



# Design Of Rectangular Slot Microstrip Antenna For Ultrawideband Applications

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## ABSTRACT

This paper presents a design of planar rectangular microstrip patch antenna connected to an offset microstrip feedline for ultrawideband applications. A rectangular shaped slot on the ground plane increase the impedance bandwidth upto 117.73% (2.9-11.2GHz). A proposed antenna is designed and fabricated on glass epoxy substrate FR4 with a dielectric constant of 4.4 and loss tangent of 0.02 having dimensions of 33 x 35.5 x 1.6 mm<sup>3</sup>. Antenna is simulated using electromagnetic simulation software CADFEKO suite 7.0. The average efficiency is 80%, and stable VSWR (1.0-2.0) achieve over 2.9GHz to 11.2GHz range in simulated and measured results. The radiation pattern of E-plane and H-plane are directional and omni directional over the entire operating band.Simulated and measured results of the proposed antenna are in good agreement.

**Key words:** L-shaped ground, rectangular shaped slot, slot antenna, UWB.

## 1. INTRODUCTION

In 2002, FCC permits a 3.1-10.6GHz unlicensed frequency range use as a ultra-wide band transmission[1]. This UWB have short range communication up to few tens of meters with high data rate without influence on other systems.UWB system commonly used due to bits features like as low cost, low spectral power density and channel capacity. Due to the extremely large bandwidth of UWB, the interference between the narrow band and UWB system is a major challenge in UWB.Different shapes of slot such as rectangle,circle,elliptical,beveled,tapered has been used for enhancing wide impedance bandwidth.

In reference[2-4], large number of experiments have been carried by researchers to achieve wide impedance bandwidth of small planar antenna.In reference [5],an inverted T-shaped conductor backed plane was used inside rectangular shaped slot on bottom layer which achieved UWB span from 3.04 to 10.87GHz. CPW-fed was used in [6].In that corners of rectangular tuning stub was beveled and also two semi circular slots were etched to improved UWB bandwidth. A

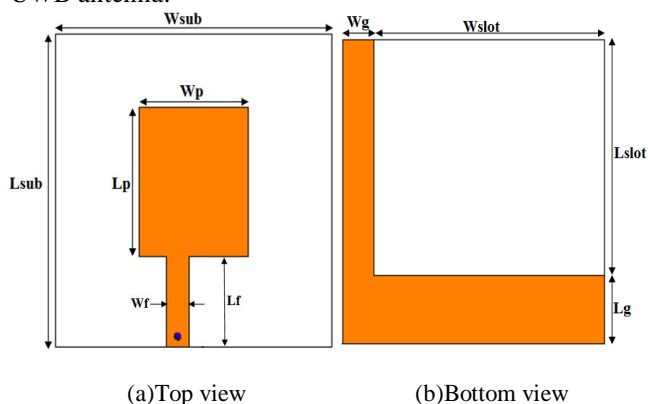
rectangular radiating patch was etched on front side of substrate in [7] and tapered slot was cut from bottom side of substrate on ground plane, achieved an over -10dB frequency bandwidth from 3.04 to 10.87GHz. Inverted T-shaped slot was cut in the square radiating patch and inverted T shaped conductor backed plane was used for enhancing wide impedance bandwidth in[8].

In this letter, a rectangular slot antenna is proposed for UWB applications .Bandwidth of this proposed antenna is effectively improved by taking rectangular slot from the ground plane.Then this ground plane looks like a 'L' shaped ground. The present paper proposed design of slotted UWB antenna which is different from other antenna in terms of its ultra wide range frequency from 2.9 GHz to 11.2GHz.

## 2. PROPOSED ANTENNA DESIGN

### 2.1 Antenna Design

The antenna is printed on a glass epoxy substrate FR4 with dielectric constant of 4.4 and loss tangent of 0.02. The proposed antenna has dimensions of 33×35.5×1.6 mm<sup>3</sup>.Figure 1 shows geometry of proposed rectangular slot UWB antenna.



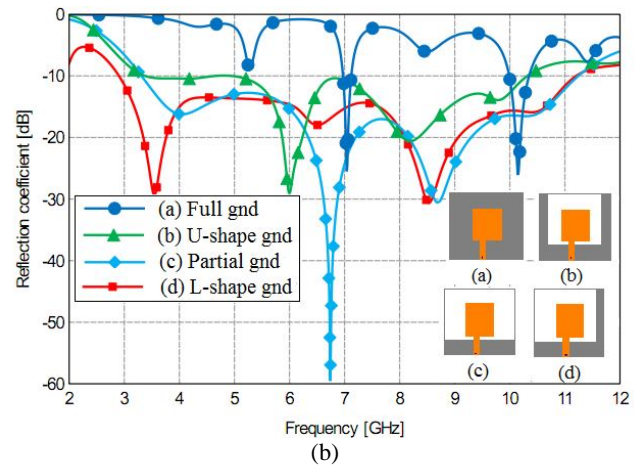
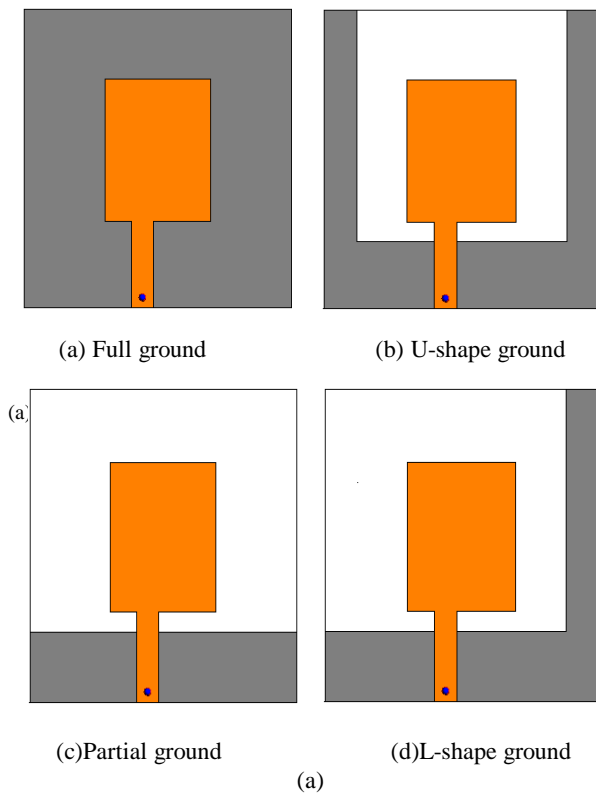
**Figure 1:** Geometry of the proposed rectangular slot UWB antenna

The width of the feedline can be calculated by using following formulae[9][10].

$$z = \frac{377}{\sqrt{\epsilon_r [(Wf / t) + 2]}} \quad (1)$$

### 2.2 Evolution of Rectangular Monopole Antenna

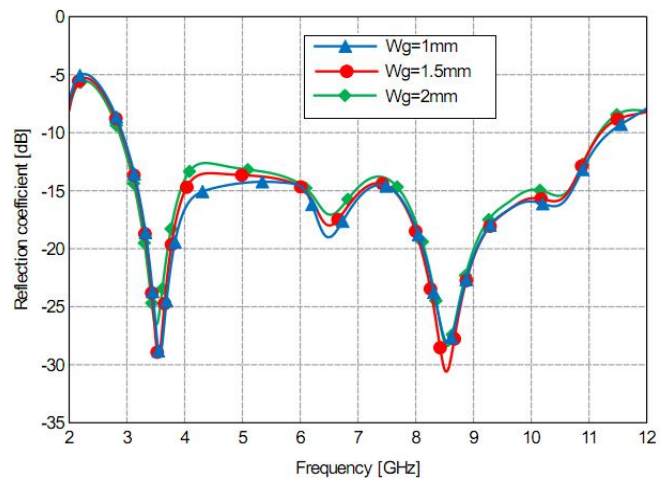
Figure 2(a) shows the evolution of rectangular monopole antenna in which first figure is rectangular monopole antenna with full ground which provide impedance bandwidth of 0.14GHz(1.98%) from 6.975-7.115GHz. It is observed that 1.98% impedance BW is very small as compared to ultrawideband impedance BW. In order to achieve the wide impedance bandwidth over entire UWB a rectangular slot is cut from the full ground plane which formed U-shaped ground plane. After forming U-shaped ground bandwidth is increased from 3.4 to 10.31GHz. So still total UWB is not achieved. Hence a wide rectangular slot is cut from full ground formed partial ground plane, which has impedance BW from 3.3-10.9GHz. So here is also still UWB lower frequency band is not achieved. Then finally, a wide rectangular slot is cut from full ground plane in such a way that it form L-shaped ground plane. So new desired impedance bandwidth is from 2.9-11.2GHz(117.73%). Figure 2(b) shows simulated  $S_{11}$  for different stages of evolution. In which large impedance bandwidth is obtained for L-shaped ground plane.



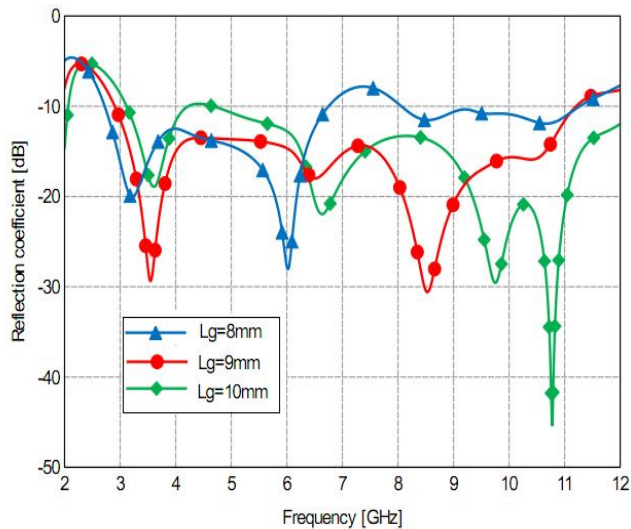
**Figure 2:** (a) Evolution of rectangular monopole antenna (b) Simulated reflection coefficient at different stages of evolution

### 3. PARAMETRIC STUDY

Parametric study is carried out by using simulation software CADFEKO [11] suite 7.0, with technique that, only one parameter is allowed to change at a time while other variables remained constant. Here we have done parametric analysis of  $W_g$ ,  $L_g$ ,  $L_p$ ,  $W_p$ ,  $W_f$  and feed position. Now first, we take a  $W_g$  shown in Figure 3, in which for all these values of  $W_g$  antenna resonates for entire ultrawideband. But for  $W_g=1.5\text{mm}$ , return loss is maximum for lower and higher frequency of operation. Hence optimum desired results are obtained for  $W_g=1.5\text{mm}$ .

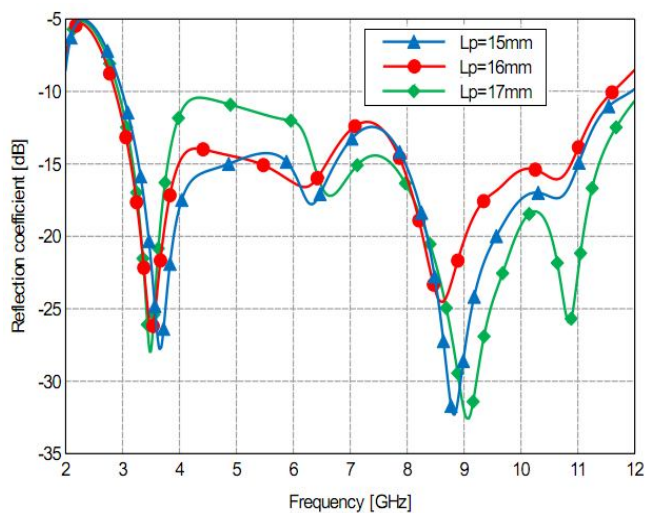


**Figure 3:** Return loss vs. frequency graph for different width of ground plane



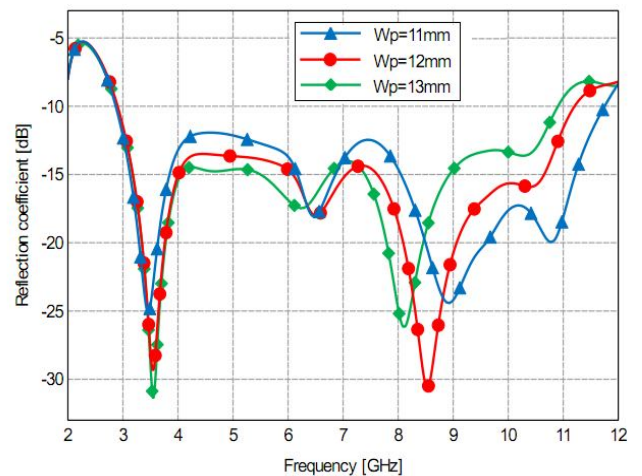
**Figure 4:** Return loss vs.frequency graph for different length of ground plane

Figure 4 and Figure 5, shows the effect of  $L_g$  and  $L_p$  parameters. In which  $L_g$  varies from 8mm to 10mm and  $L_p$  varies from 15mm to 17mm. For  $L_g=9$ mm and  $L_p=16$ mm we obtained satisfied UWB.



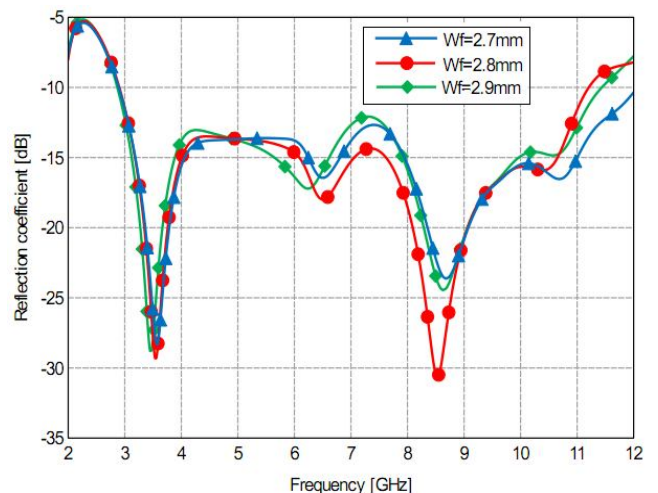
**Figure 5:** Return loss vs.frequency graph for different length of patch

In Figure 6, width of patch varies from 11mm to 13mm. In which only for  $W_p=12$ mm, return loss is maximum at higher frequency of operation. Hence desired results are obtained for  $W_p=12$ mm.



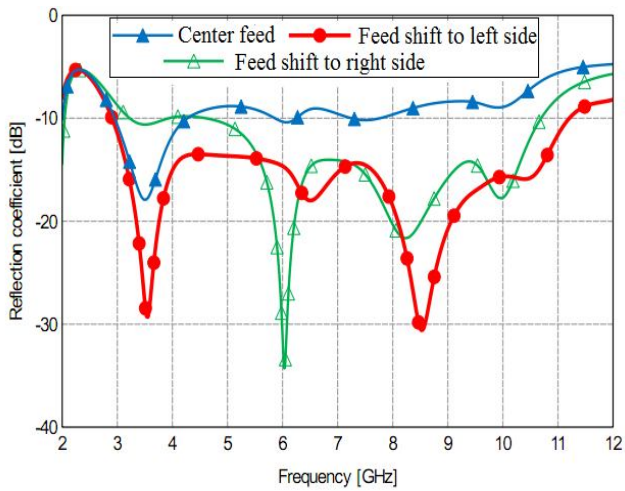
**Figure 6:** Return loss vs.frequency graph for different width of patch

In Figure 7, width of feedline varies from 2.7mm to 2.9mm. In which only for  $W_f=2.8$ mm return loss is maximum as compared to  $W_f=2.7$ mm and  $W_f=2.9$ mm. Hence, optimized results are obtained for  $W_f=2.8$ mm.



**Figure 7:** Return loss vs.frequency graph for different width of feedline

Figure 8 shows effect of feed position. From Figure 8 we can observed that only for feed shift to left side maximum impedance bandwidth is obtained from 2.9-11.2GHz.



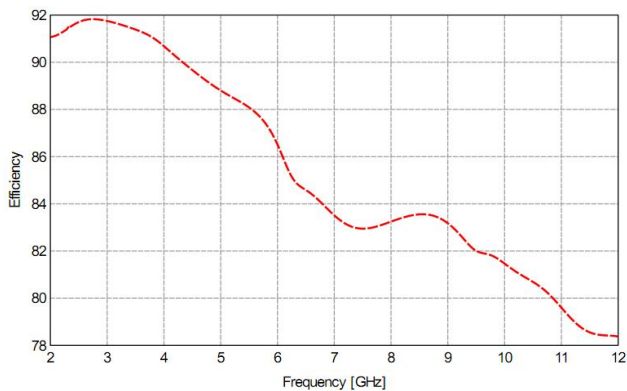
**Figure 8:** Return loss vs.frequency graph for different feed position

**4. RESULTS AND DISCUSSION**

After the parametric study of several adjustments on parameters ,the final proposed antenna is achieved.The design parameters along with their dimensions are as shown in table 1.

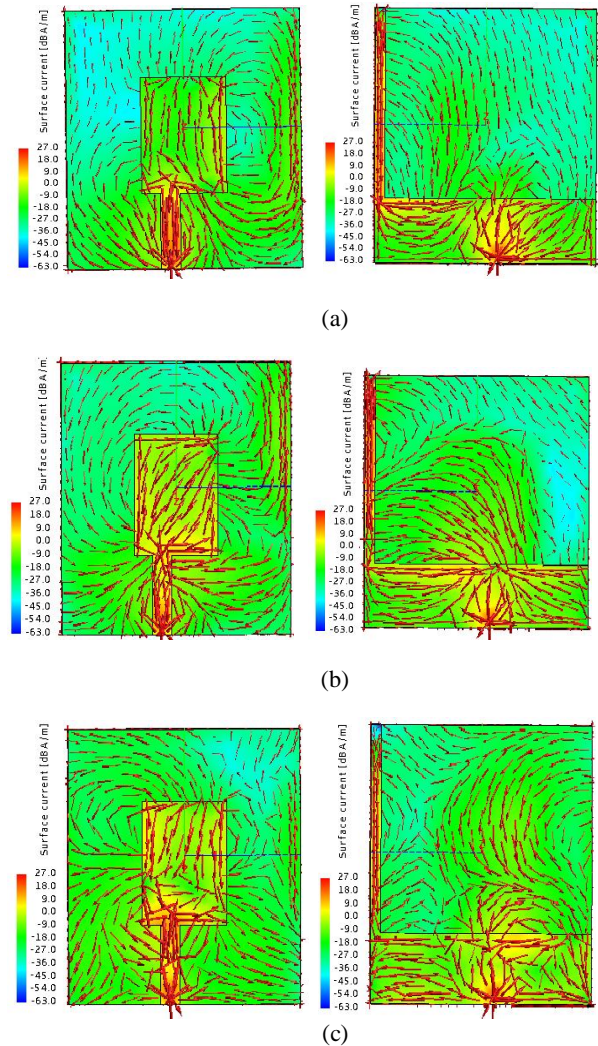
**Table 1:** Dimensions of Proposed Antenna

Parameter	Dimensions (mm)
Wsub	33
Lsub	35.5
Wp	12
Lp	16
Wf	2.8
Lf	10.25
Wslot	31.5
Lslot	26.5
Wg	1.5
Lg	9
$\epsilon_r$	4.4
h	1.6

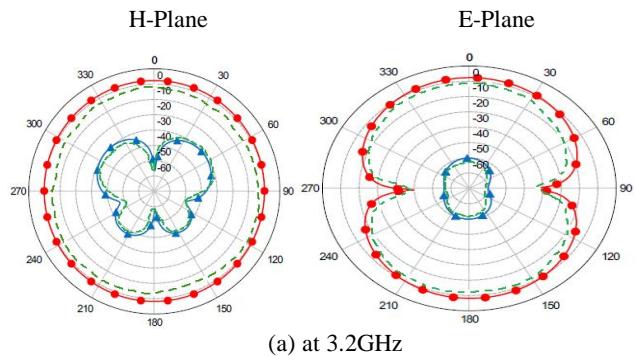


**Figure 9:** Efficiency vs.frequency graph of proposed UWB antenna

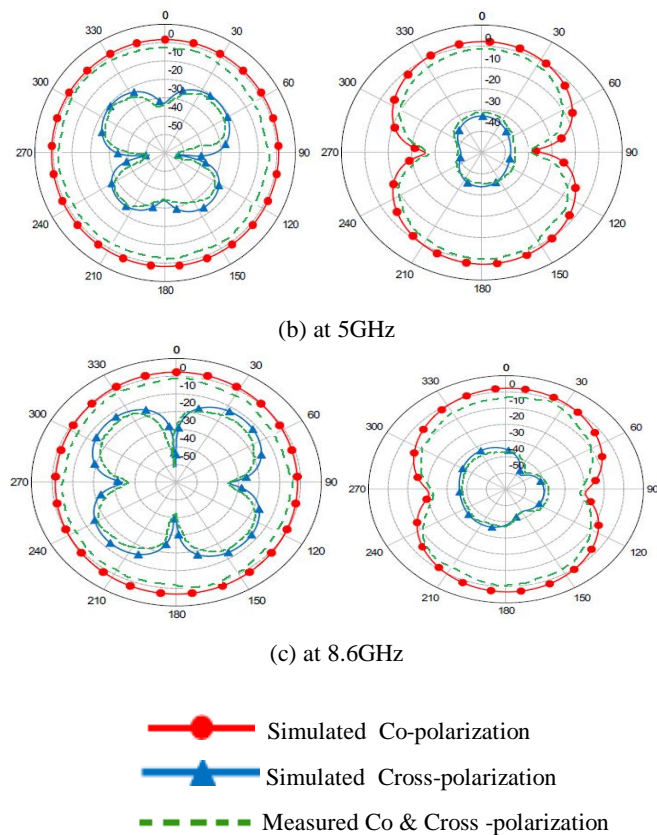
Figure 9 shows that efficiency is 91% at 3.1GHz and 80% at 10.6GHz. It decreases at higher frequency range due to dielectric losses.Figure 10 shows surface current distribution at 3.1GHz, 5.5GHz and 7.7GHz.Current distribution is more along the offset microstrip feed line and L-shaped ground plane.Current distribution is less along rectangular slot.



**Figure 10:** Surface Current distribution at (a)3.1GHz (b)5.5GHz (c)7.7GHz



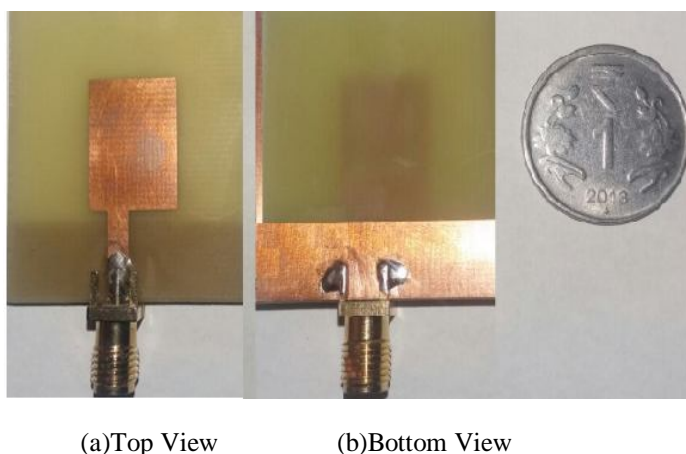
(a) at 3.2GHz



**Figure 11:** Simulated and measured radiation patterns in E-plane and H-plane at 3.2GHz, 5GHz and 8.6GHz

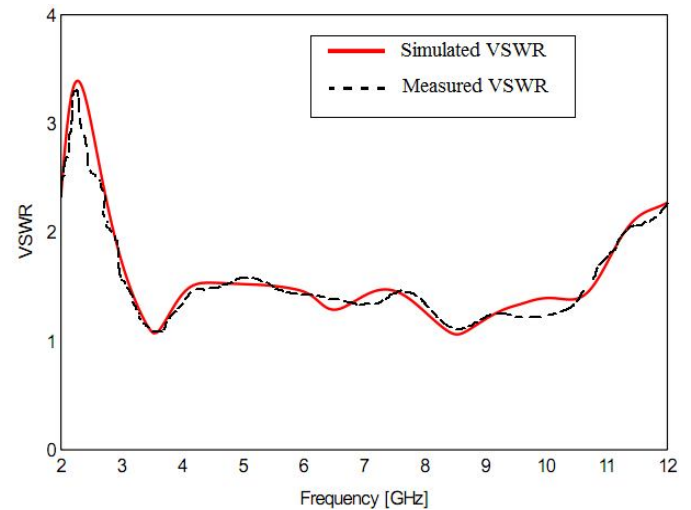
The simulated and measured patterns in the E-plane and H-planes are shown in Figure 11. Radiation pattern of figure eight is observed in E-plane and nearly omnidirectional in H-plane. Radiation pattern at 8.6GHz is distorted due to reduction in efficiency at this frequency range.

Prototype of fabricated rectangular slot UWB antenna is shown in Figure 12. This prototype of designed antenna is compared with a one rupee coin.



**Figure 12:** Photograph of fabricated prototype of rectangular slot UWB antenna

Simulated and measured VSWR of rectangular slot UWB antenna is shown in Figure 13. The N9916A vector network analyser is used for measurement and measured results are in good agreement with the simulated results for entire UWB.



**Figure 13:** Measured and simulated VSWR of proposed antenna

## 5. CONCLUSION

A novel small rectangular microstrip patch antenna has been proposed for UWB applications. By introducing a wide rectangular slot with a proper position and dimension in the L-shaped ground plane, a wide impedance bandwidth from 2.9-11.2GHz with VSWR < 2 is achieved. The proposed antenna exhibits efficiency greater than 80%. Measured results show good impedance bandwidth, nearly omnidirectional radiation patterns and dipole like patterns in the operating band.

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