

## CPW FED UWB MONOPOLE ANTENNA WITH COMPACT SIZE AND GOOD FEDILITY ANSWER

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**Abstract** – In this paper, design and analysis of compact coplanar waveguide (CPW) fed ultra-wideband (UWB) slot antenna is presented. The proposed antenna has a simple structure consisting of a rectangular slot and a Trapezoid patch at the anterior portion of the feed that acts as tuning stub of the antenna. The analysis of the proposed antenna is performed by using FEM based electromagnetic solver, HFSS. The designed antenna is fabricated using FR4 substrate with 1.6 mm thickness. The return loss and standing wave ratio of the developed antenna are measured and compared, which shows that measured result is in good agreement with simulation. With the above structural features the overall dimension of the antenna is 20mm×20mm×1.6mm and the fractional impedance bandwidth of the antenna is about 124.32% with return loss better than -10 dB (VSWR < 2). It is also seen that the proposed antenna has relatively stable Omni-directional radiation pattern in the H plane and bidirectional radiation pattern in the E plane over the frequency range of 2.8 GHz to 12 GHz. To verify the suitability of the antenna for transmission and reception of narrow pulses, the time domain analysis is also investigated and presented.

### I. INTRODUCTION

In this modern wireless communication era there is an increase in the demand for systems, which are smaller in size and support high data rate providing high performance. After the release of Ultra Wideband (UWB) for unlicensed applications by the FCC it has been receiving much attention both from the industry and academic sectors due to its inherent properties like low power consumption, high secured data rate support and simple configuration over conventional wireless communication systems [1]. With the rapid developments of such wireless systems, a lot of attention is being given to the design of antennas

since they are the key elements to radiate and receive the signals. In the recent years miniaturization of antenna receives much attention. Contemporary researchers have been working for the development of small size and cost effective antennas. By modifying the antenna geometries and using high permittivity material, the size reduction of the antenna is possible [2]. Nowadays Printed antennas attract much attention due to its features like light weight, low profile, small size and easy fabrication although its narrow bandwidth can be eliminated by the use of slot antennas [3]. For wireless applications, various antenna configurations including



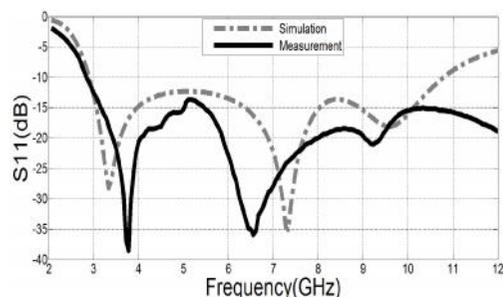
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dielectric substrate (FR4) with 1.6mm thickness and a relative permittivity of 4.4 is chosen, so that it can be easily integrated with Printed Circuit Board. The CPW feed is designed with fixed 2 mm feed line width and 0.25 mm. ground gap for 50  $\Omega$  characteristic impedance. By properly adjusting the dimension of the slot and feeding structure the impedance matching of the proposed antenna improves, which produces wider impedance bandwidth with satisfactory radiation pattern. The wide bandwidth and impedance matching with reduced size of the antenna is achieved by the different surface magnetic currents of the structure.

### III. RESULTS AND ANALYSIS

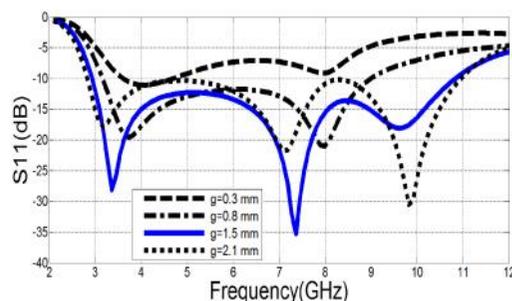
In order to evaluate the performance of the proposed antenna, the antenna is simulated through the simulation tool HFSS. To analyze the wide band coverage of the antenna, the effects of adjusting the antenna parameters are investigated. The analysis of the antenna for different parameters has been carried out by varying one parameter and keeping other parameters are constant. The designed values of the antenna are optimized with HFSS tool. The optimization was performed for the best impedance bandwidth. The comparison between simulated and measured return loss  $S_{11}$  of the proposed antenna is shown in Figure 2, which clearly indicates that the impedance bandwidth of the antenna is 9.2GHz (2.8GHz -12 GHz) for VSWR less than 2.



**Figure 2.** The comparison between simulated and measured return loss  $S_{11}$

#### A. Effect of Feed gap

For fixed values of all other parameters, Figure 3 displays the simulated return loss for different feed gaps ( $g=0.3, 0.8, 1.5,$  and  $2.1$  mm). The response clearly shows that as the feed width increases the impedance matching becomes poor at the middle frequencies and the resonant frequencies moves to the lower side. If the feed gap decreases the impedance matching over the band becomes poor and there is a shift in the resonant frequency to the higher frequencies. Hence, feed width is one of the parameters which affect the impedance matching. It is found that the optimal value for this case is 1.5 mm.



**Figure 3.** Simulated return loss curves for different feed gaps.

#### B. Effect of Trapezoid patch large side ( $W_2$ )

The effect of bandwidth for different width  $W_2$  of the Trapezoid patch, depicted in Figure 4 which discloses the profiles of the impedance matching. While increasing the width  $W_2$  the return loss  $S_{11}$  decreases and there is a shift in the resonance frequency, which implies poor impedance matching. Similarly if the height  $W_2$  is decreased, there is a decrease in the return loss  $S_{11}$  and shift in the resonance frequency. Variation in the values of 'H' influences variation in the responses and the optimal value for this case is 10 mm.

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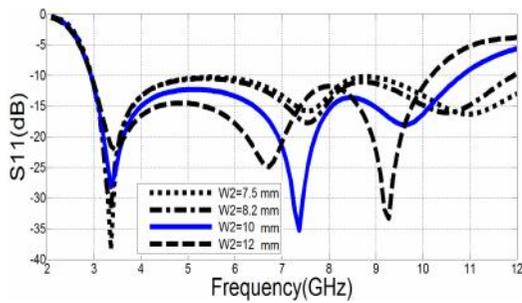


Figure 4. Simulated return losses for different Trapezoid patch width

### C. Simulated Current Distribution

The current distributions of the proposed antenna are obtained by accounting the optimal design parameter values at frequencies 3.3, 6.5, 7.3 and 11GHz, which is shown in Figure 5. It is seen that the maximum radiation is possible at these frequencies owing to the current distribution near the edges of the slot and in the patch.

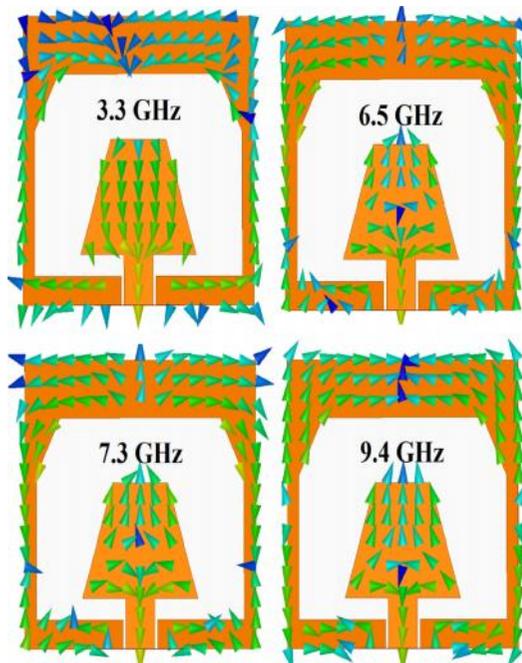


Figure 5. Current distributions

## IV. EXPERIMENTAL RESULTS AND DISCUSSIONS

The prototype of the proposed antenna shown in Figure 1 was fabricated for different parameters with their optimal values and tested that is depicted in Figure 7. Using Packard Network Analyzer (8722ES), the return loss and VSWR are measured and plotted. The schematic of the measurement setup is shown in Figure 2. There is a shift in the measured response at the low frequency, this discrepancy between the measured and the simulated one is due to the effect of soldering the SMA connector or fabrication tolerance. The simulation results were obtained by assuming coplanar input port, whereas practically SMA connector was used, the imperfect transition between SMA feed to coplanar may introduce losses [30-34] and the capacitances can lead to shift in the frequency. The soldering position of the feed point may also be reason for shift in the frequency [33-36]. The measured radiation pattern of the E plane and H plane are obtained at 3.2, 4.4, 6.5 and 9.8 GHz as shown in Figure 6. It is noticed that in H plane, the radiation pattern is omni directional and in E plane the radiation pattern is bidirectional. As the frequency increases there is a decrease in the gain due to low profile of the proposed antenna structure. Proper geometrical selection of the antenna results variations in field distribution, which in turn affects the characteristics of the proposed antenna.

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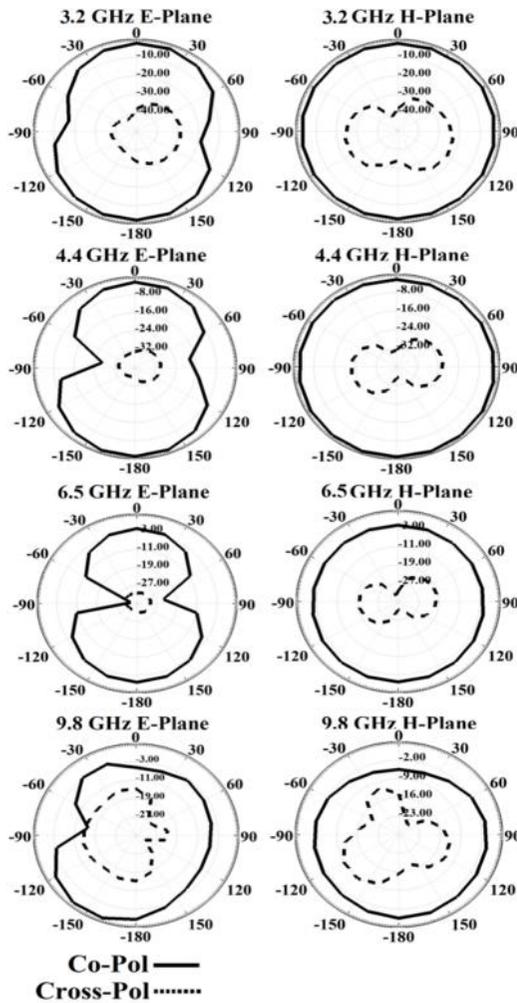


Figure 6. Measured Radiation pattern

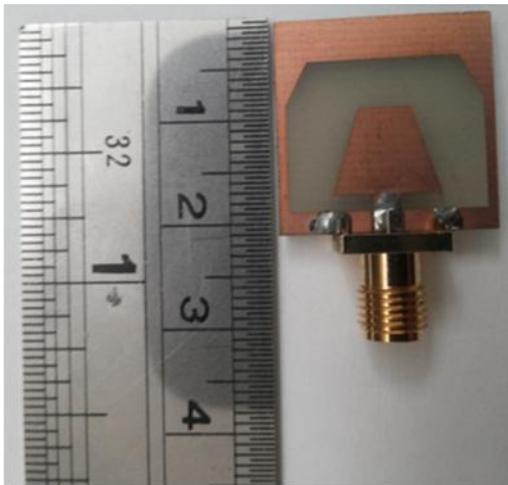


Figure 7. Fabricated antenna

## V. TIME DOMAIN ANALYSIS

In ultra-wideband systems, the information is transmitted using short pulses. Hence it is important to study the temporal behavior of the transmitted pulse. The communication system for UWB pulse transmission must provide as minimum as possible distortion, spreading and disturbance. The channel is assumed to be linear time invariant (LTI) system to verify the capability of the proposed antenna for transmission and reception of these narrow pulses. The transfer function of the entire system is computed using simulated value of 'S21' parameter [32]. The received output pulse is obtained by taking the Inverse Fourier Transform (IFT) of the product of transfer function and spectrum of the test input pulse. While computing 'S21', two identical antennas are placed face to face at a distance of 100 cm that is greater than the far-field distance of the antenna. The cosine modulated Gaussian pulse is considered for this analysis with center frequency of 6.85 GHz and pulse width of 220 picoseconds, whose spectrum is shown in Figure 10. It satisfies the requirement of FCC mask for UWB indoor emission. The comparison of input and output responses of the system for the antenna with notch and without notch is shown in Figure 11, which ensures the distortion less pulse transmission and also guarantees that the designed antenna is capable of transmitting and receiving short pulses. The ringing effect in the waveform may be due to the transmission properties of the system.

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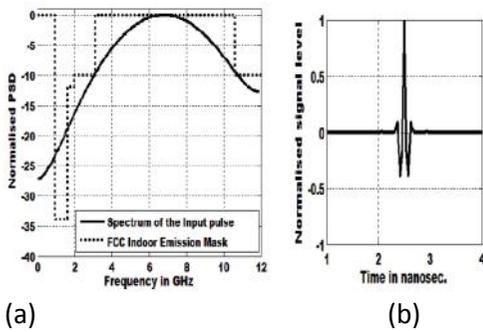


Figure 10. a) Spectrum of the test input pulse with FCC mask b) input pulse in time domain

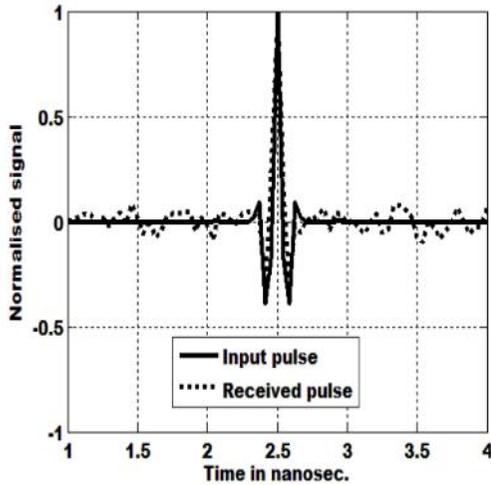


Figure 11. Comparison of input pulse and received pulse in time domain.

## VI. CONCLUSION

In this paper, a simple antenna structure has been proposed for better impedance matching with small in size. A Trapezoid tuning stub is introduced at the anterior portion of the feed to enhance the coupling between the slot and the feed. With the above structural features the overall dimension of the proposed antenna is  $21 \times 20 \times 1.6$  mm<sup>3</sup>. It is observed that 124.32% of bandwidth can be achieved with better size reduction over the frequency range of 2.8 GHz to 12 GHz. The computed time domain analysis of the antenna also ensures the suitability of the antenna working in the UWB environment. Hence, this type of antenna can be used for UWB indoor applications.

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