A Printed UWB Antenna using Embedded Slits for 3.5/5.5 GHz Band Notching

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***Abstract* – This paper presents a printed UWB antenna with notched bands. To reduce the EMI at 3.5 and 5.5 GHz, two invert L-shaped narrow slits embedded into both ground planes and modified U-shaped narrow slit embedded into radiating patch are applied for band notching of those bands, respectively. The proposed antenna provides operating frequency ranges of 3.1-3.3 GHz, 3.8-5.2 GHz and 5.9-12 GHz. Nearly omni-directional and bi-directional radiation patterns in H and E-planes are given, respectively. Therefore, this antenna is suitable to use for general UWB communication systems with the EMI reduction at 3.5 and 5.5 GHz.**

***Index Terms* — Printed UWB antenna, EMI reduction, invert L-shaped slit, modified U-shaped narrow slit.**

1. Introduction

With the extremely wide operating bandwidth on ultra-wideband (UWB) communication system, it is inevitable that the electromagnetic interferences (EMIs) are existing on wireless local area network (WLAN) and interoperability for microwave access (WiMAX) frequency bands of 3.5/5.5 GHz. The effective method with low cost to avoid the EMI effects is the designing of a printed UWB antenna with those bands rejection. Various techniques were proposed such as adding narrow slits into radiating patch [1]-[2]. A quarter wavelength small strip was used in [3]. The resonators were used for [4] and the antenna in [5] was designed using spiral and resonators. However, the antennas in [1], [3]-[4] were not designed for band notching at 3.5 GHz. The antennas in [2] and [5] were designed using both metallic sides of substrate, which may be led to complicate structure.

This paper proposes a printed UWB antenna with 3.5/5.5 GHz band notching. By embedding two invert L-shaped and modified U-shaped narrow slits into the baseline UWB antenna structure [1], the frequency band notching of 3.5 and 5.5 GHz is obtained. The proposed antenna has ability to mitigate the EMI at those bands. The design procedures, major parameter studies, the implementation and measurement of the proposed antenna are following.

2. Antenna Design and Measurement Results

Firstly, the baseline antenna in [1] is modified using tapered central line of coplanar waveguide (CPW) for impedance matching enhancement as shown in Fig.1 (a). The antenna is designed using single metallic side of an FR4 substrate with the thickness of 0.8 mm, dielectric constant of 4.4 and loss tangent of 0.019. The CST microwave studio software is used to determine the antenna characteristics. All simulated $|S_{11}|$ results are shown in Fig.1 (d). The baseline antenna shows impedance bandwidth of 10.8 GHz (2.8-12 GHz). Secondly, two invert L-shaped narrow slits are embedded into both ground planes of the CPW as shown in Fig. 1 (b). It is found that the frequency range of 3.3-3.7 GHz is rejected reducing the EMI at this band. The overall narrow slit length (2×(L2+L3)) of 27.4 mm is approximately about a half wavelength at resonant rejected frequency of 3.48 GHz (26.23 mm) corresponding to (1).

$$\lambda_g \approx \frac{3\times10^8}{f_{notch}\sqrt{((\varepsilon_r+1)/2)}} \quad (1)$$

Finally, the frequency band of 5.5 GHz is notched by embedding modified U-shaped narrow slit into radiating patch as shown in Fig.1 (c). The overall this slit length ((2×U2)+3) of 19 mm is approximately a half wavelength at resonant rejected frequency of 5.5 GHz (16.6 mm). It is clearly seen that the rejected frequency ranges of 3.3-3.7 GHz and 5.2-5.75 GHz are given. The proposed antenna in Fig.1 (c) shows the potential to reduce the EMI at WLAN/WiMAX frequency bands.

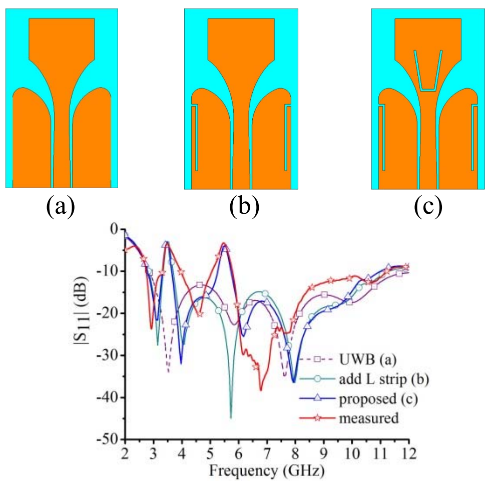
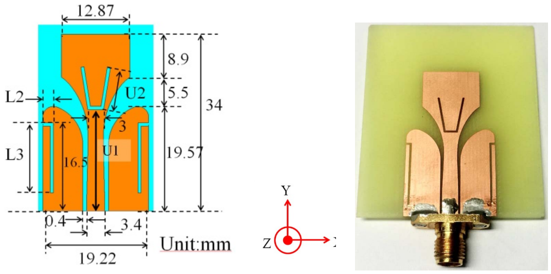
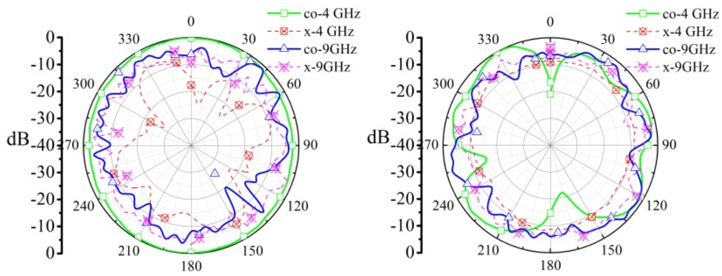


Fig. 1. Evolution of the antenna models and simulated $|S_{11}|$ results .



(a) (b)

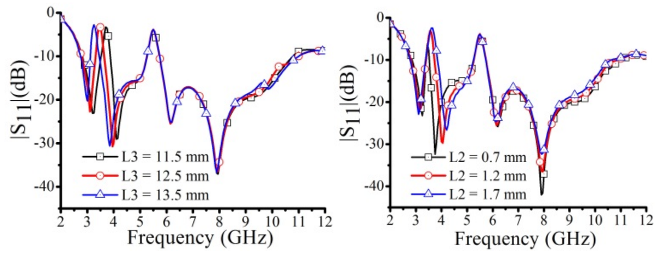
Fig. 2. The antenna (a) configuration and (b) prototype.



(a) (b)

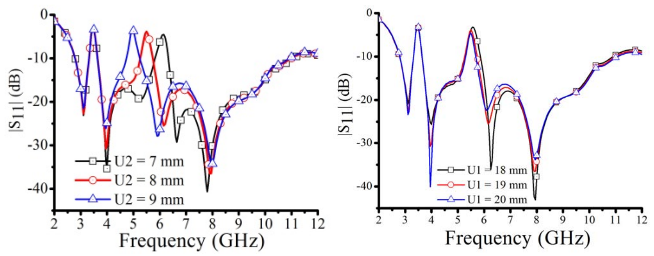
Fig. 5. Measured radiation pattern results in (a) *xz* and (b) *yz* planes.

Figs. 2 (a) and (b) display the antenna configuration and its prototype. The measured $|S_{11}|$ result is also shown in Fig. 1 (d). In design procedures, there are four major parameters affecting to the antenna characteristics. The simulated $|S_{11}|$ results of those parameters are shown in Figs. 3 and 4. It is found that the center frequency of 3.5 GHz rejected band is controlled by the invert L-shaped narrow slit length (L3), whereas the bandwidth is controlled by its position (L2). The center frequency of 5.5 GHz rejected band and its notched bandwidth can be controlled by the modified U-shaped narrow slit length (U2) and its position (U1), respectively. Figs. 5 (a) and (b) display the measured radiation patterns at 4 and 9 GHz in *xz* and *yz* planes, respectively. It is found that the antenna provides radiation patterns in *xz* plane likely omni-directional. In *yz* plane, the antenna provides nearly bi-directional radiation pattern at low frequency and likely omni-directional at high frequency. Fig. 6 shows the measured transfer function or $|S_{21}|$ and group delay time. The measurements are accomplished by using network analyzer and two identical antennas with distance of 35 mm. It is found that the proposed antenna provides the $|S_{21}|$ nearly constant for the entire operating frequency. The average delay time is about 1.4 ns which is suitable to use for any pulse communication system.



(a) (b)

Fig. 3. Parameters study for (a) L3 and (b) L2



(a) (b)

Fig. 4. Parameters study for (a) U2 and (b) U1.

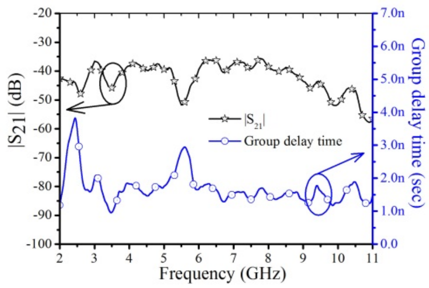


Fig. 6. Measured transfer function and group delay time.

3. Conclusion

This paper presents the printed UWB antenna which reduces the EMI at 3.5/5.5 GHz bands. To accomplish this target, the narrow slits are embedded into ground planes and radiating patch. The proposed antenna shows high potential to reduce the EMI and nearly constant group delay time, which is proper to use for pulse communications.

Acknowledgment

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