

# Design of Dual Band Mono Pole Antenna for UWB and Ku Band Applications

Penchala Reddy Sura, S Narayana Reddy

**Abstract:** Over the past few decades, the evolution in new-fashioned wireless communication systems has actuated augmented exploration on uncomplicated dual band antennas. A compact dual band mono pole antenna for UWB and Ku Band Applications is proposed. The antenna consists of a corner truncated rectangular patch etched on cost effective FR4-substrate with thickness 1.6mm and is fed with 50 ohms feed line. The ground plane is truncated to enhance impedance matching and bandwidth. The proposed antenna has the ability to operate from 3.40 GHz to 10.67 GHz and 13.48 GHz to 15.87 GHz with return loss below -10 dB. The HFSS is used to design and simulate the antennas behavior over the different frequency ranges. The simulated results of the proposed antenna indicate higher gain at the two bands. The measured results demonstrated reasonable agreement with the simulated results.

**Index Terms:** corner truncated, dual, mono pole, Ku band, UWB.

## I. INTRODUCTION

Antenna is an important device which has become an integral part of our day to day life. The accelerated development in the modern communication systems initiated tremendous needs for the dual-band antennas with wider bandwidth and higher gain operating over large range of frequencies [1].

The UWB technique unlocks the gateway for modern telecommunication system, as the modern wireless system growing rapidly. UWB antenna performs a vital role in the design of modern communication system since from last few decades. In 2005, UWB regulations for indoor, radar and imaging applications are summarized in brief [3].

The FCC sanctioned the frequency ranges from 3.1 GHz to 10.6 GHz as unlicensed UWB band in 2002. Thereafter, the design and analysis of the UWB antennas have been attracted many researches view to do their research in this challenging area. The UWB antenna has the advantages of low complexity, less cost, secure, minimum interference and higher data rate. It has been used in various applications like military, medicine, imaging and radar communication [4].

In particular, the antennas used in UWB applications would have adequately wide impedance with higher radiation gain in required directions. In recent literature, various design techniques of UWB antennas have been reported. Among these techniques, the planar mono-pole antenna technique is most commonly utilized because of its simplicity in structure, less cost and higher bandwidth. It turns into the most desirable

postulant in UWB operation. It has become one of the most considerable candidates for UWB application. The different UWB planar mono-pole antennas have been designed [5–7]. In a similar way various microstrip antennas operating in Ku-band have been stated in literature for satellite communication application [8-10]. But, most of the antennas include complicated design equations and require precious fabrication procedure. Hence, we present an easy method based on transmission line model to design corner truncated rectangular patch antenna operating at UWB and Ku band applications.

The rest of the paper is organized as: The projected antenna configuration and design is described in section II. The results are examined in Section III. Lastly, Section IV draws the conclusions.

## II. THE PROPOSED ANTENNA DESIGN

The proposed corner truncated rectangular patch antenna dimensions are computed using the transmission line modal approach [1]. The radiating patch is fed by a 50 ohms microstrip line. The dimensions of corner truncated patch and ground plane can be adjusted to radiate in the dual band.

The width of patch for effective radiation is determined based on the following equation

$$W_p = \frac{v_0}{2f_r} \sqrt{\frac{2}{\epsilon_r + 1}} \quad (1)$$

The practical length of the patch for  $TM_{010}$  mode is calculated based on the following equation

$$L_p = \frac{\lambda_0}{2\epsilon_{reff}} - 2\Delta L \quad (2)$$

The effective dielectric constant  $\frac{W}{h} > 1$

$$\epsilon_{reff} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2} \left[ 1 + 12 \frac{h}{W_p} \right]^{-1/2} \quad \text{for } \frac{W_p}{h} \quad (3)$$

$$\Delta L = 0.412h \frac{(\epsilon_{reff} + 0.3) \left( \frac{W_p}{h} + 0.264 \right)}{(\epsilon_{reff} - 0.258) \left( \frac{W_p}{h} + 0.8 \right)} \quad (4)$$

The quarter wave transformer is used to match the antenna to the 50 ohms source whose characteristic impedance is given by

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$$Z_q = \begin{cases} \frac{60}{\sqrt{\epsilon_{reff}}} \ln \left[ \frac{8h}{W_q} + \frac{W_q}{4h} \right], & \frac{W_q}{h} \leq 1 \\ \frac{120\pi}{\sqrt{\epsilon_{reff}} \left[ \frac{W_q}{h} + 1.393 + 0.667 \ln \left( \frac{W_q}{h} + 1.444 \right) \right]}, & \frac{W_q}{h} > 1 \end{cases} \quad (5)$$

The design layout of the dual band mono pole antenna is displayed in Fig. 1.

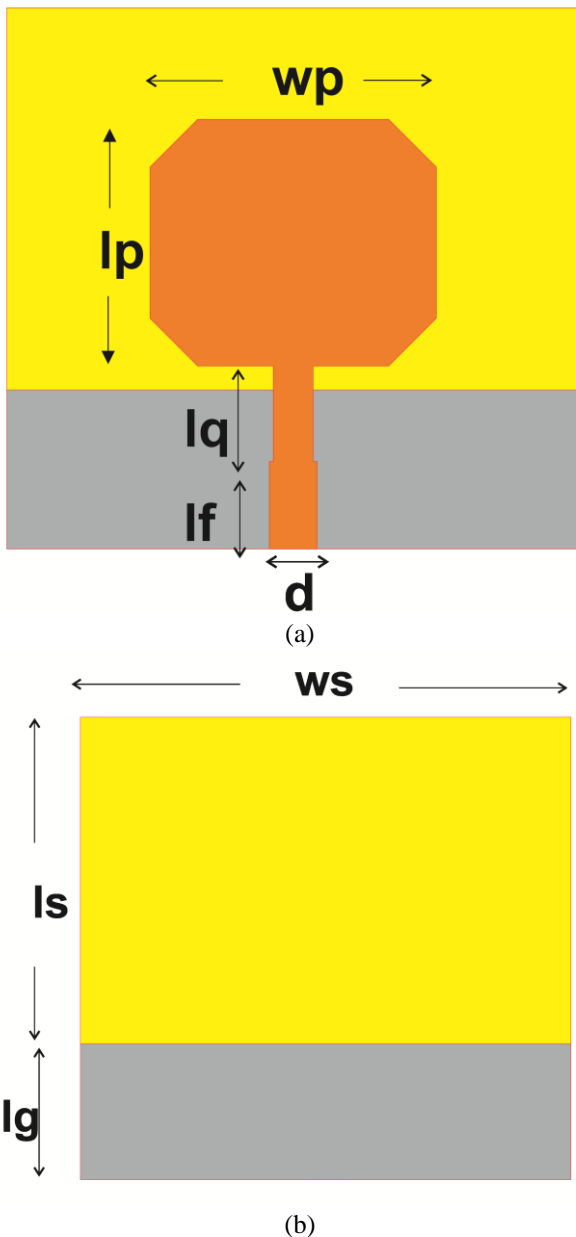


Fig.1. the antenna layout (a) front aspect (b) rear aspect

The projected antenna consists of corner truncated rectangular radiating patch erected on the cost effective FR4-substrate of thickness 1.6 mm and dielectric constant 4.4. The dielectric has loss tangent value 0.02. The four corners of the patch are truncated to improve the radiation and to enhance the bandwidth. The quarter wave line of dimensions 5.8 mm x2.4 mm is used to match the antenna impedance to 50 ohms microstrip line to reduce the reflections. The rear side of the substrate contains ground surface with truncation mainly useful for the improvement of impedance matching. The energy stored in the substrate decreases due to partial ground, which intern responsible for the reduction of quality factor and there by finds its path in the improvement of

bandwidth. Parametric analysis is used for optimization of dimensions with the help of Ansoft HFSS software. The table 1 lists the optimized dimensions.

Table I. OPTIMIZED DIMENSIONS

S.NO	Parameters	Dimensions(mm)
1	ls	25.2
2	ws	37.2
3	lg	10
4	lp	15.5
5	wp	17.5
6	lq	15.5
7	wq	2.4
8	lf	5.4
9	d	3.01
10	h	1.6

The photos of the fabricated antenna are displayed in fig.2.

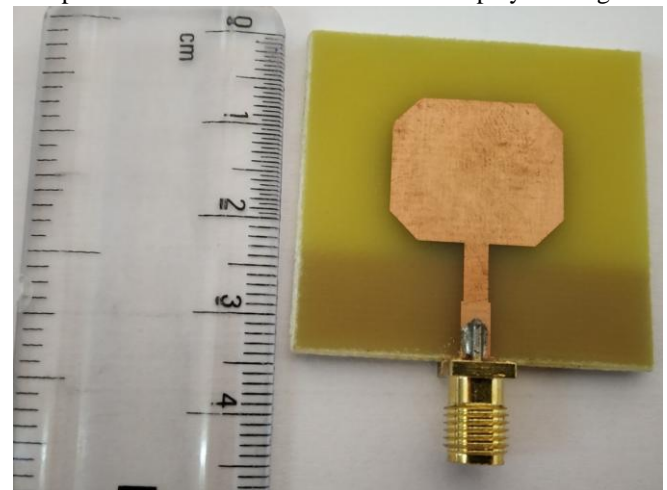


Fig.2. Fabricated antenna

### III. RESULTS

The proposed dual-band corner truncated antenna has been simulated with help of the FEM based HFSS software. The same antenna is fabricated to examine its functioning at different operating frequencies. The  $S_{11}$  of proposed antenna is measured by using network analyzer.

The Parametric survey has been carried out to optimize the antenna dimensions to get better performance over the operating frequencies. This part is essential before prototyping antenna to avoid deviations. The parametric analysis is carried out mainly to optimize the width and length of the quarter wave line and ground plane to enhance the impedance matching and bandwidth. The feed line consists of two parts one is 50 ohms strip line which is connected to the source and second one is quarter wave line inserted between antenna and 50 ohms strip line.

In the first step parametric analysis is performed for the different widths of the quarter wave line to investigate the  $S_{11}$  performance. The  $S_{11}$  plot for different widths of the quarter wave line is displayed in fig.3. From the fig.3., it is clear that 2.4 mm width of the quarter wave line exhibits



better return loss performance. This width achieves proper impedance matching and hence greater bandwidth.

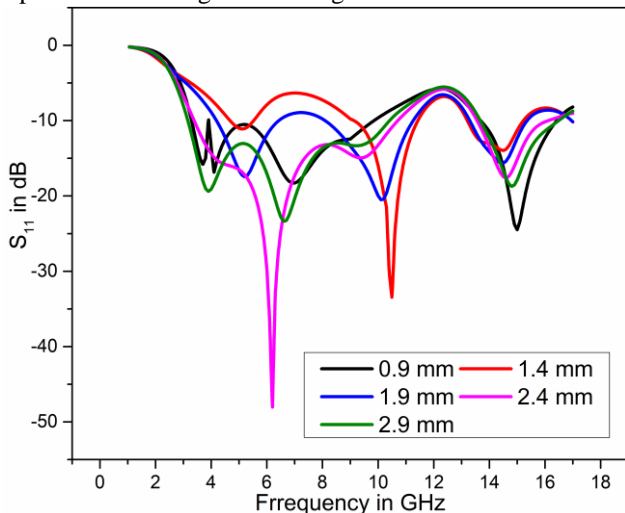


Fig.3. the  $S_{11}$  for various widths of QWL

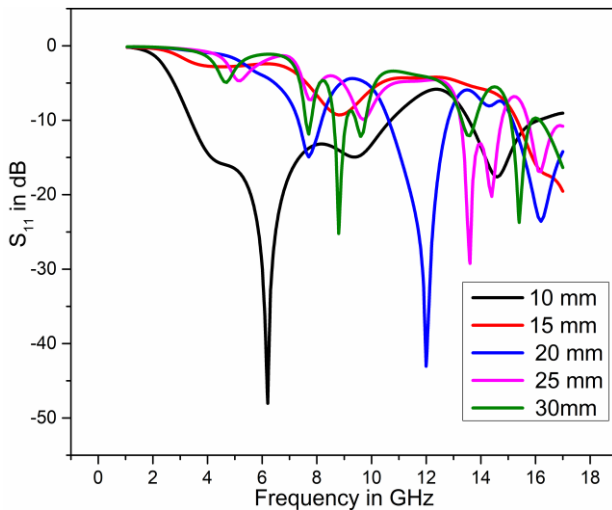


Fig.4. the  $S_{11}$  for various lengths of ground

Similarly parametric analysis is done for the different lengths of ground plane to examine the  $S_{11}$  results. The  $S_{11}$  plot for different lengths of the ground surface is displayed in fig.4.

From the fig.4., it is clear that 10 mm length of the ground plane exhibits better return loss performance. This length attains good impedance matching and hence greater bandwidth. The full grounded antenna exhibits narrow bandwidth. However, the bandwidth of antenna can be improved a lot by shortening the ground plan. The antenna exhibits better performance for 10 mm ground plane length.

The simulated reflection coefficient is compared with the measured one over the operating bands of the proposed antenna in fig.5. The designed antenna has ability to operate from 3.40 GHz to 10.67 GHz and 13.48 GHz to 15.87 GHz with return loss below -10 dB. The antenna has bandwidths of 7.27 GHz and 2.39 GHz at lower and upper bands respectively. The fig.5. also demonstrates that the measured results are meticulously matches with that simulated values.

The simulated VSWR results of the proposed antenna are compared with the measured results in below fig.6. The measured VSWR plot of the dual-band antenna closely matches with that of simulated plot. The values of VSWR lie between 1 and 2 over the two operating bands of the designed

antenna. The dual-band antenna exhibits good performance in perspective of VSWR also.

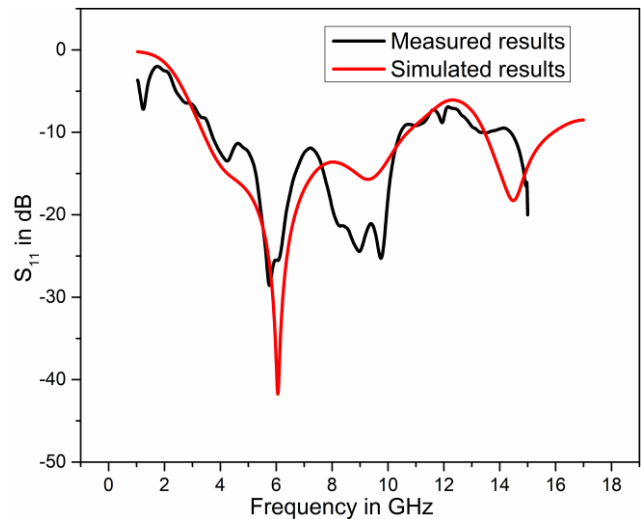


Fig.5. Reflection coefficient plot

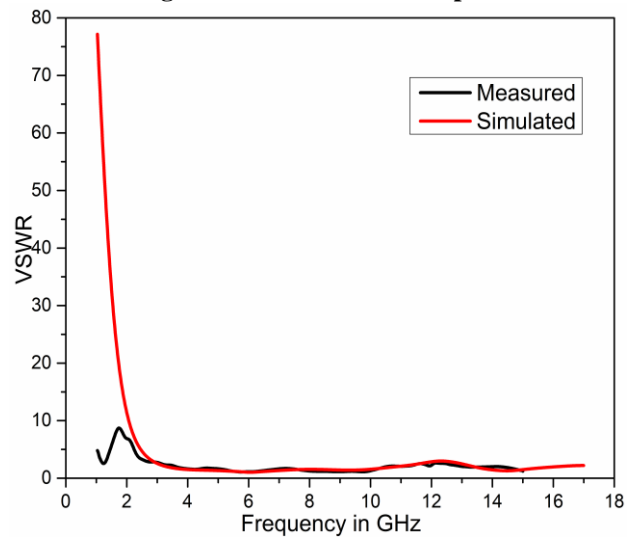


Fig.6. VSWR plot

The dual-band antenna measurement setup is displaced in fig.7.

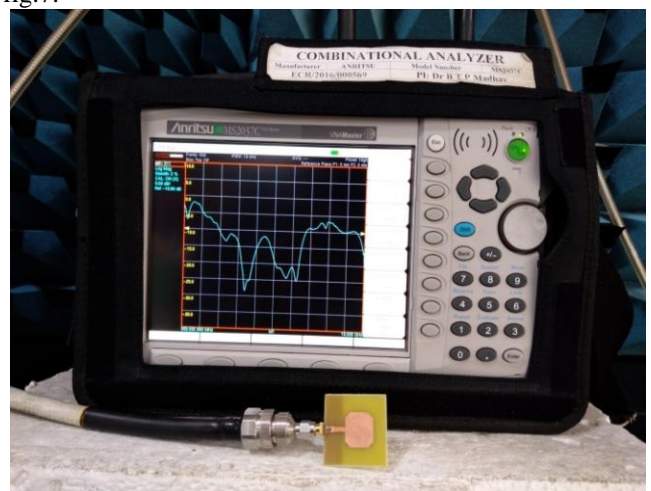
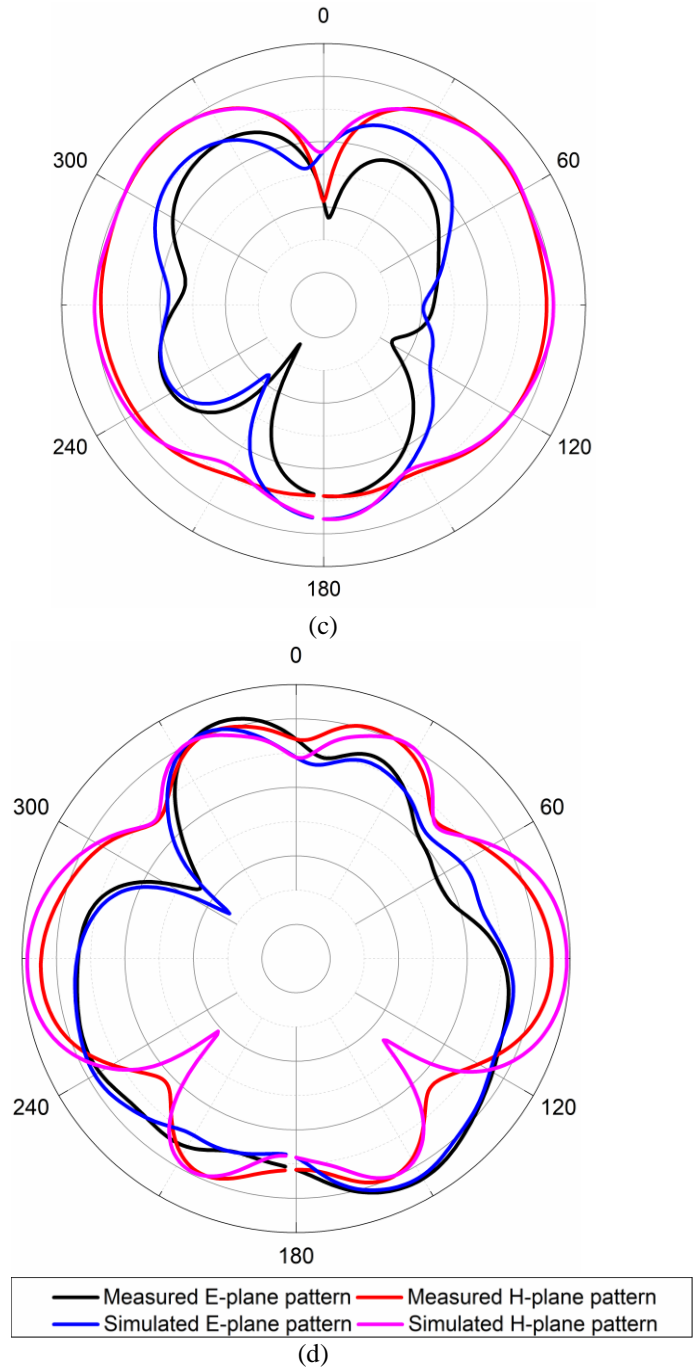
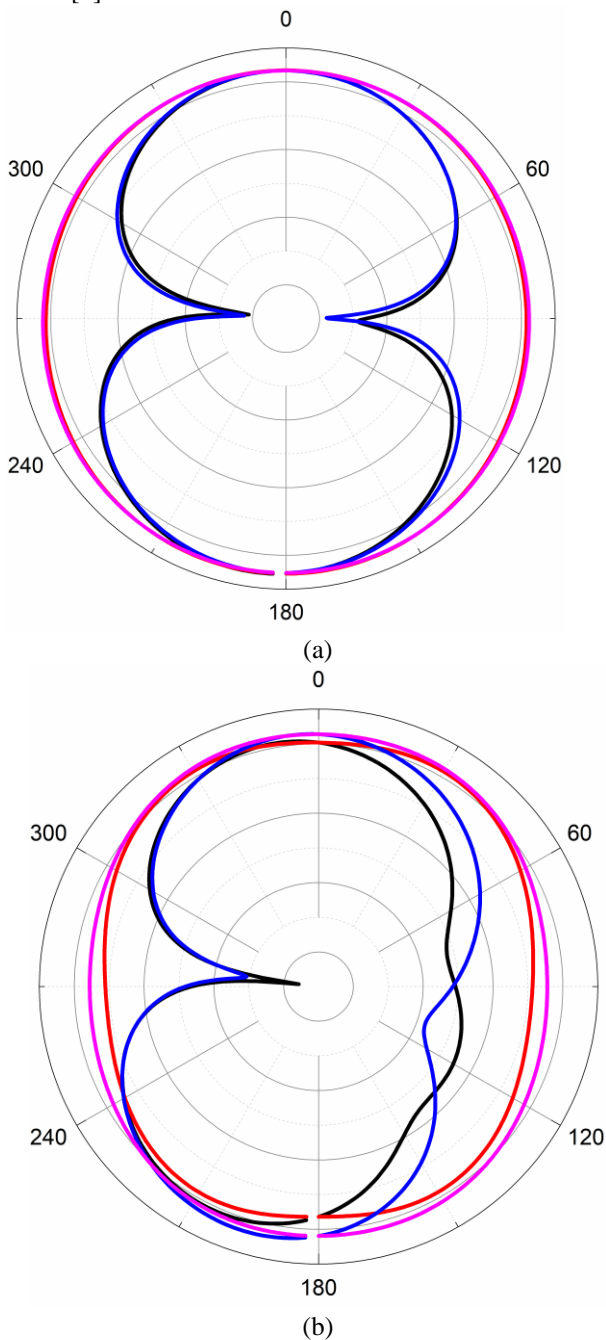


Fig.7. the photo of measurement setup of the dual-band antenna

The radiation patterns are the pictorial view of the three dimensional field variations as a function of  $\theta$  and  $\phi$ . Two principal plane cuts are needed to describe the radiation pattern in 2D. These are called the principal E- and H-plane patterns [1].



**Fig.8. the radiation pattern at (a) 4 GHz (b) 6 GHz (c) 10 GHz and (d) 14.9 GHz**

The E and H-planes radiation patterns of the given antenna are simulated then measured at the various resonant frequencies of 4, 6, 10 and 14.9 GHz respectively.

The corresponding patterns are illustrated in fig.8. The radiation pattern seems omni-directional in H-plane and monopole in E-plane. The proposed antenna gains are about 2.71, 2.3, 2.1 and 4.52 dBi at 4, 6, 10 and 14.9 GHz, respectively. The proposed antenna exhibits higher gains at the two operating bands with adequate return loss hence this antenna can be treated as better candidate for UWB and Ku-band applications.

#### IV. CONCLUSIONS

A compact dual band mono pole antenna for UWB and Ku Band Applications has been designed and analyzed. The corner truncated patch and partial ground plane are utilized to improve impedance matching and hence bandwidth. The parametric analysis is carried out to optimize the antenna performance. The proposed antenna operating principle has been described in detail. It has been demonstrated that the proposed antenna can cover the frequency bands of 3.40 GHz to 10.67 GHz and 13.48 GHz to 15.87 GHz with adequate return loss. The measured results are nearly similar to that of simulated results. This antenna may find wide applications in radar, medical imaging and satellite communications.

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