

Switched Band-Notched UWB/ WLAN Monopole Antenna

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Abstract — A switched band antenna that has a capability to operate in tri-band WLAN frequency band (2.4–2.485 GHz, 5.15–5.35 GHz and 5.725–5.825 GHz) and a band-notched UWB frequency band (the stop-band covers the frequency range from 5.15 GHz to 5.825 GHz) is presented. The antenna uses a switchable ground and a switchable monopole patch to provide a switched band property. To the authors' knowledge, the proposed antenna represents a feature that is unique to this paper.

Index Terms — Band-notched UWB, switched band, WLAN.

I. INTRODUCTION

Communication technologies have been growing rapidly in recent years. One of the breakthroughs is that the single system can be integrated with several applications, such as ultra-wide band (UWB) communications, satellite communications, and wireless local area networks (WLAN). Since these applications operate at different frequency bands, those wireless systems request the antennas can operate in various frequency bands. Therefore, to meet the demands of those systems, various frequency reconfigurable antennas which can adjust their operating frequency bands are developed. Some investigators tuned the operating bands of the frequency reconfigurable antennas by changing sizes of the radiator [1-3], such as the length of the dipoles [1-2]. The frequency reconfigurable

antenna can provide the switchable operating frequency characteristic by changing the number of the shorting strips [4]. However, most of the frequency reconfigurable antennas provide only one narrow operating band in the wide frequency ranges [1-6]. Those characteristics can not meet some wideband communication demands, for example UWB communication. The researchers use the switchable ring resonators to make the antenna work in a wide band or the dual band of WLAN [7]. However, the operating bands of the antenna can not cover band-notched UWB frequency band and tri-band WLAN frequency band via changing its operation modes [7].

A novel frequency-reconfigurable planar antenna is developed in this paper. The proposed antenna is composed of three switches, a reconfigurable monopole patch, and a switchable ground plane. By controlling the states of the switches, the proposed antenna is able to provide two operation modes whose operation bands can cover 2.45/5.2/5.8 GHz WLAN band (2400-2483 MHz, 5150-5350 MHz, 5725-5825 MHz) and the band-notched UWB band (the stop-band covers the frequency range from 5.15 GHz to 5.825 GHz), respectively. In this study, all switches create a 1 mm gap when they are in the close state and short the gap when in the open condition. Therefore, for the proof of concept [7], the "OFF" state is obtained by an air gap of 1 mm. The "ON" condition is realized by hard-wiring the air gap.

II. ANTENNA CONFIGURATIONS

Figure 1 shows the geometry of the proposed antenna. In this study, the FR4 substrate of thickness 1 mm and relative permittivity 4.6 is used. A monopole patch and a 50Ω microstrip feeding line are printed on the same side of the dielectric substrate. The conducting switchable ground plane is printed on the other side of the substrate. Two rectangle slots are etched on the ground plane. To achieve the desired frequency reconfigurability, two switches are placed over the upper section of the ground plane, while another switch is located on the monopole patch. When switch 1 is in the "ON" state and other switches are in the "OFF" state, the proposed antenna operates in tri-band WLAN mode. When switch 1 is in the "OFF" state and other switches are in the "ON" state, the proposed antenna operates in the band-notched UWB mode.

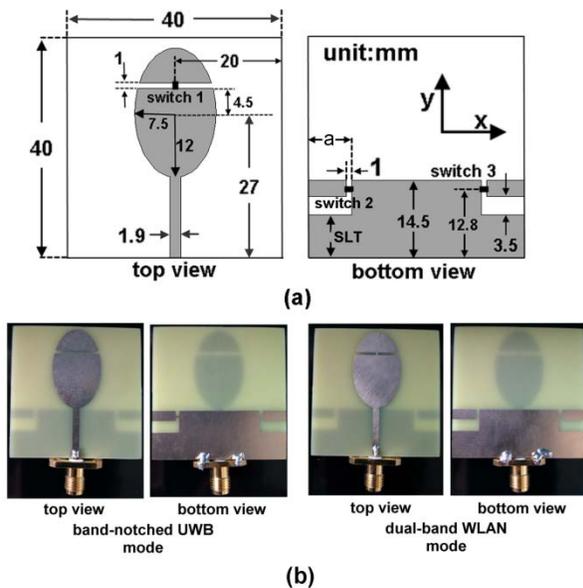


Fig. 1. Structure of the proposed antenna. (a=7mm, SLT=8mm)(a) Top view and bottom view.(b) Photos of the proposed antenna.

III. RESULTS AND DISCUSSION

The measured and simulated bandwidths of the proposed antenna are illustrated in Fig. 2. The measurement was taken by an Agilent E5071C network analyzer, and the simulations are performed using CST Microwave Studio in this study. The Agilent E5071C network analyzer has the highest measurable frequency at about 8 GHz. Though it does not cover the whole UWB band (3.1-10.6

GHz), it reaches our requirements since we were concerned with where the notch-band of the band-notched UWB mode and the triple bands of the WLAN mode are in the measurable band.

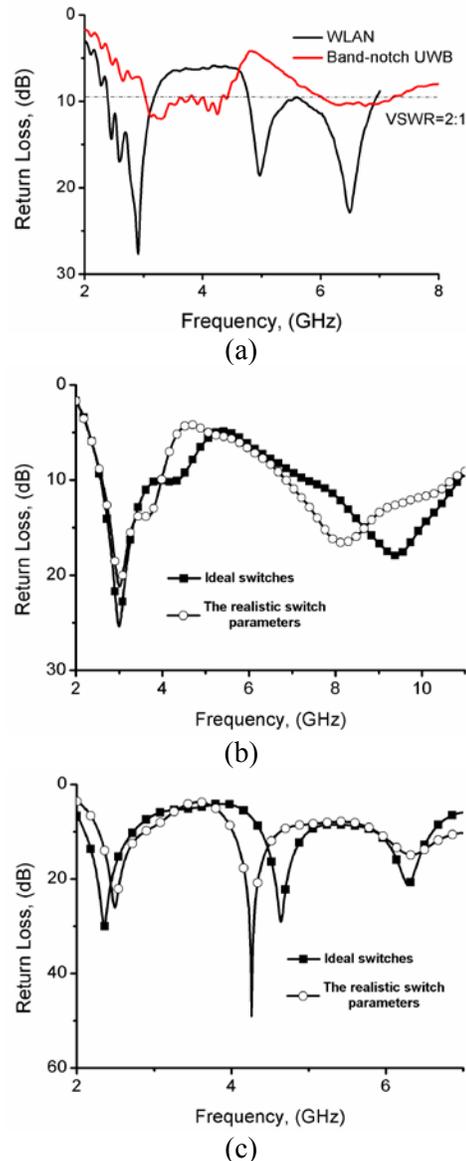


Fig. 2. Return losses of the proposed antenna in two modes: (a) measured results, (b) simulated results in the band-notched UWB mode, (c) simulated results in the Tri-band WLAN mode.

In the tri-band WLAN mode, the lower band for $V_{SWR} \leq 2$ ranges from 2.39GHz to 3.18GHz, and the higher band scans from 4.77 to 6.94GHz for $V_{SWR} \leq 2$. In the band-notched UWB mode, a stop-band ranging from 4.43 to 6.02 GHz for $V_{SWR} > 2$ is obtained. There is some discrepancy between the simulated result and the measured

result. One of the reasons for such discrepancy is the fabrication and measurement tolerance of the proposed antenna, the other is the ideal excitation port which can not simulate the real SMA connector and the weld connecting the SMA connector to the proposed antenna. Despite those nonideal effects during the fabrication and measurement, the impedance responses in Fig. 2 still sustain the consistency of the band reconfigurability of the proposed design.

The return losses of the proposed antenna with the realistic switch parameters in the two modes are also shown in Fig. 2. The RF equivalent circuit of a PIN diode, MACOM MA4AGBPL912 [8], was used and shown in Fig. 3. Since the realistic switch parameters can change impedance of the proposed antenna, it can be seen that the resonant frequencies of the tri-band WLAN mode and the notch band of band-notched UWB mode shift compared with those with the ideal switches.

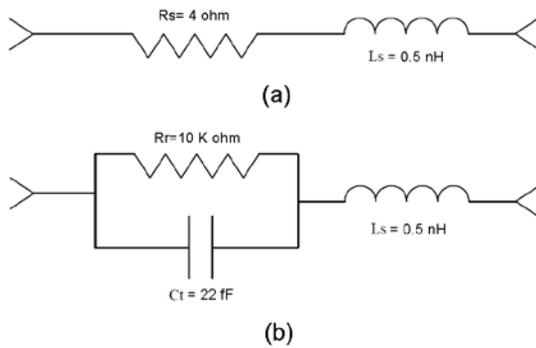


Fig. 3. RF equivalent circuit for the PIN diode in the (a) ON state and (b) OFF state.

Figure 4 displays the radiation patterns of the two modes in three plane-cuts, the x-y plane, the x-z plane, and the y-z plane. All radiation patterns of the tri-band WLAN mode and the band-notched UWB mode are roughly omni-directional. The broadside directions of the two modes are roughly identical. That means the system can remain stable when the antenna switches between the tri-band WLAN mode and the band-notched UWB mode.

It is worthwhile to mention that the two slots etched on the ground play important roles in the proposed design. When the proposed antenna operates in the WLAN mode, the two slots are located outside the ground. As a result, an inverted T-shaped ground plane which can generate two various bands is formed. When the proposed

antenna works in the band-notched UWB mode, the two rectangle slots are etched on the ground and act as a stop-band filter to notch the 5.2-GHz and 5.8-GHz WLAN bands.

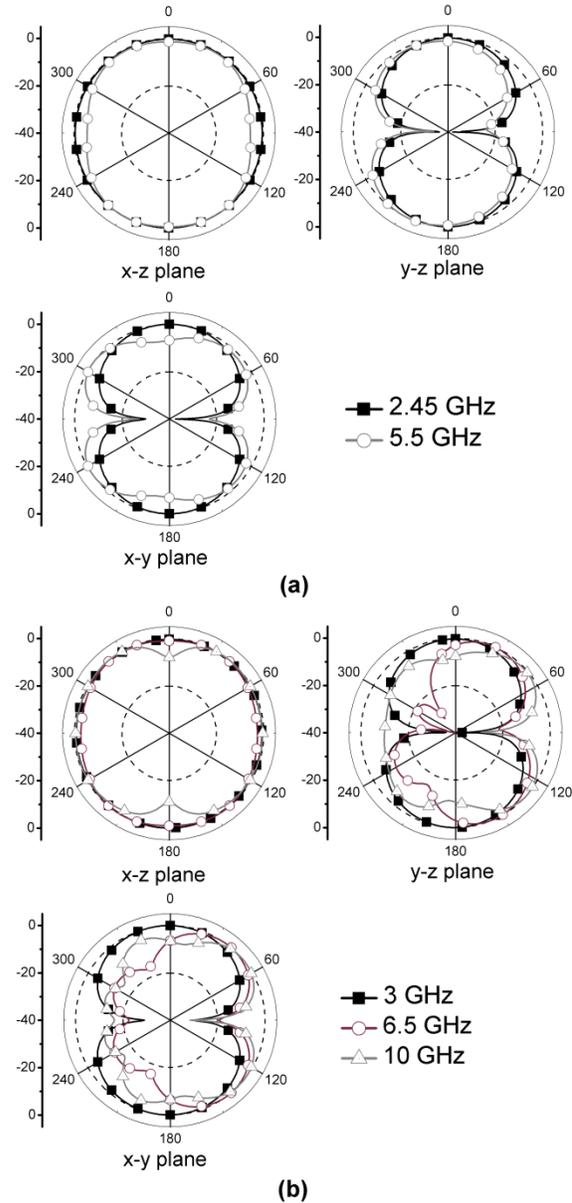


Fig. 4. Simulated radiation patterns of the antenna in two modes: (a) tri-band WLAN mode, (b) band-notched UWB mode.

To validate the above concept, the return losses of the proposed antenna with various parameter a in the WLAN mode and the band-notched UWB mode are shown in Fig. 5. The length of the two rectangle slots extends with the increase of the parameter a . That causes the current path in the

notch band to be lengthened. Therefore, it can be seen that the stop-band frequency of the band-notched UWB mode lowers with the increase of the value of parameter a . Furthermore, when the value of parameter a is increased, the length of the rectangle slots is closer to half a wavelength at the center frequency of the notch band, leading to the improvement of the rejection level. The increase of the parameter a also causes the decrease of the width of the vertical portion of the T-shaped ground plane. Since the T-shaped ground plane is a 2-order stepped-structure, the decrease of the width of the vertical portion makes the impedance of the proposed antenna mismatch, as Fig. 5 (b) shows.

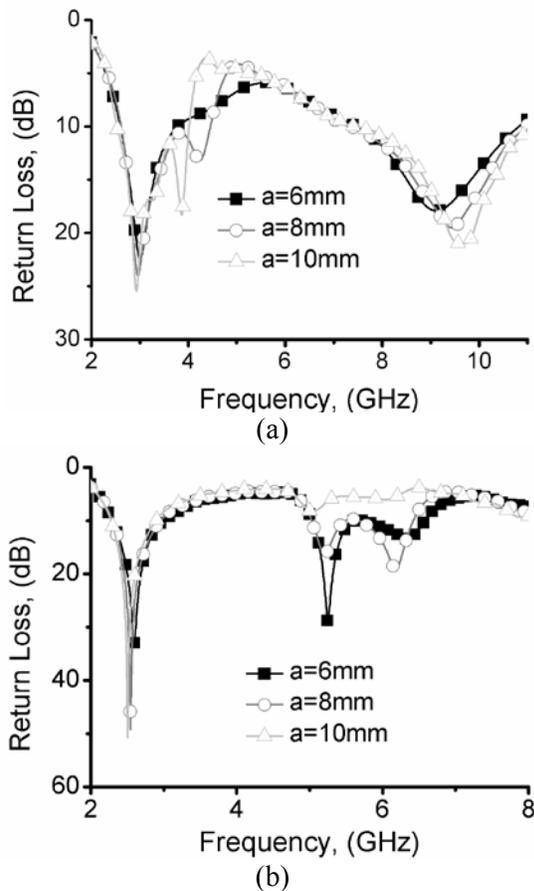


Fig. 5. Simulated return losses of the proposed antenna with various a : (a) the band-notched UWB mode, (b) the WLAN mode.

In addition, the return losses of the proposed antenna with various SLT in the two modes are shown in Fig. 6. Since the rectangle slots are closer to the signal port with the decrease of the

SLT, the resonant current around the rectangle slots is strengthened, which means the effective current path is increased. As a result, the rejection level can be improved. However, since the shape of the T-shaped ground plane vary with the decrease of SLT, the higher band of the WLAN mode is narrowed.

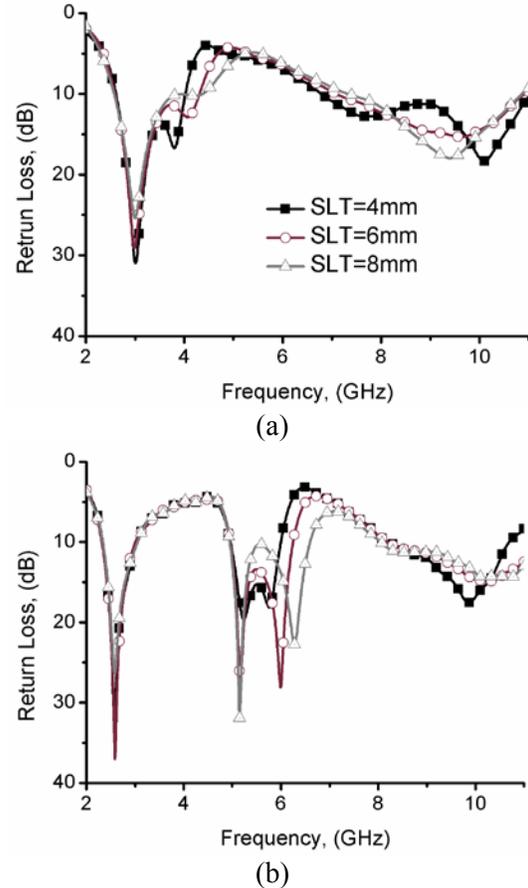


Fig. 6. Simulated return losses of the proposed antenna with various SLT: (a) the band-notched UWB mode, (b) the WLAN mode.

IV. CONCLUSION

A novel frequency-reconfigurable antenna is developed in this letter. By switching between the ON and OFF status of the switches, the proposed antenna can allow the system to operate in two modes, the tri-band WLAN mode and the band-notched UWB frequency mode. As a result, the proposed antenna can be used in the tri-band WLAN system and the UWB system.

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