Triple Band-Notched Thin-Film Ultra-Wideband Antenna fed by CPW

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Abstract: The thin-film Ultra-Wideband (UWB) antenna fed by Coplanar Waveguide (CPW) with triple band-notched characteristics is presented in this paper. This proposed antenna has concise dimensions of 34.5×27.6 mm^2 and is fabricated on flexible thin-film Mylar Polyester. In addition, the thickness and dielectric constant of polyester is 0.3 mm. and 3.2, respectively. The prototype antenna consists of fork-like tuning stub fed by CPW and rectangular slot. Moreover, two strait slots and U-shape slot is added on the top ground plane to accomplish triple band-notched at frequency range of 3.3 – 3.7 GHz (WiMAX), 5.1 – 5.8 GHz (WLAN), and 7.25 – 7.75 GHz (X-Band downlink). For measurements of antenna, the operating frequncy is 2.8 – 13.5 GHz which has three notched-frequency at 3.5, 5.5, and 7.5 GHz. Furthermore, the measured gain is average 3.6 dBi entire bandwidth except notched frequencies which decrease extremely lower than 0 dBi. As the results of measurement, the prototype antenna can appropriately attain triple notched-band for WLAN, WiMAX, and X-Band Communication and is also properly used in UWB equiptment and system.

Keywords-- **Thin-film UWB antenna, Triple band-notched, CPW-fed**

1. Introduction

Over the last decade, the innovations of wireless communications have been developed swiftly and extremely influenced to people in the modern life. Several applications of modern communication technology require much more high-speed data rate transmission, As the results of that, the researches and developments in the field of bandwidth and channel capacity have been adtended. In 2002, the Federal Communication Commission (FCC) allowed the authorization of using 3.1 – 10.6 GHz unlicensed band for commercial UWB communication [1]. UWB technology received a lot of attention in research on wireless communication system using UWB technology. The Ultra-Wideband (UWB) technology has many advantages, such as, high precision, high data rates, and low power consumption which is suitable for several mobile coomunications [2]. Nevertheless, the entire frequency range of UWB systems is the cause of interference to the existing communication systems, for example, WiMAX, WLAN, and downlink of X-band. Therefore, the design of UWB antenna has been interested that mean the useable antenna for UWB applications should prevent interference from the existing frequency band. Many researcher have demonstrate to attain UWB antenna with band-notched response using various methods, for instance, adding difference shape of slots [3], inserting parasitic elements [4], and etc. Afterwards, the dual band-notched UWB antenna has been presented by using combining of foregoing metthods[5].

In this paper, a simple and thin triple band-notched UWB antenna with notch frequencies at 3.5, 5.5, and 7.5 GHz is designed, fabricated and measured. The simulation of this proposed antenna uses the commercial software Zeland IE3D to design and optimization. The prototype is fabricated to determine the UWB characteristic and operation of triple band-notched responses. Eventually, analysis of the simulation and measurement from proposed antenna are compared and discussed.

2. Antenna Geometry and Design

In this section, The complement and design of triple band-notched thin film UWB antenna is presented. The proposed antenna is designed on thin film substrate, Mylar Polyester film, with dielectric constant $\varepsilon_r = 3.2$ and thickness $h = 0.3$ mm. Figure 1 shows compositions of the proposed antenna, which consists of a rectangular slot with fork-like tuning stub to assure impedance matching and 50 Ω CPW fed line. To make triple band-notched characteristics, two strait slots achieve two band-notched characteristics of frequency range 5.1 – 5.8 GHz and 7.25 – 7.75 GHz and U-shape slot attains 3.3 – 3.7 GHz band-notched. The length of all slots can be calculated using equation (1), (2), and (3) for 5.5 GHz, 3.5 GHz, and 7.5 GHz band-notched center frequencies, respectively. The peak of two notch frequencies of narrow slot is defined by optimizing *Ln1* and *Ln3*, while the peak of 3.5 band notched is controlled by adjusting *Ln2*, *Wn2* and *Gu*. The optimum dimensions of proposed antenna are shown in table 1.

$$f_{n1} = \frac{c}{(0.71(2L_{gn1}\sqrt{\varepsilon_{eff}}))} \qquad (1)$$

$$f_{n2} = \frac{c}{(0.33(2L_{gn2}\sqrt{\varepsilon_{eff}}))} \qquad (2)$$

$$f_{n3} = \frac{c}{(0.75(2L_{gn3}\sqrt{\varepsilon_{eff}}))} \qquad (3)$$

$$\text{Where}: \varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left(1 + \frac{12h}{W}\right)^{-1/2}$$

Where c is the speed of light, ε_{eff} is the effective dielectric constant, L_{gn1} and L_{gn3} are the total length of narrow slot $Ln1$ and $Ln3$, L_{gn2} is the total length of U-shape slot in this case is given by $2Ln2+4Wn2 - 2Gu$.

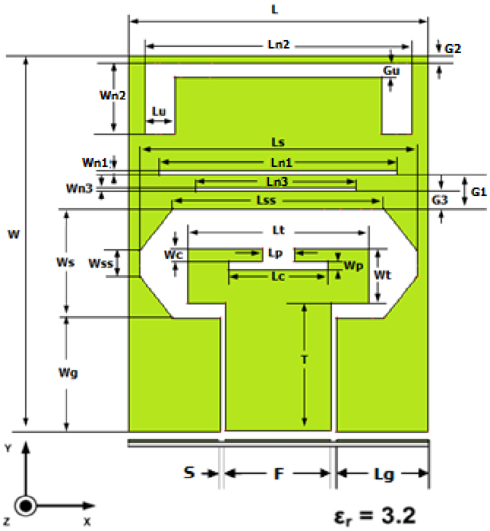


Figure 1. Triple band-notched UWB Antenna Geometry.

Table. 1 Optimum dimensions of triple band-notched thin film UWB antenna with size 34.5 × 27.6 mm^2

Parameters	Dimensions (mm.)	Parameters	Dimensions (mm.)
Ws	10	*Ls*	25.3
Wss	2.3	*Lss*	19.3
Wt	5	*Lt*	16.5
Wp	0.8	*Lp*	3
Wc	1.2	*Lc*	9
Wg	10.15	*Lg*	8.3
F	9.7	*T*	11.8
S	0.5	*Ln1*	0.5
Wn1	0.5	*Ln2*	24.8
Wn2	6.3	*Ln3*	15
Wn3	0.3	*Lu*	3
G1	3	*Gu*	1.3
G2	0.75	*G3*	1.4

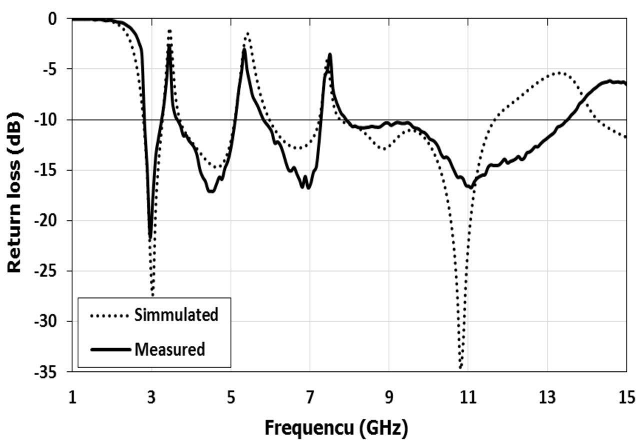


Figure 2. Simulated and measured return loss results

Table. 2 Comparison of maximum return loss at each notched frequency

Systems	Notched Frequency (GHz)	Maximum Return loss (dB)	
		Simulated	Measured
WiMAX	3.5	-0.93	-2.68
WLAN	5.5	-1.45	-3.03
X-Band Downlink	7.5	-4.08	-3.65

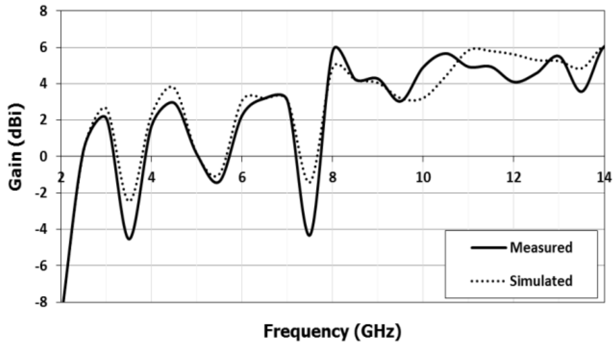


Figure 3. Simulated and measured gain results

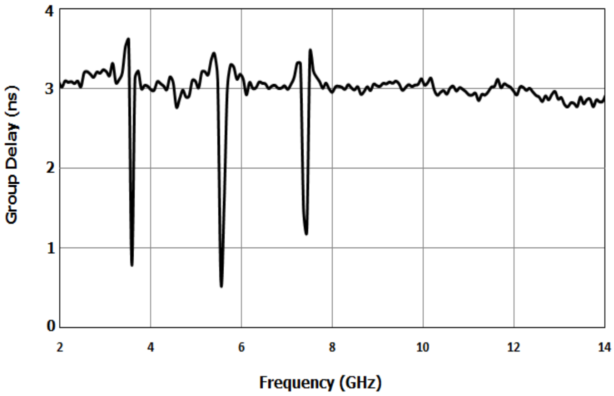
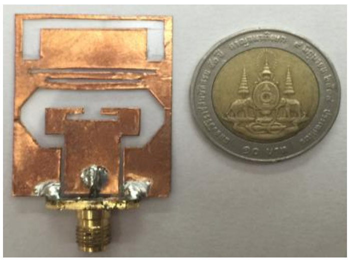
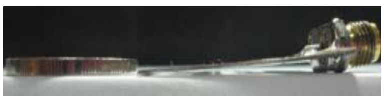


Figure 4. Measured group delay results



(a)

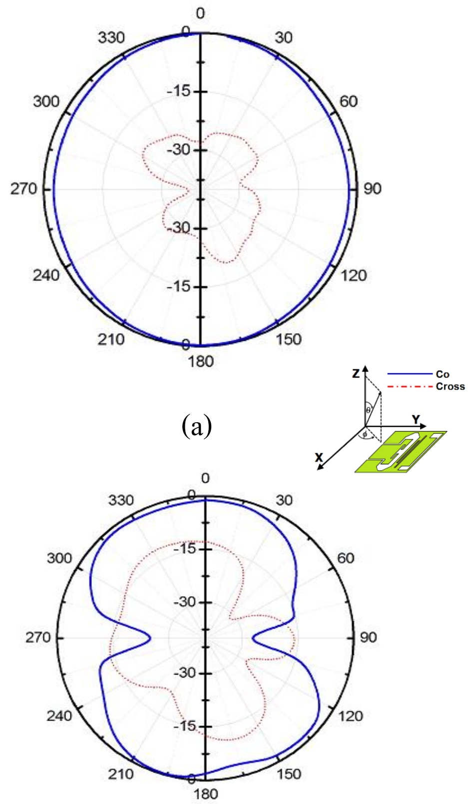


(b)

Figure 5. Fabricated prototype antenna (a) Front view and (b) Side view

3. Results and Discussions

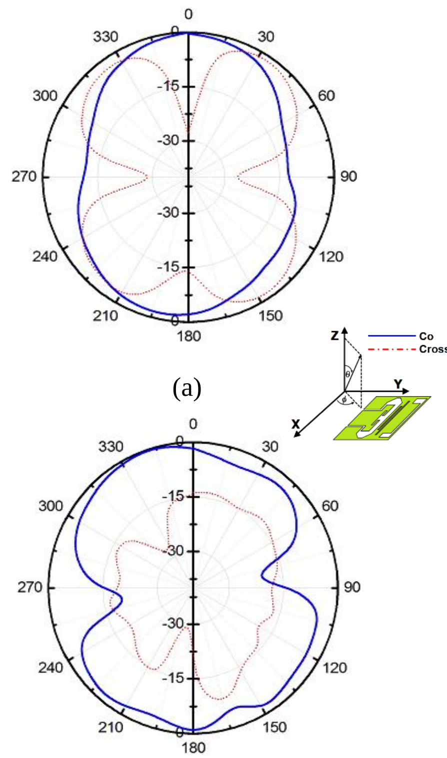
The proposed antenna is fabricated and measured by using Agilent E8363B network analyzer. In this section, simulated and measured results of return loss and gain are discussed. First, Figure 2 shows that the result of return loss for – 10 dB is wideband impedance matching 2.8 – 13.5 GHz that covering 3.1 – 10.6 GHz and clearly has triple band-notched response of frequency 3.5 GHz, 5.5 GHz, and 7.5 GHz. Table 2 shows that the peak of return loss of each band-notched is – 0.93, -1.45, and -4.08 dB for simulation and -2.68, -3.03, and -4.08 for measurement. As the results of return loss, it can be obviously seen that measured and simulated notched response are nearly results. Moreover, the gain of proposed antenna is shown in figure 3. The simulation and the measurement attain similarly gain results. In detail, The ga/in of triple band-notched UWB antenna is about 2 – 6 dBi of entire usable bandwidth. Meanwhile, the measured gain at band-notched frequencies decreases essentially to -4.2, -1.8, and -4 dBi, for 3.5, 5.5, and 7.5 GHz band-notched response, respectively which indicates the effect of band prevented definitely because that mean this proposed antenna can not radiate at triple band frequency because miss imphedance matching and minus gain. Furthermore, Group delay (small variations of antenna phase response), a parameter is a significant frequency domain characteristic for UWB antenna that indicates the degree of distortion of pulse signal. The measured group delay results is shown in figure 4. As a results of the response, it is constant entire desired UWB frequency range at operation band (2.8-13.5 GHz) which can be seen that the group delay is mostly smooth with distinction value less than 0.5 ns except at the tri-notched frequency 3.5 GHz, 5.5 GHz, and 7.5 GHz. This confirms that the triple band-notched UWB Antenna has a little pulse distortion. The measured radiation patterns of the fabricated UWB antenna with dual band-notched characteristics are considered in this section. Figure 5(a) and 5(b) show the fabricated prototype antenna in front view and side view, respectively. Moreover, the 2D radiation patterns of the proposed antenna is shown in figure 6 and figure 7 which is measured at frequency 4.5 GHz and 10 GHz, respectively. The radiation patterns of co-polarization and cross polarization in xz-plane and yz-plane at 4.5 GHz are shown in figure 6(a) and figure 6(b), respectively. figure 7(a) and figure 7(b) are also presented the radiation pattern in xz-plane and yz-plane at 10 GHz. As the results of both radiation patterns, it is noted that the radiation patterns of both frequencies have same shapes. In the xz-plane, the radiation patterns show coherently an omnidirectional pattern, but the radiation patterns in yz plane are definitely bi-directional. Finally, the current distribution of all desired band-notched frequencies is shown in Figure 8. It is extremely concentrated on U-shape slot and two narrow slot at band-notched frequency. The simulated current distribution confirms that the added slot structure of such notch do not have effect on the antenna performance, but they only have an affectation for the notch frequency. Figure 8(a) shows that the current is massive distribution in U shape slot which produce 3.5 GHz notched. and both straight slots have the effect at frequency 5.5 GHz and 7.5 GHz which is shown in figure 8(b) and figure 8(c), respectively.



(a)

(b)

Figure 6. 2D Radiation pattern at 4.5 GHz on (a) xz-plane and (b) yz-plane



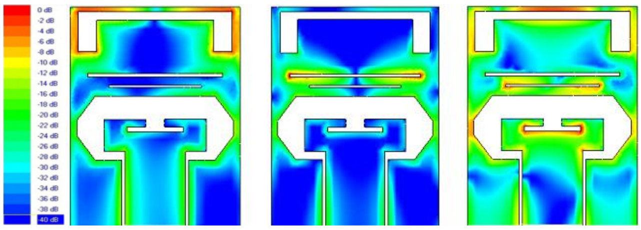
(a)

(b)

Figure 7. 2D Radiation pattern at 10 GHz on (a) xz-plane and (b) yz-plane

4. Conclusions

Triple band-notched thin-film UWB antenna is presented, designed, and fabricated. The prototype antenna is inexpensive because of using Mylar Polyester substrate, compact and low-profile, etc. this antenna is designed to prevent the interference from WLAN, WiMAX, and X-Band downlink communication which can be controlled by adjusting the insering slot. Futhermore, the proposed antenna has a desireable results in term of return loss and antenna gain. Consequently, this proposed antenna is successful and practical for several UWB application.



(a) (b) (c)

Figure 8. Current distributions at frequency (a) 3.5 GHz, (b) 5.5 GHz, and (c) 7.5 GHz

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