Design of Ultra Wideband Planar Antenna Characterized of a Notched-band for Wireless Local Area Network

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***Abstract*—A single notched-band characteristic of an ultra-wideband is studied and presented. The designed antenna's characteristic is compared with a typical UWB planar antenna. The single slit in the elliptical plane is considered to cause notched-band characteristic. The notched band is characterized to reject frequency band between 5 and 6GHz. Thus, Wireless Local Area Network (WLAN) 802.11a which is coexisted with the UWB frequency bandwidth is rejected. Notched-band characteristic is simply be generated by the horizontal slit in the elliptical plane. The designed antenna has a simple and compact structure.**

***Keywords*—UWB, WLAN, elliptical element, single slit,**

I. INTRODUCTION

Ultra-Wideband frequency bandwidth has been established by the Federal Communication Committee (FCC) since 14 Feb 2002. Ultra-wideband frequency bandwidth is distributed from 3.1 to 10.6GHz. Ultra-wideband is defined as any radio transmitter that occupies more than 20% spectrum of the center frequency and meets the power limits assigned by the FCC [1]. UWB has an advantage which it can cart huge amount of information rate in small pulse. UWB communication system is applied in many fields. In the beginning, UWB is applied in military. However, eventually the applications are spread into commercialization to the public use. The applications of UWB are widely used such as in medical, civil and bio-medical engineering [2-7].

UWB large frequency bandwidth has coexisted with several communication systems such as WLAN, WIMAX and Meteorological Satellite. Frequency spectrums for WLAN, WIMAX and Meteorological Satellite are allocated at 5.125 to 5.825, 3.3 to 3.7 and 7.4 to 8.4GHz. Coexisted frequency bandwidth between communication systems could affect communication device and operation [8-14]. The interference that is occurred could have resulted data loss, signal interruption and device malfunction. Thus, avoiding the interference in communication system has become essential [15-19].

The structure of the reference and designed antennas are explained in the next section. The antenna performances are illustrated and described in part iii and the conclusion are discussed in part iv.

II. ANTENNA DESIGN

Ultra-wideband planar antenna with an elliptical structure is illustrated in Fig. 1. FR4 substrate material is used in this design. The substrate permittivity, length and width are given by ε_r , (L_d+L_g) and W_g. The major and minor radiuses of the elliptical plane are L_1 and L_2, correspondingly. The ground plane length and width are L_g and W_g, respectively. The thickness of the substrate and the conductor plane are h_s and h_c.

The reference and the designed antenna is simulated using Computer Simulation Technology (CST) software. The simulation for the reference and designed antenna ran in Transient solver. Reference and designed antenna are simulated in an open boundary space from 3 to 11GHz. Convolution Perfect Match (CPM) layer is set up in 0.0001 for reflection minimization in the simulation. The feed of the reference antenna is located in the elliptical element. The feeding port is placed between edges of the elliptical and the ground plane.

Ultra-wideband frequency spectrum is attained by the adjustment of the radiuses of the elliptical plane. The impedance matching is characterized by the alteration of the feeding gap, *F*. Elliptical element is etched in the right part. A slit is structured in horizontal of the center right of the elliptical plane. It is considered to interrupt the perpendicularly polarized face current distribution in the elliptical plane. Slit structure is configured in Fig. 3. Slit is structured by the parameters length and width which is known as *l* and *w*. The band notch is attained by changing the slit parameters of the elliptical plane. Band notch is desired between the 5 and 6 GHz. By changing the structure of the elliptical element, it is considered to cause the impedance mismatched of the designed antenna.

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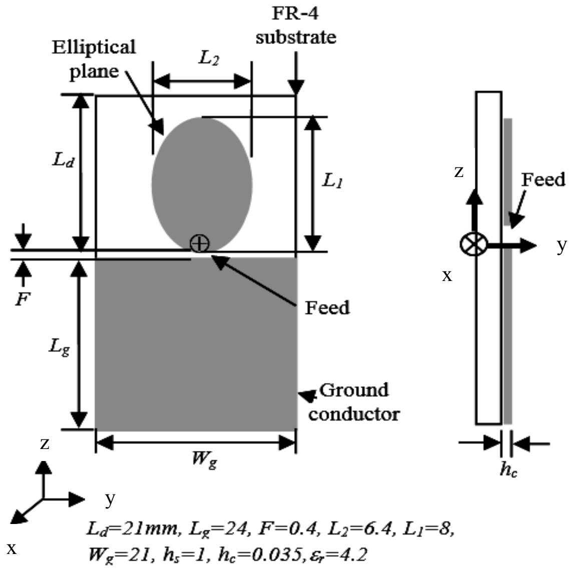

Fig. 1. Reference antenna

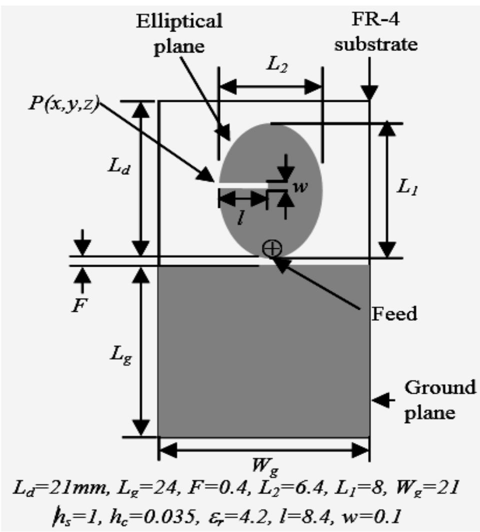

Fig. 2. Uwb planar antenna with a notched-band characteristic

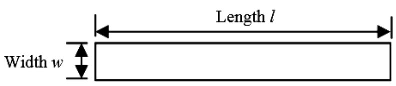

Fig. 3. Uwb planar antenna with a notched-band characteristic

III. ANTENNA PERFORMANCES

The reference and designed antenna performances such as the reflection coefficient S_{11}, radiation pattern *RP* and gain *G* of the reference and the designed antenna is studied and compared. Reference and the designed antenna characteristics are discussed in sub-chapter *A* and *B*, respectively.

A. Characteristics of UWB Planar Antenna with an Elliptical Plane

Impedance matching in the reference antenna is achieved by feed gap adjustment. Reflection coefficient S_{11}, for the reference antenna for feed gap F_1 is depicted in Fig. 4. Reflection coefficient S_{11} is higher in the low frequency area when $F< 0.4mm$. The high frequency area is higher when $F> 0.4mm$. It is clear that the ultra-wideband frequency spectrum is reasonably attained for $F=0.4mm$. Thus, the feed gap for the reference antenna is determined and finalized $F=0.4mm$.

The face current allocation of the reference antenna at the frequency *f*=3.5, 5.5 and 9.5 GHz are depicted in Fig. 5. Based on the feature, it is clear that the face current is dispersed in symmetric on the conductor element. It is obviously clear from the symmetrical structure of the reference antenna. Higher concentration of surface current distributed in the feed area. Face current is higher in the edge region in the elliptical and the ground plane.

Radiation pattern *RP* of the reference antenna is presented in Fig. 6. Co- and cross-polarized pattern is represented by the red and green colored line. The radiation pattern in co-polarization in the *xy*-plane is in omni-directional. The cross-polarization in the *xy*-plane is comparatively larger in the higher frequency. The co-polarization of the radiation pattern in the *xz*-plane is in bi-directional. However, the cross-polarized pattern in the *xz*-axis is significantly minor. The reference antenna radiation pattern is almost similar to the monopole antenna. The gain *G* is maximized in the *xy*-and *xz*-axis for the frequency $f=3.5$ and 9.5GHz is given by $G_{max}=2.34$ and 3.76dB. The location of the maximum gain at the frequencies of interest are located in the $-x$ coordinate for the *xy*-axis and in the $+z$ coordinate for the *xz*- axis.

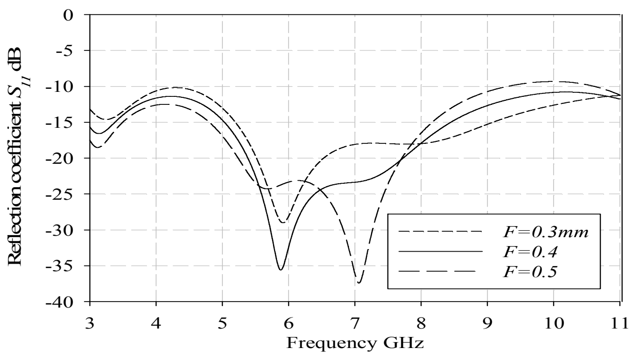

Fig. 4. Reflection coefficient S_{11} due to feed gap F

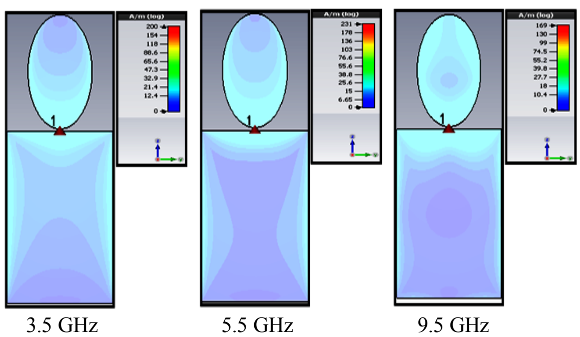

Fig. 5. Face current dispersions of the reference antenna

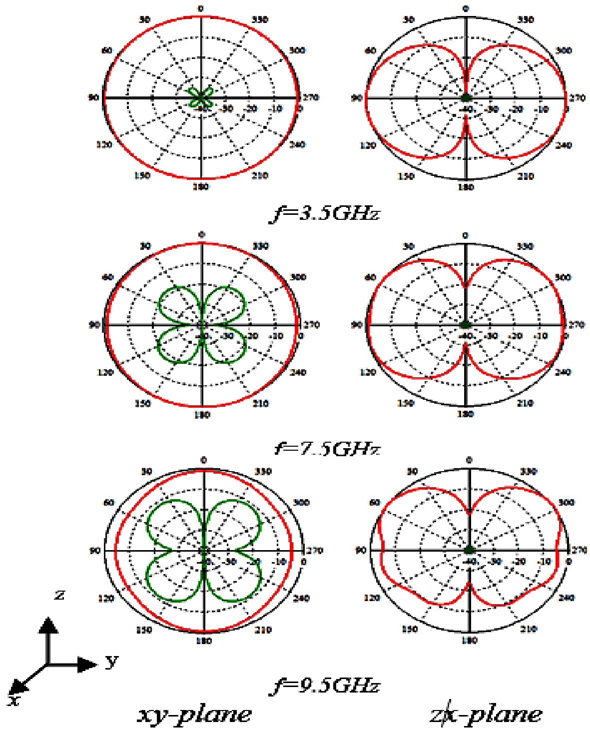

Fig. 6. Radiation patterns of the reference antenna

B. *Characteristic of the Designed Antenna*

The relation between the slit and band notch characteristics is studied and discussed. It is clear from Fig. 7 that the slit has caused and characterized the notched-band. Notched-band is located between 5 and 6 GHz, with the given bandwidth of 1 GHz. The center frequency is located at f=5.5 GHz. Maximum reflection coefficient S_{max} is -3.5 dB.

The face current distribution in the frequency f=3.5, 5.5 and 9.5 GHz for the designed antenna is presented in Fig. 8. Face current distribution is congregated in the slit region. The parallel slit is considered to interrupt the perpendicularly polarized face current distribution. The slit in the elliptical plane has changed the input impedance of the feed. Thus, the impedance of the proposed antenna is mismatched at the certain frequency.

Radiation patterns for the designed antenna are illustrated as Fig. 9. Co- and cross-polarization is depicted in presented in red and green. It is clear that the co-polarization of the designed antenna is unaffected when compare with the reference antenna. However, the cross-polarization in the E-plane is comparatively larger when compare with the reference antenna. The cross-polarizations of the designed antenna for the frequency of interest 3.5, 7.5 and 9.5 GHz in the *xz*-plane are increased due to the horizontal slit existence in the elliptical element. The radiation patterns are unchanged when referred to the reference antenna. The radiation patterns are in bi-directional.

It is clear that slit existence in the elliptical plane has influenced the cross-polarization. From the frequency of interest, the maximum gain in the planes of H- and E- are located at the frequency *3.5* and *9.5* GHz. The max gain is G_{max} =*2.66* and *3.4*dB, consecutively. The max gain G_{max} is located in *–x* and *+z –axis* in the planes H- and E-plane.

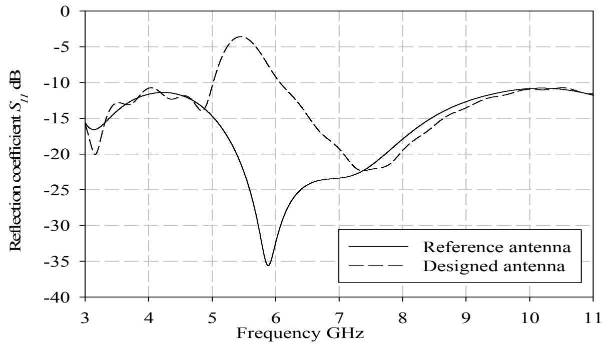

Fig. 7. Reflection coefficient S_{11} for reference and designed antenna

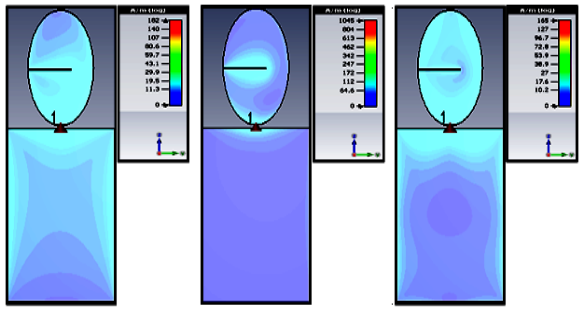

Fig. 8. Face current dispersion for the designed antenna

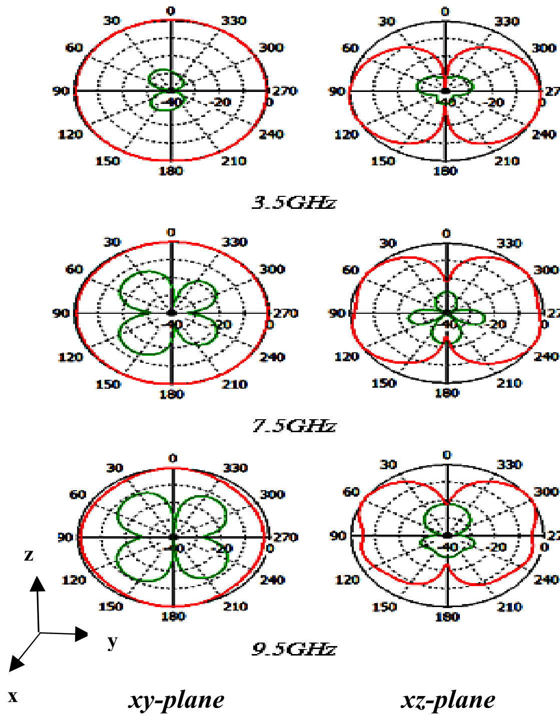

Fig. 9. Radiation patterns for the designed antenna

Maximum gain versus frequency and the radiation efficiency of the reference and the designed antenna is presented in Fig. 10. The max gain *G* for the designed antenna is slightly increased compares with the reference antenna between the frequency 6 and 7 GHz. In addition, the max gains are increased for the frequency f=3~3.1, 3.4~3.7, 3.8~4.0, 4.2~4.4, 4.6~4.8 GHz, accordingly. The maximum gain has decreased between 5 and 6 GHz. It is clear within the band rejection of the frequency bandwidth. The maximum gain *G* has decreased significantly clearly because the impedance mismatched at the desired frequency region.

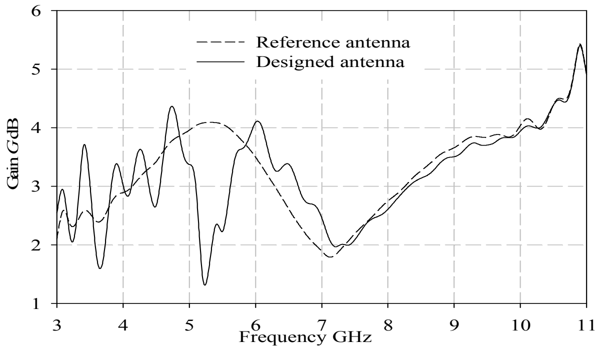

Fig. 10. Max gain *G* over frequency *f* of the reference and designed antenna

IV. CONCLUSION AND FUTURE WORK

Ultra-wideband planar antenna with an elliptical plane with characterized notched-band is presented and designed. The designed antenna has simple and compact feature. The characterized notched-band is generated by slit in the elliptical plane. The designed antenna gain is comparatively higher than the reference. Slit in the elliptical plane clearly does not affect the radiation pattern characteristic significantly. Future works are described as follows.

1. To conduct fabrications and measurements for the designed antennas.
2. To verify the simulation with the measurement results.
3. To conduct slit parametric study in the means of identifying the dominant slit parameters that influence the band notch characteristics.
4. To design multiple band notch characteristics for other coexisted communication system with uwb frequency bandwidth.

ACKNOWLEDGMENT

The research is supported by Universiti Teknologi Malaysia (UTM) Grant vote no. 4J283.

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