# A study of printed monopole antenna for ultra wideband systems

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**Abstract**

*A printed monopole antenna with CPW-fed is proposed. The proposed antenna includes a rectangle shape radiator, two ground planes with symmetrical notch and feed excitation. It covers the all ultra wideband (UWB 3.1GHz ~ 10.6GHz) and has 7.8GHz (2.8GHz ~ 10.6GHz) measured return loss bandwidth. In modifiable design, we choose to design the notches on the ground plane, the high of the proposed antenna and the width of the radiator, and have to obtain broad impedance bandwidth and accessible measurement parameters. The experiment results have shown omnidirectional radiation pattern and fine gain over UWB operation in this paper.*

## 1. INTRODUCTION

The ultra wideband (UWB) technology has another name called the technology of pulse radio (Impulse Radio), in 1960. According to the regulation of FCC, It had bandwidth range 7.5 GHz from 3.1 GHz to 10.6 GHz [1]. American military has used for many years, applied the Ground Penetrating Radar Systems, Through Wall Imaging Systems, etc. new technological UWB of communication, because it has transmission speed quickly, low power dissipation and low taking up the chip space, etc. The FCC already visits mines to reach in the open frequency band in February of 2002. In wireless communication in the wide-band room, FCC also opens 3.1-10.6 GHz for UWB communication and measuring system to use.

Recently, various UWB antennas have been published for ultra-wideband applications, such as coplanar waveguide-fed rectangular slot antenna [2], planar half-disk antenna [3], printed circular disc monopole antenna [4], planar half-circle-shaped notch antenna [5], and microstrip-fed antenna [6]. However, the UWB communication is develop latent energy, has already become a hot topic of tomorrow of the commercial market in recent years, the global big famous factory will competitively bet resources even more, vie for attacking the market first chance. In this paper, we proposed a monopole antenna with CPW-fed. To verify the validation of the proposed antenna, the simulated and measured return losses against frequency are presented. Also, measured radiation patterns and gains of over the UWB band are shown and discussed.

## 2. ANTENNA CONFIGURATION AND PERFORMANCE

The configuration of the printed CPW-fed monopole antenna has a single layer metallic structure is shown in Figure 1. The dimensions of the antenna were firstly studied by Ansoft HFSS simulation electromagnetic software, and then verified by experiment. The ground planes are composed of rectangle planes ($15\times16mm^2$) and two half-circular shape of radius of 7.5mm.The proposed antenna is printed on the FR4 substrate with thickness of 1.6mm, relative permittivity of 4.4 and loss tangent of 0.0245. The radius of the major modified axis is $R_1$ and another axis is $R_2$. This antenna parameters are $W$=13.6mm, $L$=39mm, $W_g$=15mm, $L_g$=16mm, $R_1$ =11mm, and $R_2$ =7.5mm. The proposed antenna has 50-ohmic CPW-type feed with signal line of length 16mm and width 3mm, and gap distance ($g$) of 0.3mm between the feed line and the two ground planes. The proposed antenna was built and tested in the Microwave and Wireless Components Laboratory at Taipei, National Taipei University of Technology (NTUT). The measurement chamber could measure from 0.7GHz to 20.5GHz and cover UWB band, and dimension of 3.25 m × 2.82 m× 6.65 m. Moreover, S-parameters and radiation patterns are obtained with the 8720C Network Analyzer.

Figure 2 shows the simulated and the measured voltage standing wave ratio (VSWR) curves. The measured VSWR curves aggress well with the simulated one in most of the frequency band range except between 3GHz and 10GHz. It is shown that the different resonance occurs at 3.5GHz, 4.5GHz and 8GHz in the simulation; this resonance also appears in the measurement, but it is not apparent, this could be due to the effect of the SMA port. The measured impedance bandwidth has 7.8GHz from 2.8GHz to 10.6GHz operation. The impedance performance of the proposed antenna with either notch or not it is shown in Figure 3. The real part value variation reduces from 102 T to 57 T on full UWB spectrum. The imaginary part of the proposed antenna with notches the on ground plane is around zero, without big variation.

## 3. EFFECTS OF DESIGN PARAMETERS

It has been shown in the simulation that the operating bandwidth of the monopole antenna with CPW-fed is critically dependent on the two notches at the ground plane ($L_1$ $L_2$), the high of the proposed antenna ($L$) and the width of the radiator ($W$). So these parameters could be optimised for board bandwidth. In addition, it is noticed that this SMA port mainly affects the second and third resonances by shifting their resonant frequencies.

*A. The Effect of Notches on The Ground Plane*

Figure 4 shows the simulated return loss curves with different two notches at the ground plane ($L_1$ $L_2$) when other parameters are fixed. It could be seen in Figure3 that the return loss curves have similar shape for the six different notches, but the -10dB bandwidth of the antenna changes significantly with the variation of $L_1$ *and* $L_2$. In the resonance frequency, almost there is not great change on low frequency. It is mainly effect the match of the middle and high frequencies section, and proper modified could change reactance value and should reach fine match on high frequency. It is also noticed that the higher edge of the -10dB bandwidth increases when $L_1$ *and* $L_2$ get bigger. The optimised notches are found to be at $L_1$ *=0.5mm and* $L_2$*=0.6mm.*

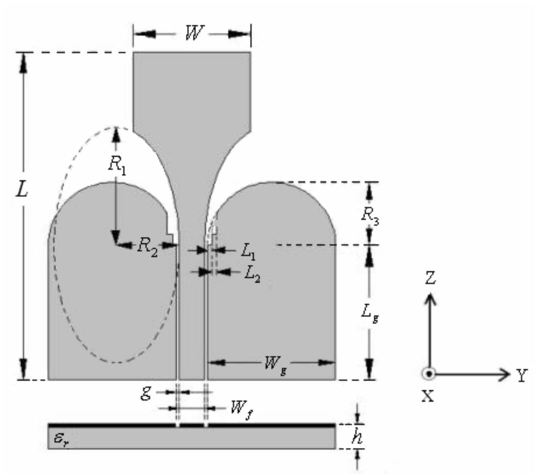


Fig. 1: Geometry of proposed antenna

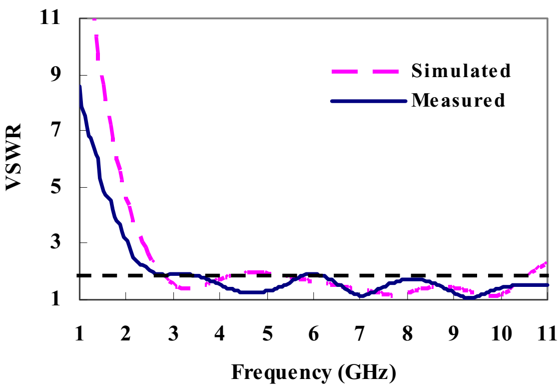


Fig. 2: The simulated and the measured VSWR curves

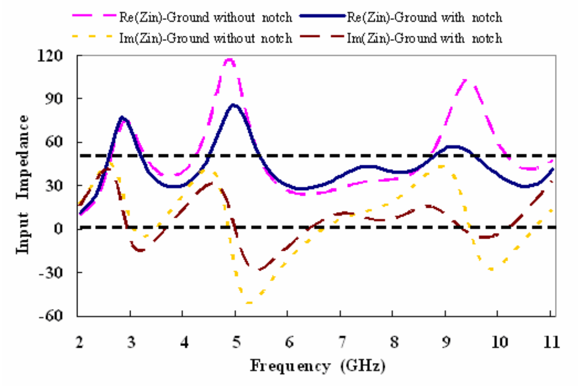


Fig. 3: The impedance parameters of proposed antenna

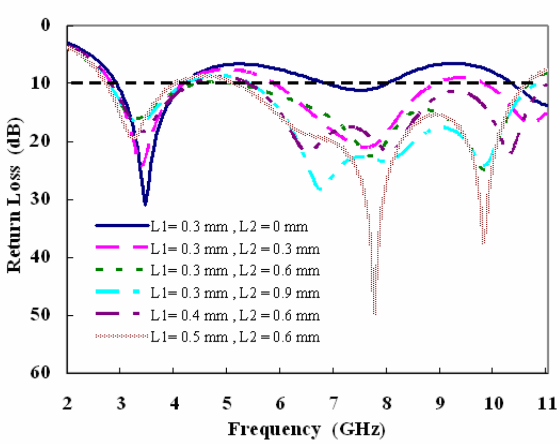


Fig. 4: The simulated return loss curves for different notches on the ground plane

*B. The Effect of The High of Proposed Antenna*

In fact, the monopole antenna resonance length has around quarter wavelength. We could modify the high of proposed antenna and get first resonance mode of return loss. Figure 5 shows the simulated return loss curves for different high of proposed antenna with their respective optimal designs ($W$=13.6mm, $L_1$=0.3mm, $L_2$=0.6mm, $W_g$=15mm, $L_g$=16mm, $R_1$ =11mm, and $R_2$ =7.5mm, $W_f$=3mm, $g$=0.3mm). It is observed from Figure 5 that the first resonant frequency decreases with the increase of the high of proposed antenna.

*C. The Effect of The Width of Radiator*

We studied to modify dimension of the width of radiator and obtained the results in Figure 6. Other parameters are fixed at the optimized state. If the antenna has completed the width of radiator, the performance of impedance bandwidth only will be broadband situation. By increasing the width of radiator, the electromagnetic coupling effects between the radiator and the ground planes could expand the overall bandwidth of the antenna for UWB operation. The effect of the high and the width both influence high-band on all operation.

### 4. Radiation Patterns and Gain

Figure 7-9 show the measured far-field radiation patterns at three purpose frequencies of 3, 6, and 9 GHz for monopole antenna with CPW-fed. It is shown that three planes of this proposed antenna. The experiment results show the patterns in horizontal plane have closed omni-directional for 3 and 6 GHz. The patterns are also acceptable for 9 GHz. Besides, the radiation patterns of E-plane are similar to dipole in lower band. Figure 10 shows the measured antenna gains from 3 to 12 GHz for the proposed antenna with notches on the ground plane. The peak gain with frequency among x-y, y-z, and x-z plane is selected for the proposed antenna measured gain curve, and it is shown that when the frequency increases from 3.5GHz to 10GHz, the gain rises from 0.868dBi to 8.168dBi; other frequencies does not change much and fixed at around 7dBi.

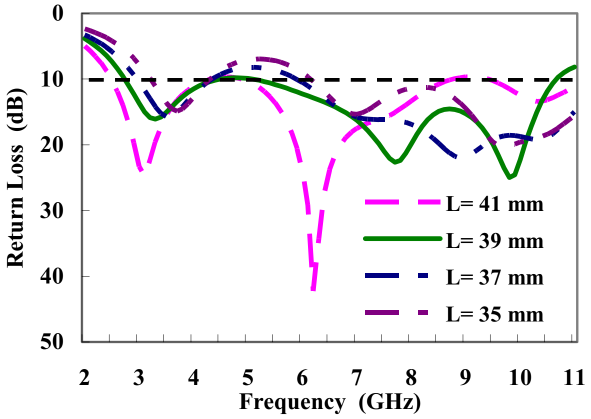


Fig. 5: The simulated return loss curves for different the high of proposed antenna

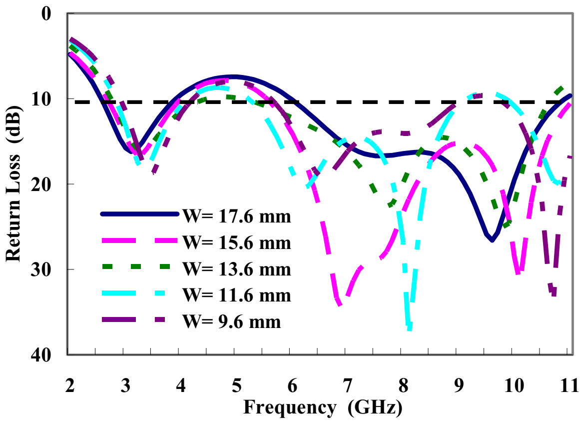


Fig. 6: The simulated return loss curves for different the width of radiator

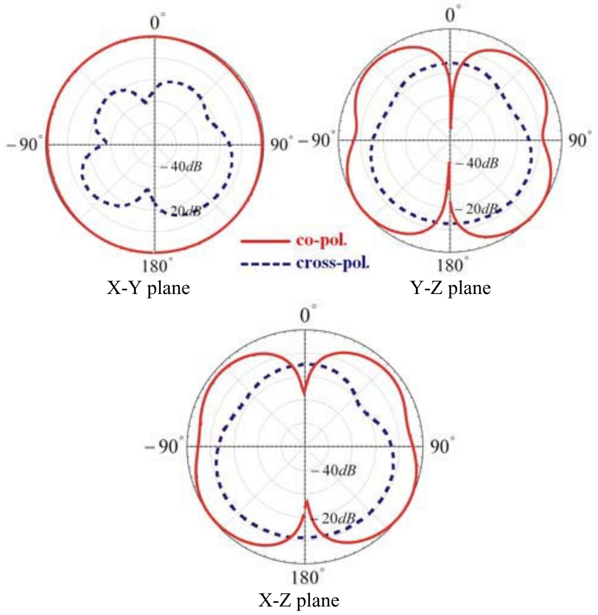


Fig. 7: The measured radiation pattern at 3GHz

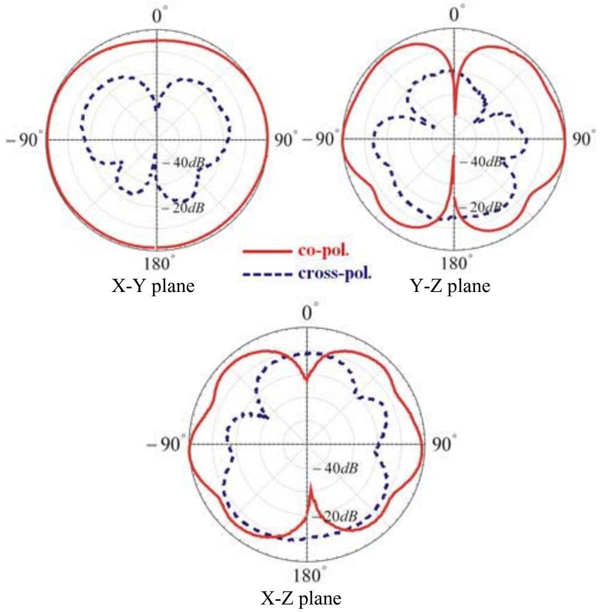


Fig. 8: The measured radiation pattern at 6GHz

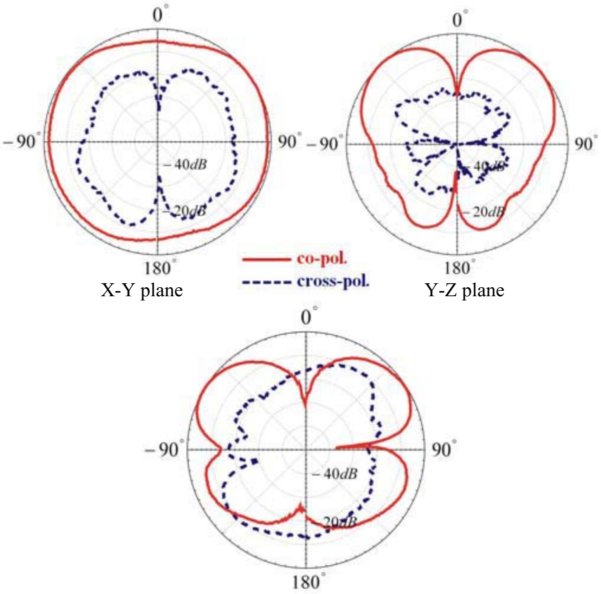


Fig. 9: The measured radiation pattern at 9GHz

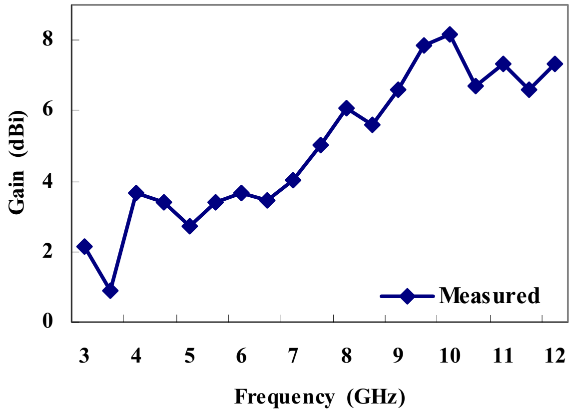


Fig. 10: The measured peak gain from 3GHz to 12GHz

## 5. Conclusion

The new designed monopole antenna with modified parameters for UWB spectrum is successful demonstrated. In the proposed antenna, the resonant mode has impedance bandwidth of 7.8GHz, which covers 3.1GHz ~ 10.6GHz band for UWB operation. Measured results of the proposed antenna exhibit fairly good omni-directional patterns at x-y plane for all operating band. The measured results of the designed antenna exhibit fairly good agreements with these simulated ones. It shows good performances for ultra wideband applications.

## References


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