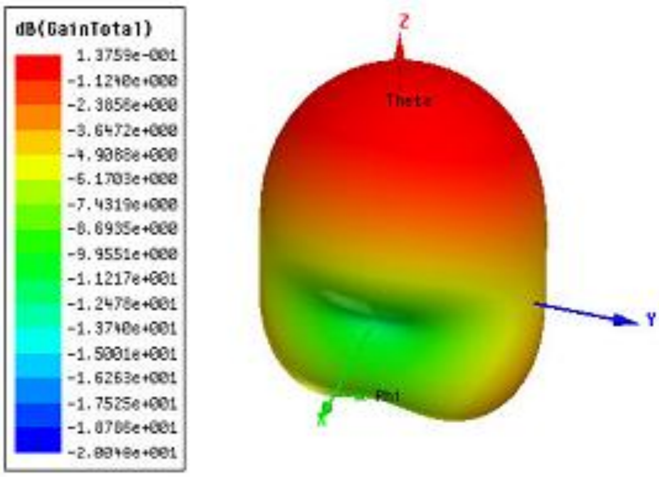


Fig. 5. Represents 3D gain total

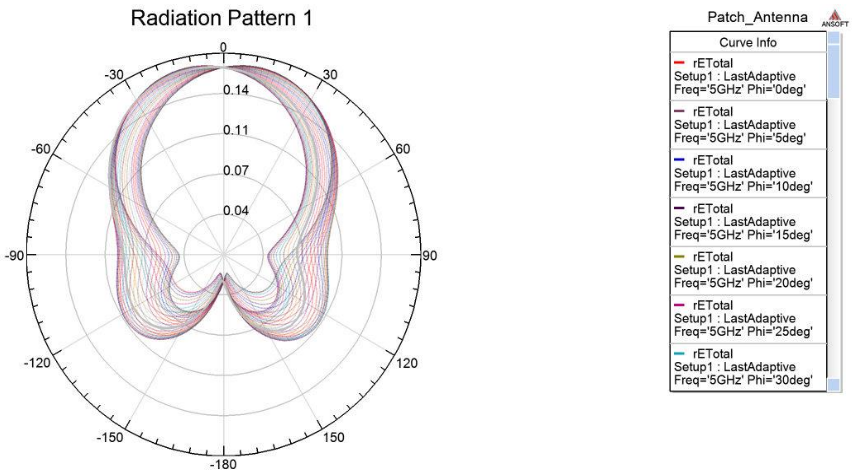


Fig. 6. Represents 2D gain total

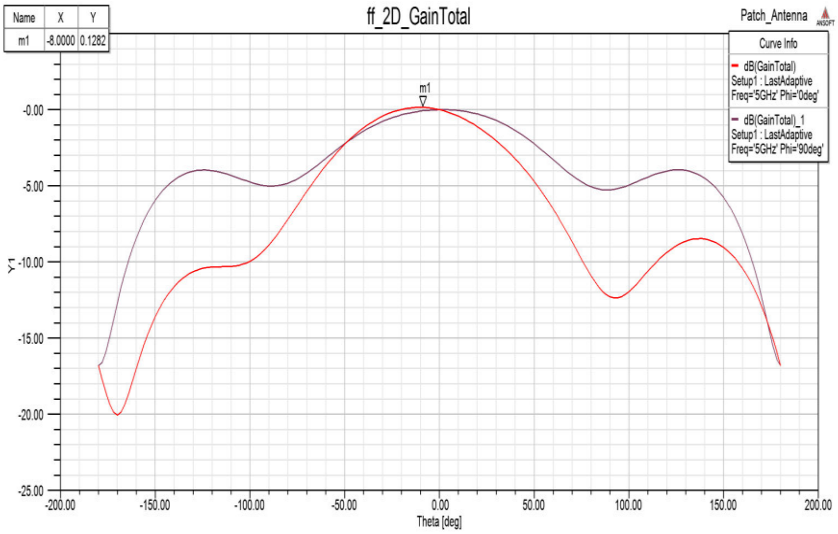


Fig. 7. Represents 2D gain total

And the results of elliptical patch antenna with double U-shaped slot are below.

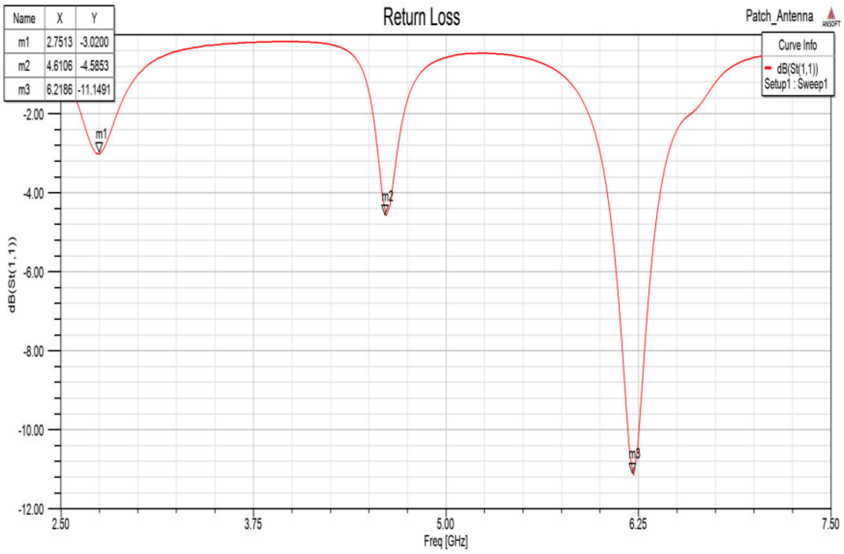


Fig. 8. Represents Return losses

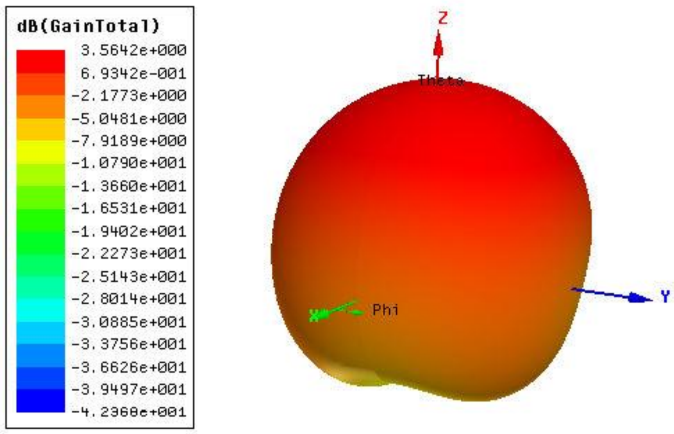


Fig. 9. Represents the 3D gain total

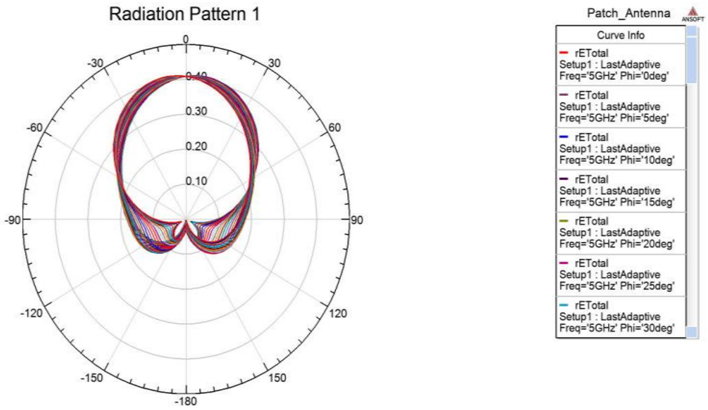


Fig. 10. Represents the Radiation pattern

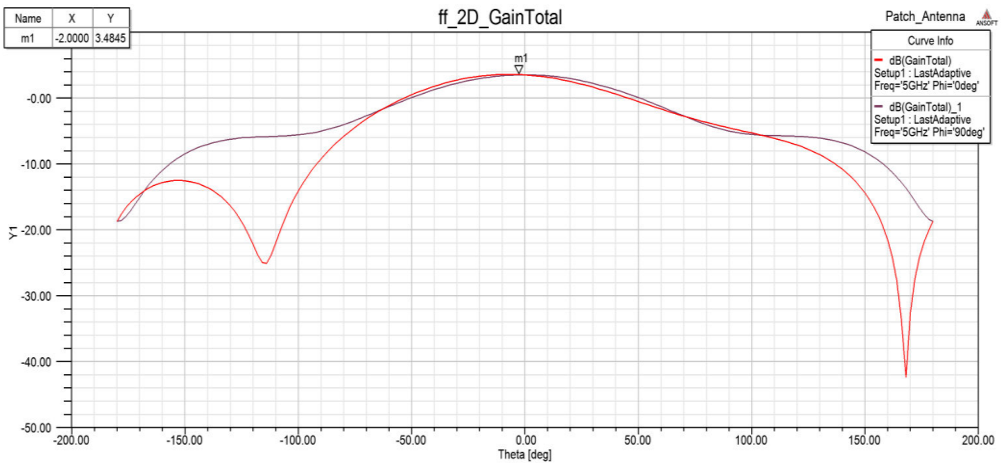


Fig. 11. Represents the 2D gain total

The antenna gain is the key performance figure which combines the antenna's directivity and electrical efficiency. A plot of the gain as a function of direction is called the radiation pattern. The term antenna gain also describes how much power is transmitted in the direction of peak radiation of that of an isotropic source. The gain of a real antenna can be as high as 40-50 dB for very large dish antennas. Directivity can be as low as 1.76 dB for a real antenna.

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## IV. CONCLUSION

In this paper, antenna is designed with a novel shape derived from the U-shaped slot with an elliptical patch antenna structure. The antenna operated with a multiband frequency making it most suitable for the wireless applications. The antenna achieves good impedance matching and gain in the entire band of operation. The antenna does serve well in radiating in all frequencies of operation with good radiation efficiency.

## REFERENCES

[1] Antenna theory analysis and design by CONSTANTINE A. BALANIS

[2] Ratnesh kumari and Mithilesh kumar (member IEEE), Design of Multiband antennas for wireless communication, 2013 International conference on Communication Systems and Network Technologies.

[3] J.Chen, S.T.Fan, W.Hu, and C.H.Liang, Design of Tri-band printed monopole antenna for WLAN and WIMAX applications, progress in Electromagnetics Research C, Vol. 23, 265-275, 2011.

[4] Joseph Costantine, Karim Y.Kabalan, Ali El-Hajj, and Mohammad Rammal, New Multi-Band Microstrip Antenna Design for Wireless Communications, IEEE Antennas and Propagation Magazine, Vol. 49, No. 6, December 2007..
[5] A.Beno and D.S.Emmanuel, High gain inverted U-shaped miniaturized patch antenna for multiband wireless applications, May 2012.
[6] Hussain Falih Mahdi, Simulation of Rectangular Microstrip Antenna by Integrating Matlab in Visual Basic, Diyala Journal of Engineering Sciences, Vol.03, No. 01, pp. 16-24, June 2010.
[7] ANTENNA THEORY AND WAVE PROPAGATION by K.D.Prasad.
[8] A new dual-band microstrip antenna with U-shaped slot, J.Ghalibafan and A.R.Attari.