Design of U-Slot Patch Antenna

Padmasri Prasadam[#1], Sandhya Prattipati[*2], Mounica Pilli[#3], Haritha Podila[*4], G Naveen Kumar[5]

[1,2,3,4]*UG Students,* [5]*Asst. Prof,*

[1,2,3,4,5]*Department of ECE, Vasireddy Venkatadri Institute of Technology, Namburu (V), Guntur (Dt), Andhra Pradesh, India.*

[1]padmasriprasadam14@gmail.com

[2]sandhyaprattipati29@gmail.com

[3]mounicaammulu1497@gmail.com

[4]harithapodila5@gmail.com

Abstract--- *In high performance applications where size, weight, cost and ease of installation are constraints. For the applications such as aircraft, spacecraft, and satellite and missile require low profile antennas. Slot antennas exhibit wider bandwidth, lower dispersion and lower radiation loss. The slot antenna concept has been used in patch antenna designed to reduce antenna size. The structure of an antenna is simple to manufacture, versatile in nature and due to small size it can be embedded in various portable devices. As U slot micro strip antenna is best for its wideband characteristics, we prefer this. The basic geometry of U-slot antenna was introduced by Huynh and Lee in 1995. In this, the patch antenna can be designed for dual band and triple band application by cutting U-slots on the patch fed by coaxial cable. It has wireless applications which require more bandwidth such as for covering wireless applications of WLAN. The parameters of the proposed antenna are described and simulated using MATLAB software package.*

Keywords-- **Antenna, Low profile antenna, U-slot antenna, Dual and Triple band, Coaxial cable, MATLAB.**

I. INTRODUCTION

The U-slot microstrip antenna fed with coaxial cable was firstly introduced by Huynh and Lee in 1995. The advantage of placing U-slot on patch antenna is, the bandwidth increases. By placing U-slot on patch antenna we can convert wideband characteristics to multiband characteristics. It is a low profile antenna, able to adapt to many activities and can be easily carried. Because of these attractive features U-slot patch antennas are mainly used in aircraft, space, satellite and mobile communications. U-slot on patch antenna disturbs the current flow n patch; as a result there is a change in bandwidth of antenna. U-slot inserts a high Q-factor to lower the disruption and it inserts additional capacitance which lowers the inductance when thick substrate is used providing gain about 6-8dBi. We can use any of the fed like L-probe fed, M-probe fed, Co-axial fed etc. As Co-axial fed is flexible we have chosen it. U-slot delivers impedance bandwidth more than 30% for air substrate and 20% for microwave substrate having thickness of about 0.08λo. As the design belongs to single layer there is no need of adjustment between multiple layers of dielectrics and metals.

In this paper, we prove that the Co-axial fed technique is flexible not only for single band characteristics but also for dual and triple band characteristics by placing U-slots at any desired location according to our design, we design a U-slot patch antenna which decreases the reflection coefficient .Another method to decrease the reflection coefficient is increase the thickness of substrate but this method increases the size of the antenna which is not desired.

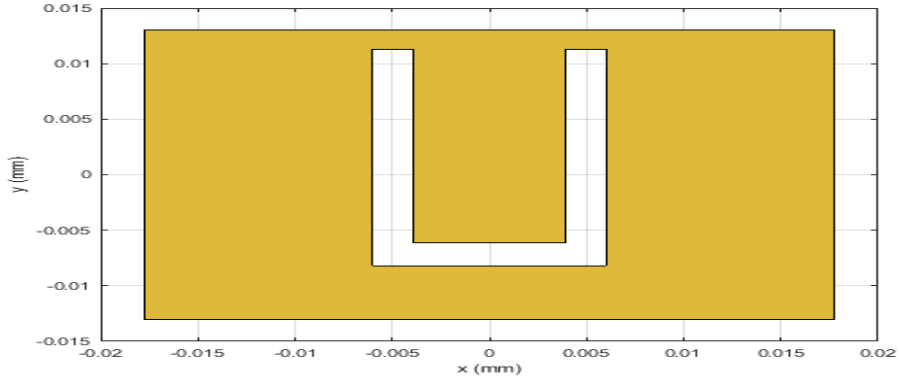


Fig. 1 Top view of single U-slot patch antenna

II. Proposed Antenna Design

The configuration of the above suggested U-slot rectangular patch antenna is shown in Fig. 1. The fundamental shape of the coaxial fed patch antenna is shown in Fig. 2.

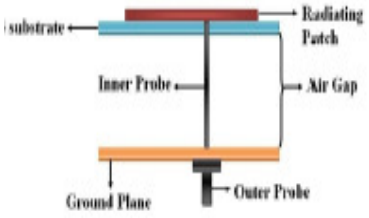


Fig. 2 Side view of single u-slot patch antenna

The highest frequency of operation of single layer U-slot patch antenna is 6GHZ. U-slot patch antenna basically consists of three layers. The upper layer is a metal layer having U-slot; middle layer is a substrate layer and the lower layer is the ground plane with the below mentioned dimensions. The length of rectangular metal layer of U-slot patch antenna is 26mm and width is 35.5mm. The length of rectangular ground plane of U-slot patch antenna is 71mm and width is 52mm having broadness about 5.75mm.Here the substrate used is air having the dielectric value as one. By placing a single U-slot a wideband is divided into two bands, by placing two U-slots a wideband is divided into three bands and placing three U-slots a wideband is divided into four bands by inserting notches.

A. Single U-slot patch antenna

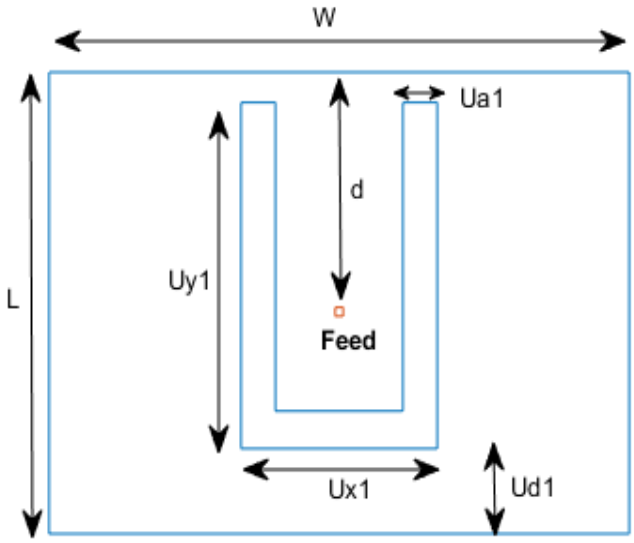


Fig. 3 Single U-slot patch antenna

TABLE I
Specifications of Single U-slot Patch Antenna

Specifications	Units(mm)
Length of rectangular patch(L)	26
Width of rectangular patch(W)	35.5
Height of substrate(H)	5.75
Broadness of U-slot(Ua1)	2.1
Width of U-slot(Ux1)	12
Length of U-slot(Uy1)	19.5
Ud1	4.8
D	13.5

B. Double U-slot patch antenna

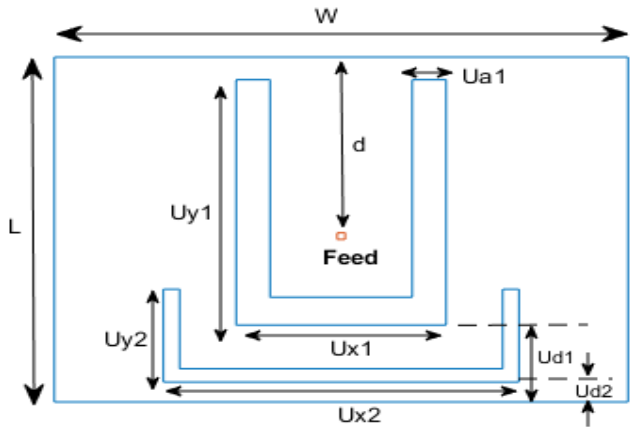


Fig. 4 Double U-slot patch antenna

TABLE II
SPECIFICATIONS OF DOUBLE U-SLOT PATCH ANTENNA

Specifications	Units(mm)
Length of rectangular patch(L)	26
Width of rectangular patch(W)	35.5
Height of substrate(H)	5.75
Broadness of first U-slot(Ua1)	2.1
Width of first U-slot(Ux1)	13
Length of first U-slot(Uy1)	18.5
Ud1	5.8
D	13.5
Width of second U-slot(Ux2)	22
Length of second U-slot(Uy2)	7
Broadness of second U-slot(Ua2)	1
Ud2	1.5

Triple U-slot patch antenna is same as shown in Fig. 4 but we have to place another U-slot on patch.

C. Triple U-slot patch antenna

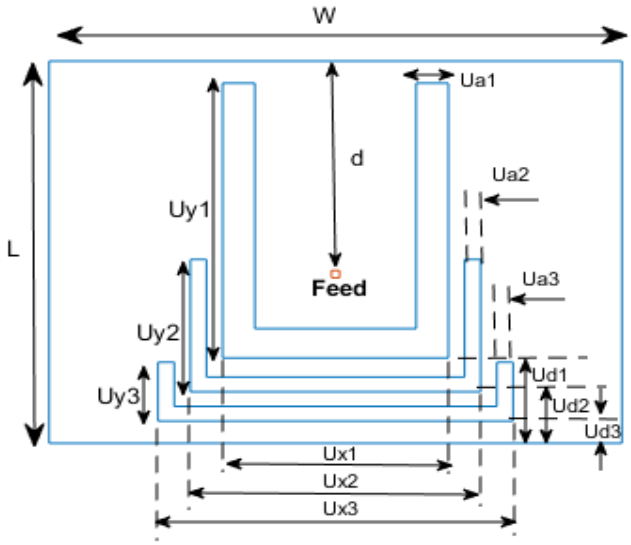


Fig. 5 Triple U-slot patch antenna

TABLE III
SPECIFICATIONS OF TRIPLE U-SLOT PATCH ANTENNA

Specifications	Units(mm)
Length of rectangular patch(L)	26
Width of rectangular patch(W)	35.5
Height of substrate(H)	5.75
Broadness of first U-slot(Ua1)	2
Width of first U-slot(Ux1)	14
Length of first U-slot(Uy1)	18.7
Ud1	5.8
D	14.5
Width of second U-slot(Ux2)	18
Length of second U-slot(Uy2)	9
Broadness of second U-slot(Ua2)	1
Ud2	3.5
Width of third U-slot(Ux3)	22
Length of third U-slot(Uy3)	4
Broadness of third U-slot(Ua3)	1
Ud3	1.5

III. DESIGN CONSIDERATIONS

- Width of Patch antenna is given by

$$w = \frac{c}{2fo\sqrt{\frac{\varepsilon_r + 1}{2}}}$$

Where c is the velocity of light and εr is the value of dielectric constant. Here εr=1.

- Length of patch antenna is given by

$$\Delta L = (0.412 * h) \times \frac{(\varepsilon_{reff} + 0.3) \times \left(\frac{w}{h} + 0.264\right)}{(\varepsilon_{reff} - 0.258) \times \left(\frac{w}{h} + 0.813\right)}$$

- The resonant frequency for any mode is given by

$$fo = \frac{c}{2\sqrt{\varepsilon_{reff}}} \left[\left(\frac{m}{l}\right)^2 + \left(\frac{n}{m}\right)^2 \right]^{1/2}$$

Where m and n are the values of the mode at which antenna operates.

Coaxial-probe feeding technique is one of the most flexible and commonly using techniques for patch antennas because the feed can be located at any desired location in patch in order to match with its input impedance. Here the feed diameter is given as 0.5mm.

IV. SIMULATION RESULTS

The proposed antenna is simulated using MATLAB software package. MATLAB is Matrix Laboratory. Compared to other antenna simulation tools it is easy to use and it has more technical support. According to the simulated results the U slot technique decreases the reflection coefficient of antenna. The more the number of U-slots, the less the reflection coefficient is as shown in the below graph (Fig. 6). The resulting single layer U-slot antenna uses Coax fed which is very flexible.

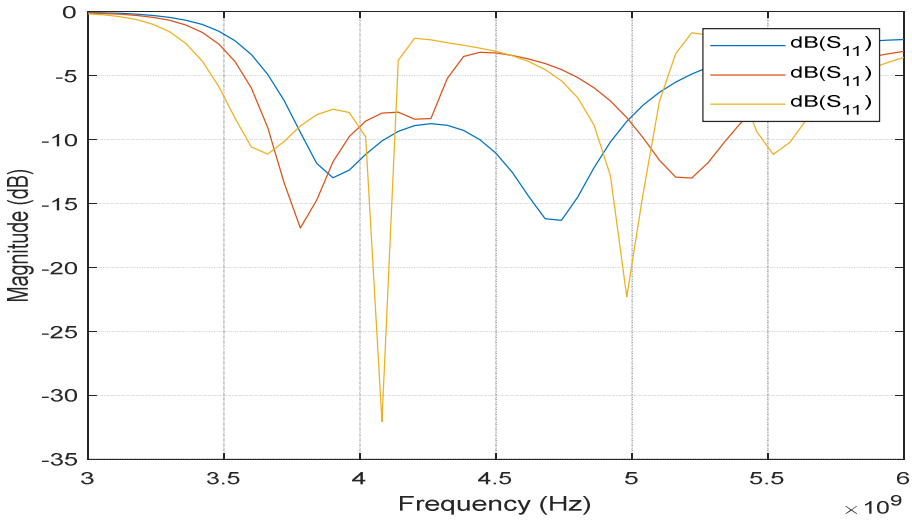
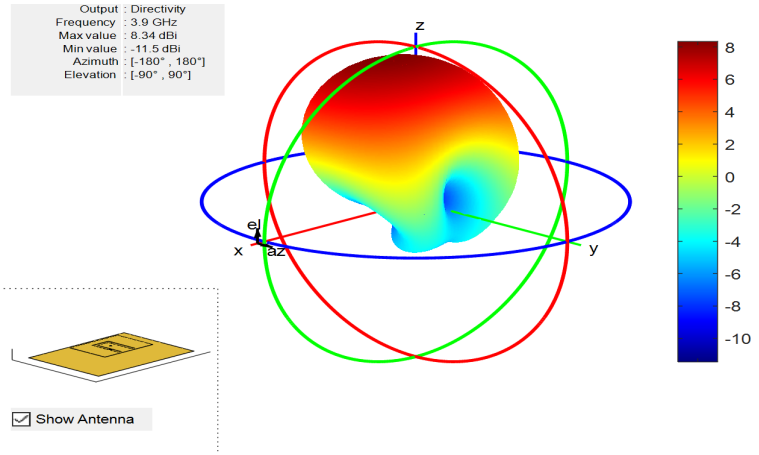


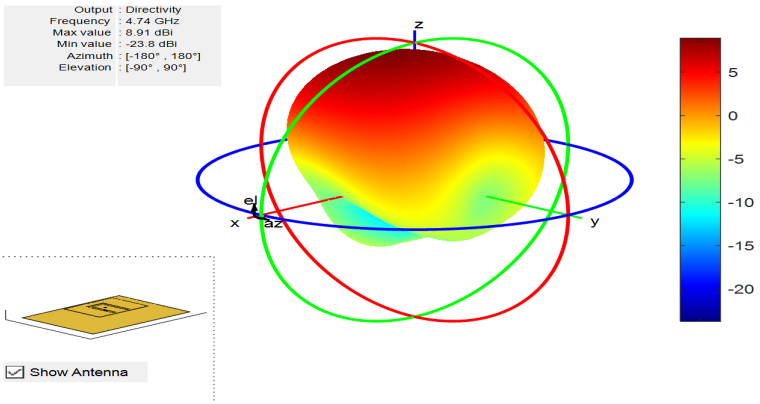
Fig. 6 Reflection coefficient graph of U-slot patch antenna for single, double and triple U-slots

In Fig. 6 blue curve represents the reflection coefficient curve for single U-slot, red curve for double U-slot and yellow curve represents the reflection coefficient curve for triple U-slot. From Fig. 6 we observe that the reflection coefficient decreases with increase in number of U-slots.

A. Radiation pattern



For 3.9 GHZ frequency



For 4.74 GHZ frequency

Fig. 7 Radiation pattern of single U-slot patch antenna

V. CONCLUSIONS

In this paper, U-slot patch antenna is designed and is simulated using MATLAB software. The simulated results have minimized reflection coefficient and have the attractive features like light weight, low profile and portability. Not only the reflection coefficient but also the parameters like the radiation pattern, Directivity, bandwidth gets improved by cutting the U-slots on the patch. But we are mainly concentrating on reflection coefficient parameter. Analysis of this antenna has been carried out on the basis of type of antenna that is with single U-slot, double and triple U-slot. Simulated results of proposed antenna are suitable for communication purpose.

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