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COMPACT UWB BANDNOTCH ANTENNA WITH TRANSMISSION-LINE-FED

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Abstract—In this paper, a compact band-notched UWB planar antenna with Transmission-Line-fed is presented and I'm using a new technique by etching a narrowband resonance H-shape slot in the ground plane of the antenna. This antenna is capable reducing the interference at the WLAN bands by eliminating the 4.85–6.17 GHz band. The proposed antenna has compact size of $16 \times 22\,\text{mm}^2$ including the ground plane and because of miniature dimensions, good radiation patterns with monopolar characteristics are obtained in the frequency band of interest i.e., at least 10 dB isolation exists between co-polarization and cross-polarization. The gain is suppressed very well in WLAN bands. The maximum suppression is in 5.4 GHz that is 13.6 dB less than the gain of normal antenna.

1. INTRODUCTION

Ultra-wideband (UWB) technology has become the most promising solution for future short-range high-speed indoor data communication applications. In 2002, the Federal Communication Commission (FCC) in United States officially released the regulations for UWB technology, and the spectra from 3.1 to 10.6 GHz were allocated for unlicensed UWB indoor medical, measurement and communication applications. Two distinct schemes, the DS-UWB (direct-sequence UWB) and the MB-OFDM (multiband OFDM), have been proposed to compete for the IEEE 802.15.3a Standard. To avoid potential interference to the coexistent WLAN applications, which are at 5.15–5.35 GHz for HYPERLAN/2 and 5.725–5.825 GHz for IEEE 802.11a, both schemes call for an additional band-stop filter to reject these frequency bands. This filter, nonetheless, inevitably increases the circuit complexity. To overcome this difficulty, antennas with band-notched characteristics have been introduced [1–11]. The most common approach to designing antennas with band-stop properties is to directly etch narrowband resonance slots on the radiators [1, 2, 12–19].

In this paper, I change the ground plane current distribution with subtracting the H-shape slot from that. I want to design the dimensions of antenna include ground plane less than $16 \times 22\,\text{mm}^2$. The 4.85–6.17 GHz band ref to VSWR < 2 was eliminated where the maximum VSWR at 5.4 GHz is equal to 14.26. The phase of S_{11} is linear enough for UWB applications. Even in vicinity of upper frequency band, H-plane patterns remain omni-directional. Antenna gain in WLAN bands is suppressed. Totally with these modifications, the desirable spatial-independent band-stop characteristics can be achieved. In advance, experimental results including return losses, phase of S_{11}, input impedance, radiation patterns and gain variations are presented and discussed.

2. ANTENNA DESIGN

The antenna geometry is shown in Fig. 1. This antenna is constructed on Rogers RT/duroid 6002 substrate with thickness $\sim 1.5\,\text{mm}$, relative dielectric constant ε_r of 2.94 and $\tan\delta = 0.0012$ which has dimensions of $16 \times 22\,\text{mm}^2$ ($W_{sub} \times L_{sub}$). The width of the H-shape slot, S_1 is 12.2 mm. The length of these two arms sides of main slot, L_2 and distance of the slot from the top edge of the ground, d_1 (were then tuned by the commercial software HFSS v10.0) are equal to 3.8 mm and 0.375 mm respectively. The remaining parameters are: $L_1 = 7.14\,\text{mm}$, $L_{gnd} = 6\,\text{mm}$, $W_1 = 15.5\,\text{mm}$, $W_2 = 7.9\,\text{mm}$, $W_3 = 2.6\,\text{mm}$, $W_4 = 0.3\,\text{mm}$, $S_2 = 0.1\,\text{mm}$.

I want to design antenna with maximum dimensions of $16 \times 22\,\text{mm}^2$ i.e., for this antenna, the shape of slot must has a good effective length. The H-shape slot is selected for this elimination. We can see the in advance proofs that H-shape slot has a good effective length. Also, H-shape notch let us to change and control notch bandwidth and center frequency of band notch (commonly the frequency has a maximum VSWR), without noticeable decreasing in its VSWR value, for constant center frequency. This process is done easily by decreasing or increasing the L_2 and increasing and decreasing S_1 respectively. However, this operation can do by $d_1$change. By increasing d_1, notch band width is increased but the center frequency and maximum VSWR value is decreased. Totally, we can say the Q (Quality factor) is decreased. In this paper, the substrate has been selected smartly. Because the maximum width of the antenna is 16 mm, high ε_r substrate is important in this antenna. Actually in constant center frequency,

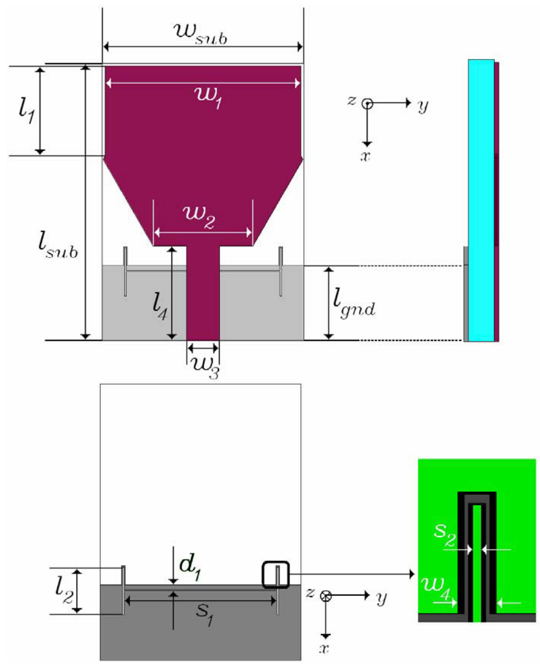


Figure 1. Geometrical parameters of antenna with band notch characteristics.

if the ε_r of substrate increases, the total length of slot decreases and also, the loss tangent is increases commonly in commercial substrates. In notch band, the high Q and maximum value of VSWR is very important. Thus, the Rogers RT/duroid6002 has been selected as trade off between high ε_r and low loss tangent. The length of conventional slot for 5.5 GHz is 18.5 mm, this is calculated from (1)–(3) [20] for $w = 0.1$ mm, $h = 1.5$ mm and $\varepsilon_r = 2.94$. The total length of H-shape slot is 19.8 mm and we will see in next section, the center frequency of notch band is 5.4 GHz i.e., from (1)–(3), the effective length of H-shape slot is 18.83 mm.

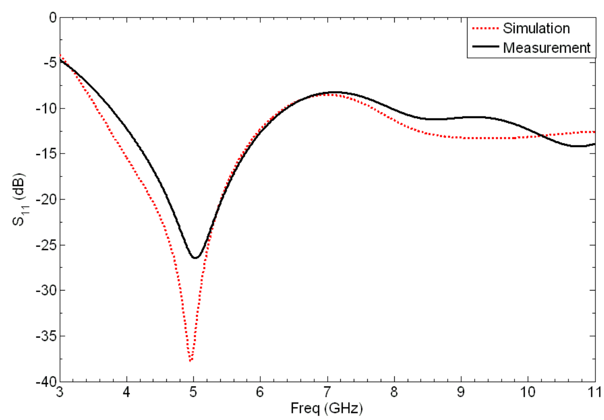
$$\varepsilon_{eff} = \frac{(\varepsilon_r + 1)}{2} + \frac{(\varepsilon_r - 1)}{2}\left(\sqrt{1 + \frac{12h}{w}}\right)^{-1} \tag{1}$$

$$\Delta l = \frac{0.412h\,(\varepsilon_{eff} + 0.3)\left(\frac{w}{h} + 0.262\right)}{(\varepsilon_{eff} - 0.258)\left(\frac{w}{h} + 0.813\right)} \tag{2}$$

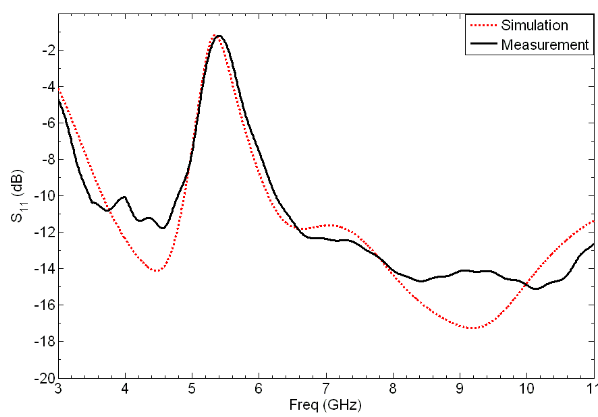
$$f = \frac{c_o}{2(L + 2\Delta l)\sqrt{\varepsilon_{eff}}} \tag{3}$$

3. EXPERIMENTAL RESULTS

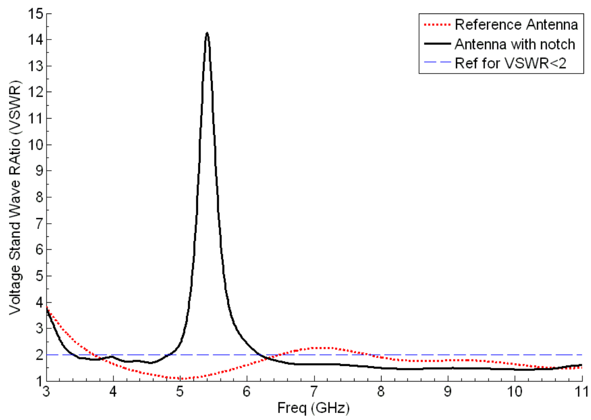
I named normal antenna as antenna1 and band notch antenna as antenna2. In Fig. 2(a) and Fig. 2(b), the comparison between simulation and measurement results for return loss of antenna1 and antenna2 are shown respectively. Plots show the good match between simulation and measurement results of proposed antennas. Start frequency for antenna1 is 3.7 GHz while for antenna2 is 3.4 GHz in measurements. Antenna1 has small mismatch ref to VSWR $<$ 2 between 6.5–7.8 GHz band. This defect is modified in antenna1. Fig. 2(c) shows the comparison between antenna1 and antenna2 VSWR results. Antenna2 has band notch from 4.85–6.17 GHz ref to VSWR $<$ 2 and the maximum VSWR at 5.4 GHz equal to 14.26.



(a)



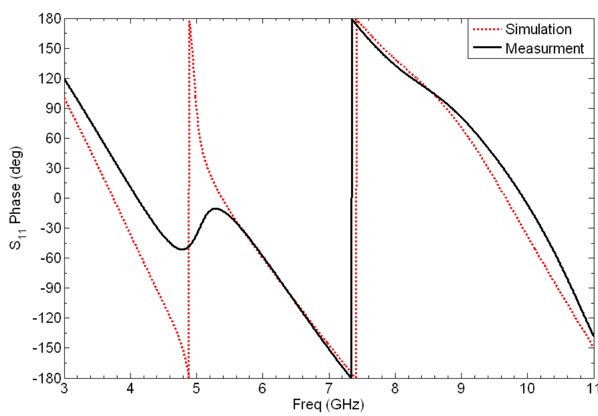
(b)



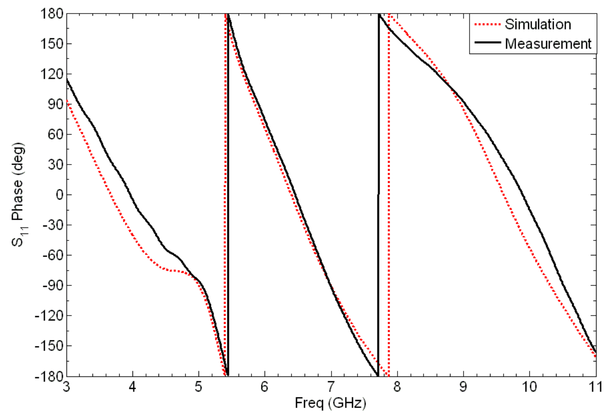
(c)

Figure 2. Input S_{11} magnitude and VSWR of antennas (a) return loss for antenna1, (b) return loss for antenna2, (c) VSWR measurement results.

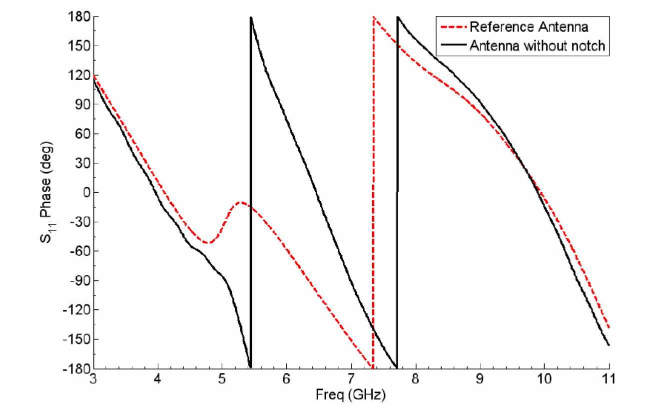
In Fig. 3(a) and Fig. 3(b), show comparison between simulation and measurement results for phase of S_{11} of antenna1 and antenna2 respectively. The comparison between phase of S_{11} measurement results for antenna1 and antenna2 is shown in Fig. 3(c). Phase of S_{11} for antenna2 is acceptably linear for UWB applications.



(a)



(b)



(c)

Figure 3. Input phase of S_{11} (a) antenna1, (b) antenna2, (c) compare measurement results of two antennas.

In Fig. 4, measured input resistance (top) and reactance (bottom) of the both antennas are shown. These plots can help us to get better insight about changing characteristics of antenna2 after subtracting H-slot from its ground plane. Input resistance plot for antenna1 around 5.4 GHz shows the resistance near null and also. Also, we can see that H-shape slot change the minimums and maximums resistance value in antenna1 and shift frequency of them around 4.5–6.5 GHz band approximately. Moreover, this cause to create band notch in 4.85–6.17 GHz and the second noticeable effect of H-shape slot is modifying the small mismatch in 6.5–7.5 GHz in antenna1 and this mismatch doesn't exist in antenna2.

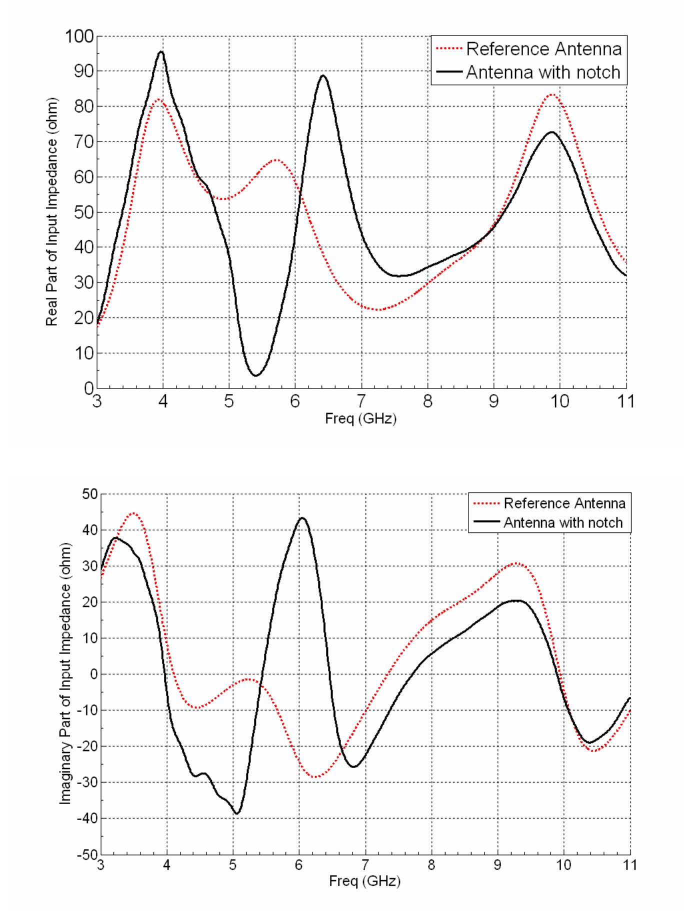


Figure 4. Input resistance (top) and reactance (bottom). Antenna1 (dash line) and antenna2 (continues line).

In Fig. 5, the plots correspond to operating bands of 3.5, 6.5 and 9.5 GHz for antenna1 are shown from left to right respectively. The top row of this figure shows the *E*-plane radiation while the bottom row shows the *H*-plane radiation patterns. The radiation plots display very good monopolar mode radiation and at least, the cross-polarization is 10 dB lower than the co-polarization in all frequency. The *H*-plane patterns are rather uniform over the frequency band of interest. However, it should be noted that, the effect of the finite size of the ground-plane must be taken into account when analyzing the patterns on these figures [21].

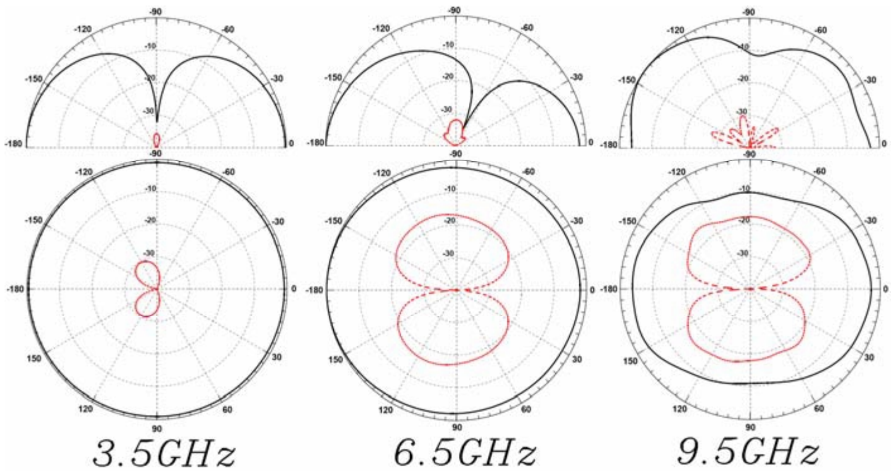


Figure 5. Radiation patterns of antenna2, E-plane (top) and H-plane (bottom), Co-polarization (continues line) and Cross-polarization (dash line).

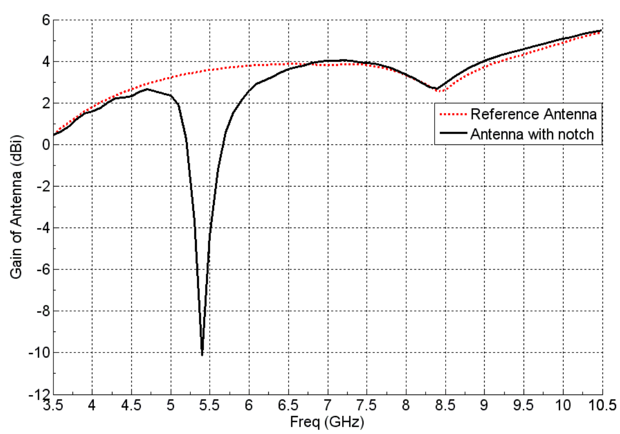


Figure 6. Peak gain in (dBi), antenna1 (dash line) and antenna2 (continues line).

The antennas peak gain (dBi) is depicted in Fig. 6. It reveals that the peak gain is very stable over the frequency band of interest. In addition, the required gain suppression at the WLAN bands is 2.2 dB and 3.1 dB at 5.15 GHz and 5.825 GHz, respectively, and can be as high as 13.6 dB at the center frequency (5.4 GHz) of the stop-band. This means that by subtracting the band-notched structure from the ground plane of the antenna and the undesired spatial-dependent band-stop properties can be eliminated.

4. CONCLUSION

In this paper, the current distribution of antenna is changed by subtracting H-slot from ground plan of normal antenna. The compact UWB planar antenna with transmission-line-fed with 4.85–6.17 GHz band elimination is achieved and the interference to other occupied frequency bands can be reduced. In addition, the newly proposed configuration has proved to be capable of providing favorable spatial-independent band-notched characteristics. This band-notch antenna can be implemented in a variety of UWB applications as well and can be the basis paper for developed in UWB band notch antenna with change in ground of planar antenna.

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