

## RESEARCH PAPER

# CPW-fed printed UWB antenna with open-loop inverted triangular-shaped slot for WLAN band filtering

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*A compact CPW-fed printed monopole slot antenna is presented for ultra-wideband (UWB) applications. The antenna comprises of a dome-shaped radiating element in which embedded is an open-loop inverted triangular-shaped slot (TSS). The antenna is fed through a coplanar waveguide to provide an ultra-wide impedance bandwidth of 8.95 GHz (2.58–11.53 GHz) which corresponds to a bandwidth ratio of 1:4.46 for VSWR < 2. The antenna possesses a notch band functionality to filter out interfering C-band signals like wireless local-area network (WLAN). The notch band frequency is determined by physical parameters defining the TSS that allows fine control of the notch's location. The proposed antenna also possesses a flat gain response except at the notched band and occupies a relatively small volume of  $25 \times 25 \times 0.8 \text{ mm}^3$  for ease of system integration.*

**Keywords:** Slot antenna, CPW-fed, Band-notched function, WLAN, Ultra-wideband

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## 1. INTRODUCTION

Development of ultra-wideband (UWB) systems has increased the demand for compact antennas that can be economically manufactured and possess omni-directional radiation patterns. It is well known that printed monopole antennas have attractive features, namely: (1) large impedance bandwidth; (2) ease of fabrication using conventional MIC technology; (3) acceptable radiation properties; and (4) light weight. Consequently such antennas have received great attention for UWB applications. In fact, since the Federal Communications Commission (FCC) launched the bandwidth defined between 3.1 and 10.6 GHz [1] for commercial use, UWB technology has now become the favored choice for short-range and high-speed indoor data communications.

Several printed monopole antennas with different geometries have been reported recently [2–15]. Unfortunately UWB systems have to operate in an electromagnetic spectrum occupied by several narrow band signals used by wireless communication systems such as wireless local-area network (WLAN) IEEE802.11a and HIPERLAN/2 WLAN operating in 5–6 GHz band. This necessitates the use of filters to suppress these much stronger interfering signals that would

otherwise degrade the operation of UWB systems. However, this requirement would unnecessarily increase the complexity, weight and volume of the UWB systems. Hence additional functionality is required from UWB antennas. Over the recent years numerous antennas have been developed to eradicate electromagnetic interference between the UWB and other narrowband systems such as WLAN. Over recent years various printed antennas have been reported for application in UWB systems using different structures and feed methods such as coplanar waveguide, coaxial and microstrip. Xie et al. [6] used proximity coupled resonator, Zhao et al. [7] proposed a slotted planar antenna using  $\pi$ -shaped slot. In [8] band notch function based on slot-type electric LC resonator on patch has been presented. Wu et al. [9] described applying an open-looped resonator, and Cho et al. [10] in reference proposed a U-shaped filter in radiating element. For WLAN-notched operation, a slot with semi rectangular shape has been used in [11]. Segmenting a circular patch to create a stop-band is presented in [12]. To realize the rejection band inverted U-shaped slot is added in the hexagonal patch in [13]. Other techniques include: slotted arc-shaped edge rectangular antenna [14], and utilizing a pair of inverted-L-shaped slots on the ground-plane [15].

In this paper we present the results of the proposed antenna that exhibits a VSWR  $\leq 2$  in the frequency band between 2.50 and 12.12 GHz, with a notch band frequency between 5.02 and 5.93 GHz (both simulated). The antenna has been analyzed using Ansoft High Frequency Structure Simulator (HFSS) [16]. The experimental results show the antenna has an impedance bandwidth of 8.95 GHz between 2.58 and 11.53 GHz (126.8%). A compact, yet structurally simpler configuration is proposed. Table 1 compares the size

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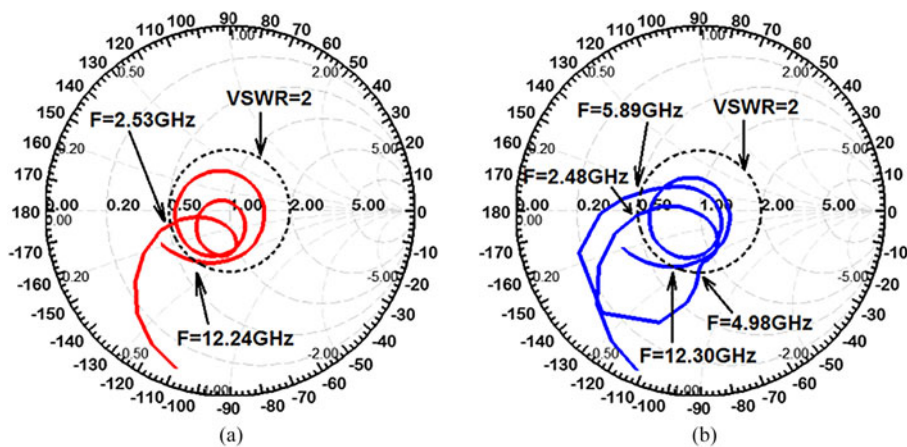


Fig. 4. Smith Chart of the antenna (a) for antenna with no slot and (b) antenna with the open-loop inverted TSS.

### III. PARAMETRIC STUDY RESULTS

To attain a deeper insight of how the antenna's parameters influence its performance a parametric study was necessary. Figure 6(a) shows the effect of the width parameter  $L_{s2}$  on the antenna's VSWR response.  $L_{s2}$  mainly affects the center frequency of the stop-band. This is the key parameter that enables rejection of the interfering signals at the desired WLAN band (5–6 GHz) for which  $L_{s2} = 0.75$  mm or at C-band (3.7–4.2 GHz) when  $L_{s2} = 0.25$  mm. To filter the WLAN the width  $L_{s2}$  was fixed at 0.75 mm. Furthermore, Fig. 6(b) shows the simulated band reject characteristics of the antenna as a function of width  $L_{s1}$ . When  $L_{s1}$  is changed from 0.2 to 1 mm, the stop-band at around 6.2 GHz shifts down to 4.8 GHz. Moreover, the parameter  $W_s$  plays an important role in the position of the stop-band. This affect is shown in Fig. 6(c). The notched band corresponds to the width of  $W_s$ . It can be observed from this figure that by increasing  $W_s$  from 3 to 4.5 mm, the notched band moves to a lower frequency. Also, it can be observed that by changing

the length of  $W_s$ , suitable band notch characteristic can be achieved. Therefore through this analysis  $W_s$  was fixed at 4 mm.

### IV. RADIATION PATTERN, GAIN, AND GROUP DELAY

Figure 7 shows the far-field measured radiation patterns of the proposed antenna with the co- and cross-polarization in the H-plane ( $x$ - $z$  plane) and E-plane ( $y$ - $z$  plane). It is observed that the radiation patterns in  $x$ - $z$  and  $y$ - $z$  plane are approximately omni-directional and mono-pole like, respectively, at the various frequencies (i.e. 3.4, 4.6, 6.2, and 11.1 GHz). This demonstrates that the antenna actually radiates over a wide frequency band. Figure 8 shows the antenna gain from 2 to 12 GHz for the primary and proposed antenna. The figure indicates that the primary antenna (without TSS) has flat gain and it is nearly the same when TSS is etched on patch except at the notch band where the gain drops

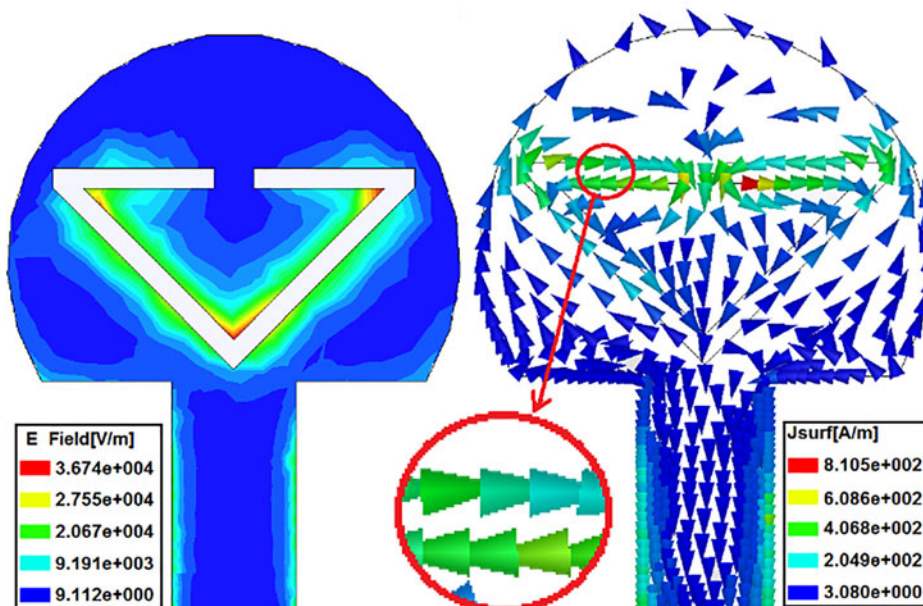


Fig. 5. Surface current density distribution and electric-field vectors over the patch at 5.5 GHz.



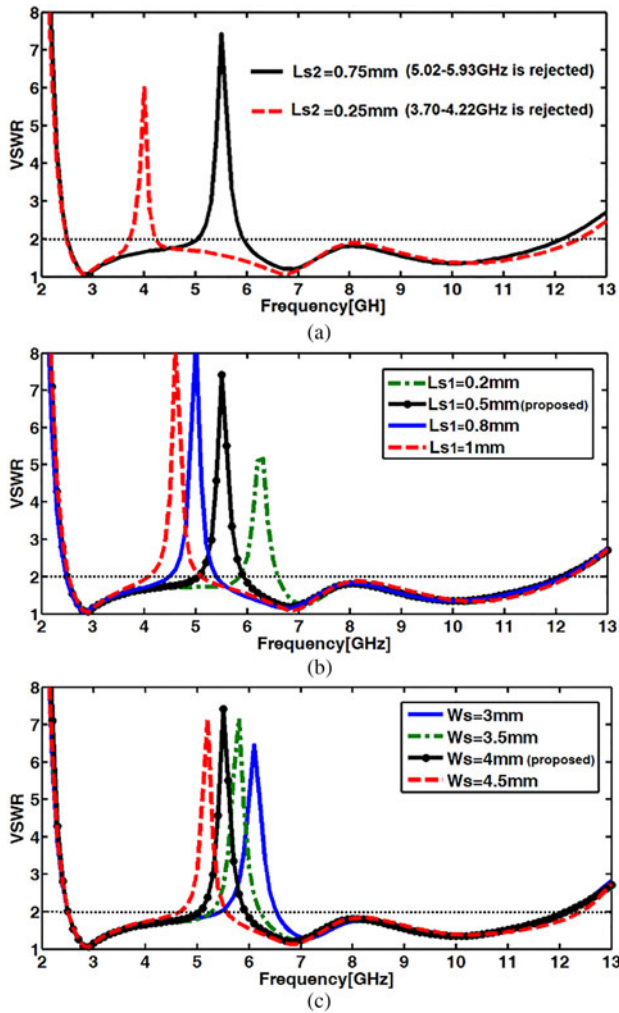


Fig. 6. VSWR response as a function of antenna parameters: (a)  $L_{s2}$ , (b)  $L_{s1}$ , and (c)  $W_s$ .

drastically. In addition, as shown in the figure, there is good agreement between measured and simulated gain curves of the proposed antenna. To verify the proposed design, a prototype of the antenna was fabricated and it is shown in Fig. 9 based on optimized dimensions in Fig. 1. The impedance bandwidth was measured using an Agilent 8722ES vector network analyzer, and the results shown in Fig. 10 indicate good agreement between simulation and measurement. The discrepancy in the results is attributed to manufacturing tolerance. It is observed from the results that the designed antenna with the TSS exhibits notched band of 4.81–5.83 GHz, which cover the GHz (5.15–5.35/5.725–5.825 GHz) WLAN bands while performance from 2.58 to 11.53 GHz. These results show the proposed is suitable for UWB systems.

## V. CONCLUSION

A compact CPW-fed printed mono-pole slot antenna is proposed that exhibits UWB performance with a frequency band of 8.95 GHz (2.58–11.53 GHz) for  $VSWR < 2$ , and filters interference signals over the 4.81–5.83 GHz band. The notch band frequency can be altered by simply changing the length of the open-loop inverted TSS. The proposed

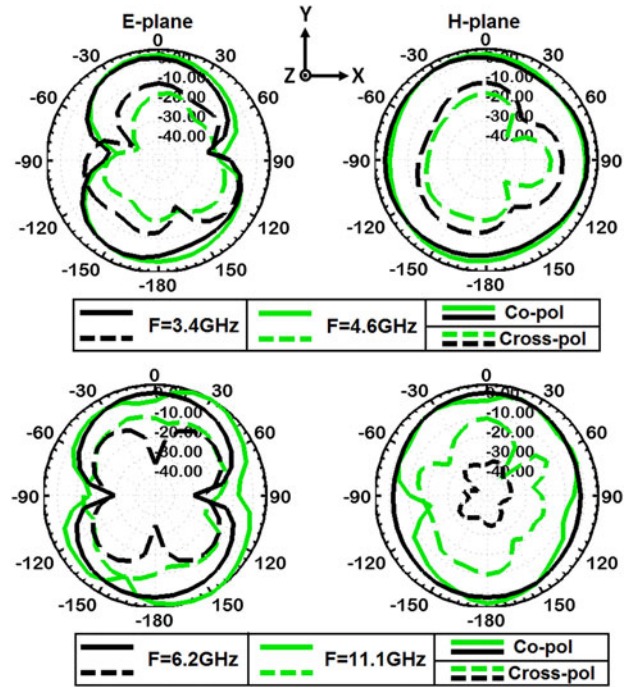


Fig. 7. Measured radiation patterns of the proposed antenna at various frequencies.

antenna consists of a dome-shaped patch. The proposed antenna radiates omni-directionally in the H-plane and has an average gain of 2 over the UWB frequency bandwidth except at the notch band. Measurement results show that the fabricated antenna is suitable for UWB applications.

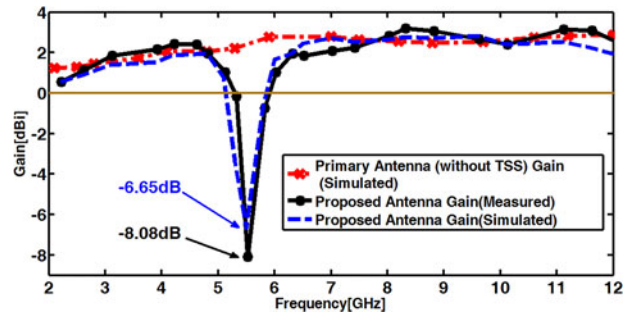


Fig. 8. Measured and simulated gain of the proposed antenna.

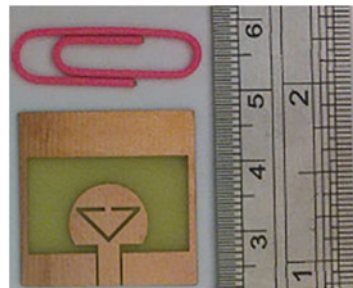


Fig. 9. Photograph of the fabricated antenna.

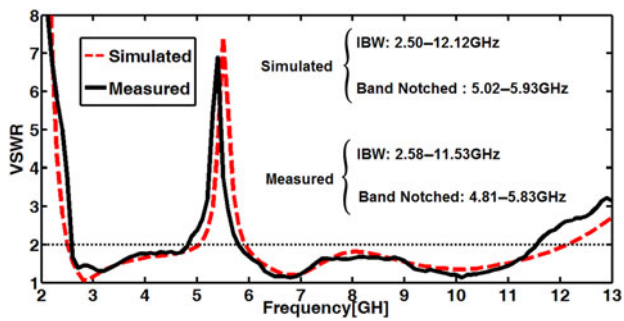


Fig. 10. Measured and simulated VSWR response of the proposed optimized antenna and primary antenna.

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