Design of A UWB Slot Antenna with Frequency Band-notched Characteristic

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ABSTRACT

An ultra-wideband (UWB) slot antenna with frequency band-notched characteristic is designed and measured. The proposed antenna consists of an elliptical radiating element, the ground plane and a U-shaped slot. This U-shaped slot is notched a certain frequency band and the length of the U-shaped slot is affected a notch frequency band. The printed antenna has impedance bandwidth of about 3 - 12 GHz and shows changes of band-notched frequency between about 4 GHz and 8 GHz by adjusting the length of the U-slot.

1. INTRODUCTION

One of the very important leading components of the wireless communication system is an ultra-wideband (UWB) system because of high speed, low power consumption and efficient frequency use. UWB has been used for military purpose from an early stage to 2002s and the UWB spectrum made available by the Federal Communications Commission (FCC) can be utilized with impulse radios that have been developed to date [1].

In the current the FCC has allocated 7,500MHz of spectrum for unlicensed use of ultra-wideband devices (UWB) in the 3.1 to 10.6 GHz frequency band [1]. However, UWB systems are required to meet the condition harmonious operation with the present existing standards such as the (5.150 - 5.350 GHz) and (5.725 - 5.825 GHz) bands, which may cause interference with the UWB operation [2]. These bands are used for the WLAN (Wireless Local Area Network) service at the IEEE802.11a and HIPERLAN/2 in USA and Europe, respectively [2][3]. In this case, UWB antennas can solve by inserting additional circuit such as the notch filter. Therefore, UWB antennas with band-notched characteristics in WLAN band are demanded. To avoid any electromagnetic interference on Wireless LAN systems, many UWB antenna structures and techniques have been studied. Also, the broadband antennas of the various types with a stop-band notch have been reported [2]-[10].

In this paper, the proposed UWB antenna modifies an existing UWB antenna [11]. The modified UWB antenna structure inserting a U-shaped slot on the radiating patch produced an UWB antenna with band-notched frequencies between 4 GHz and 8GHz as adjusting the length of the slot.

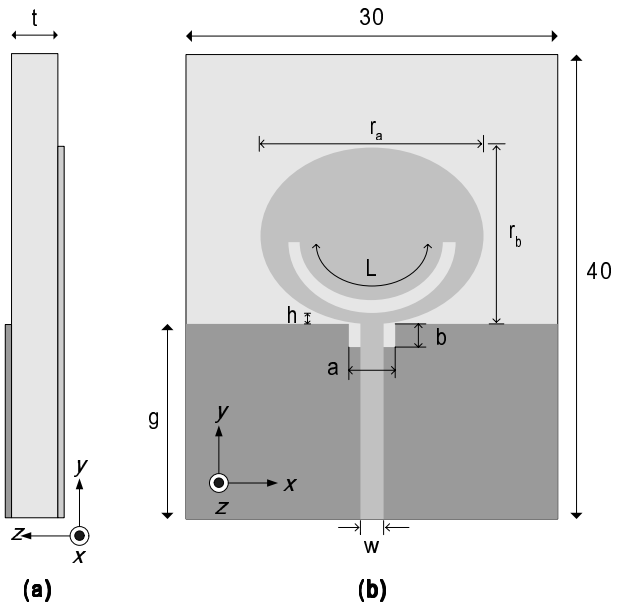

Fig. 1. Configuration of the proposed band-notched elliptical UWB antenna (a) Side view. (b) Top view.

Details of the proposed antenna make a comparative study on the basis of the simulated and measured results about a change of U-slot length.

2. THE PROPOSED ANTENNA DESIGN

The geometry of the proposed UWB antenna with band the frequency band-notched characteristic is illustrated in Fig. 1.

This antenna is made up of an elliptical-shaped patch to improve bandwidth, a partial modified ground plane with cutting slot for effective impedance matching under the feed line and a U-shaped slot which prevents interference with the WLAN band in the planar monopole antenna [11].

The antenna has dimension of 40×30 mm^2 that is fabricated on the FR-4 substrate with a thickness (t) of 1 mm and relative dielectric constant of 4.4. The elliptic patch for radiation of antenna has a compact size of $r_a \times r_b$ mm^2 and fed by 50Ω microstrip line of width w.

TABLE 1 : OPTIMIZED VALUE OF EACH PARAMETER IN FIG. 1

Parameters	Values [mm]
r_a	22
r_b	20
w	1.5
a	3.5
b	1
h	0.6
g	15
t	1

The ground plane located bottom face of substrate has size of 30×15 mm^2 with cutting slot of a × b between radiating element and ground plane.

When there is no U-slot in the elliptical patch, the antenna can cover a wide operating bandwidth of the 3.1 – 10.6 GHz UWB band. When there is U-slot with a width of 1 mm of in the patch, the antenna can be achieved a notched frequency band between about 4 and 8 GHz in proportion as a change of slot's length (L). And to generate an ideal notched frequency, U-slot is located symmetrically with respect to the centreline of the radiator, with its opening facing the feeding point at a distance (h). This is caused stronger current distribution exists in the vicinity of distance (h) of feed point on the radiation element more than any other region of the radiation element [9]. Because the current is concentrated around the edges of the U-slot at proposed antenna, it causes the antenna to operate in a transmission line-like mode, which transforms the high impedance at the top of the band-notched feature to nearly zero at the antenna feed point. This leads to the desired high attenuation near the notch frequency [12].

The optimized values of each physical dimension of the proposed antenna are shown Table 1.

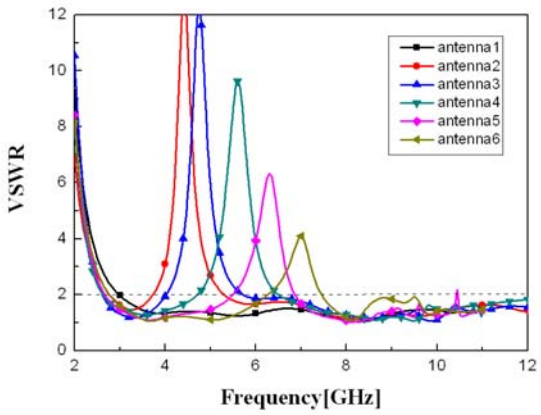

Fig. 2. Simulated VSWR for the reference antenna1 and proposed antennas with slot. (antenna2 – antenna6)

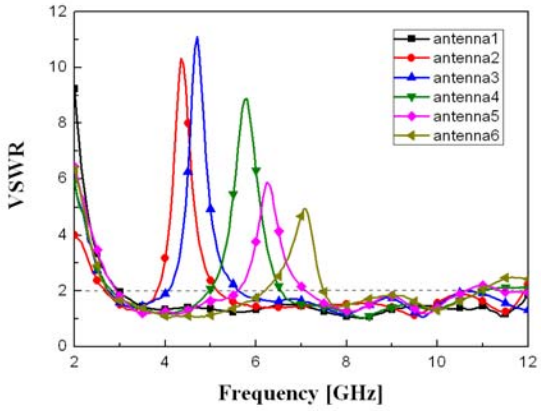

Fig. 3. Measured VSWR for the reference antenna1 and proposed antennas with slot. (antenna2 – antenna6)

3. EXPERIMENTAL RESULTS

The configuration of the proposed antenna is shown in Fig. 1 and Table 1. Note that the design dimensions of the proposed antenna are obtained result of Fig. 2 using Ansoft HFSS commercial software. And the measured results are shown in Fig. 3 and Table 2 using the Agilent Technologies N5230A PNA-L network analyzer. As you see, these measured results nearly correspond with simulated result in this paper. First, the reference antenna 1 without U-slot is satisfied with impedance bandwidth of UWB band (3.01 – 10.6 GHz) for VSWR<2. In this design, by properly cutting the dimension of the smile-shaped notch (antenna 2 – antenna 6) obtained the results like Table. 2. In this table, we can know that the more length of U-slot decrease, the more notched frequency band shifts toward high frequency. This confirmed by both simulated (Fig. 2) and measured (Fig. 3) results.

Although the proposed antenna doesn't obtain ideal narrow rejection bands, notched frequency is demonstrated that is controlled by the length of the U-slot. This means that the resonant frequency of a notched band is determined by the total length of the slot.

Fig. 4 shows the normalized current distributions at notch frequency and the else's band when the length of U-slot is 23 mm (antenna3). In Fig. 2 (b), we can see more and stronger current distributions in a smile-shaped slot than any other area at 4.5 GHz of a notch frequency. We can find that it plays a role in a band-notched filter.

The measured maximum gain of the proposed antenna shows in Fig. 5. The reference antenna without U-slot obtained a maximum gain of 4.6 dBi at 9 GHz. The proposed antenna 3 and antenna 4 is shown a sharp decrease of maximum antenna gain in the notched frequency at 4.7 GHz and 5.8 GHz, respectively. For other frequencies except the notched frequency band, the antenna gain with a slot is similar to those without one. The gain in the rejected band is found to be as low as -5.6 dBi and -4.2 dBi at the antenna2 and antenna4, respectively.

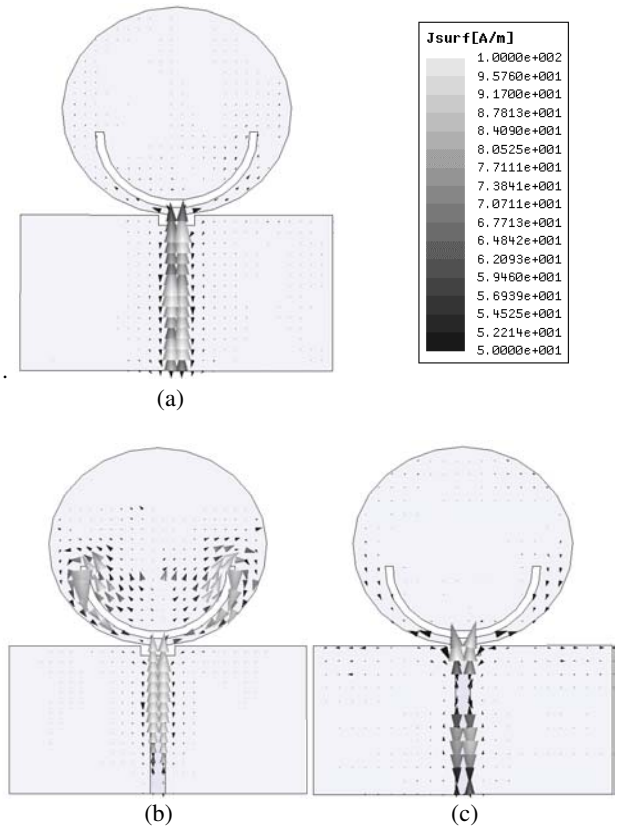

Fig. 4. Current distribution of the proposed band-notched antenna3 (a) 3 GHz. (b) 4.7 GHz. (c) 9GHz.

4. CONCLUSION

In this paper, a novel microstrip-fed monopole UWB antenna with band-notch characteristic has been designed and manufactured. By inserting U-slot on the proposed radiating element produced notched frequency band. The required notched frequency band demonstrated that it can be easily controlled that simply by adjusting the length of the slot from the results of simulations and measurements. Thus, it makes clear that the proposed antenna is applied to the UWB system without the additional circuit for the suppression of the WLAN band or creating multi-band antennas.

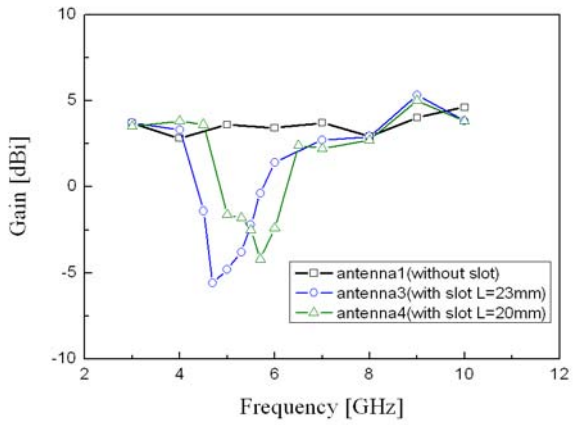

Fig. 5. Measured maximum gain of the reference antenna1 and proposed antennas with slot. (antenna3, antenna4)

TABLE 2 : MEAURED BAND-NOTCH CHARACTERISIC BY CHANGE OF THE SLOT LENGTH (L)

Antenna	Slot length L(mm)	Notch frequency(GHz)	Notch bandwidth(GHZ)
Antenna1	no	-	-
Antenna2	26	4.40	3.82 – 5.11
Antenna3	23	4.72	4.07 – 5.67
Antenna4	20	5.79	4.94 – 6.55
Antenna5	17	6.26	5.6 – 7.12
Antenna6	15	7.10	6.18 – 7.52

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