Design Analysis of Slotted Planar Antenna for Wireless Applications

Mawarni Mohamed Yunus and Noor Badariah Asan

***Abstract*—In this paper, a compact planar antenna with a bandwidth enhancing technique named folded patch feed is presented. The design adopts contemporary techniques; coaxial probe feeding, slotted patch structure and shorting wall. The composite effect of integrating these techniques and by introducing the proposed patch, offer a low profile, broadband and low cross polarization level. The results for the VSWR and radiation patterns are presented. The antenna operating the band of 2.39-2.49 GHz (impedance bandwidth of 3.3%) and upper band of 5.03-6.45 GHz which shows an impedance bandwidth of 24.8%. Good radiation characteristics, including low cross-polarization level in E-plane for both bands have been obtained.**

***Index Terms*—Planar antenna, slotted, folded patch feed.**

I. Introduction

The use of wireless system has given a big impact to the development of recent mobile technology and other technologies such as WLAN, Wi-Fi, Bluetooth, and HYPERLAN [1]. The rapid developments in WLAN technologies demand the integration of IEEE 802.11 WLAN standards of the 2.4 GHz (2400–2484 MHz), 5.2 GHz (5150–5350 MHz) and 5.8 GHz (5725–5825 MHz) bands into a single unit. To comply with the above requirements, compact high performance multiband antennas with good radiation characteristics are required. Also, a dual band/ multiband antenna is better than a wideband antenna if both of them are required to cover two frequency bands that are far away from each other.

A dual-band antenna [2]-[5] operates at 2.4 GHz and covering the entire 5 GHz band can be used in mobile units has been reported. Several methods have been reported to develop this type of antenna. They involved cutting a special slot [6] and using a stacked structure [7] on the traditional quarter-wave shorted patch antenna. Although these antennas has dual-band characteristic, its impedance bandwidth of each frequency band is less than 10% [4]-[7]. In order to tackle this problem, a bandwidth widening technique is needed. Recently, a new feeding technique has been proposed namely folded-patch-feed. With the folded patch feed design; the patch connected to the probe is folded downward which shortened the probe length, leads to a smaller probe inductance, thus widening the impedance bandwidth of the antenna [8].

In this paper, a novel dual-band planar antenna is presented that consists of a double-L slot facing each other when viewed from the top configured together with folded-patch feed and shorting wall is presented. All these modification will strongly contribute to reduce antenna size and broaden the bandwidth, compared with a simple patch. The geometrical configuration, the size and the position of the probe feed are the most significant factors to help realize the desired dual band operation covering both 2.4 GHz and entire 5 GHz bands. Furthermore, the proposed antenna has good characteristics of radiation pattern and gain for WLAN/Bluetooth applications.

II. Antenna Design

A prototype of the proposed antenna has been developed by using 0.2 mm copper sheet which has been cut and properly bent in order to obtain tridimensional element. The idea of using copper material is to have an antenna that can be easily integrated on top of the circuit board of the mobile devices to reduce packaging cost [1]. The layout of the proposed antenna is shown in Fig. 1. The radiation element is physically supported by a coaxial cable and shorting wall. They are electronically consisting of a feeding structure. The 50 Ω coaxial cable directly feeds to a radiation patch.

The probe feed with diameter 0.8 mm is located on the horizontal central line of the folded patch feed with 10 mm away from the left edge. A longer probe length will cause more probe inductance. With the aid of folded patch feed design, the probe length is shortened, leading to a smaller probe inductance [8]. It is important to note that the overall height of the proposed antenna is 7 mm, whereas the length of the probe used is only 4 mm. Therefore a thick antenna is achieved without increasing the probe inductance.

The proposed antenna consists of double-L slot when viewed from the top. The first resonance is mainly determined by the size of the L-slot on the upper patch, while the second resonance is mainly governed by the size of the lower patch, which is also associated with the second L-slot. The slot also appears to introduce a capacitive reactance which reduces the inductive reactance of the probe [5]. The total size of the proposed antenna has the volume of $15 \times 12 \times 7$ mm^3, and on top of the ground plane with dimension of 57×54 mm^2.

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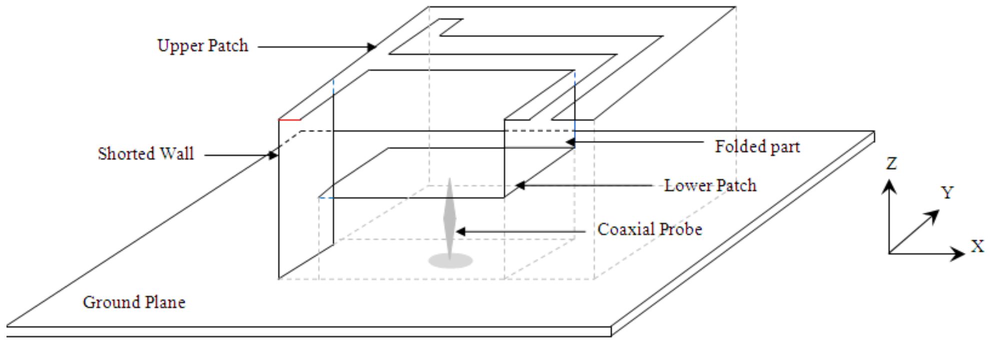
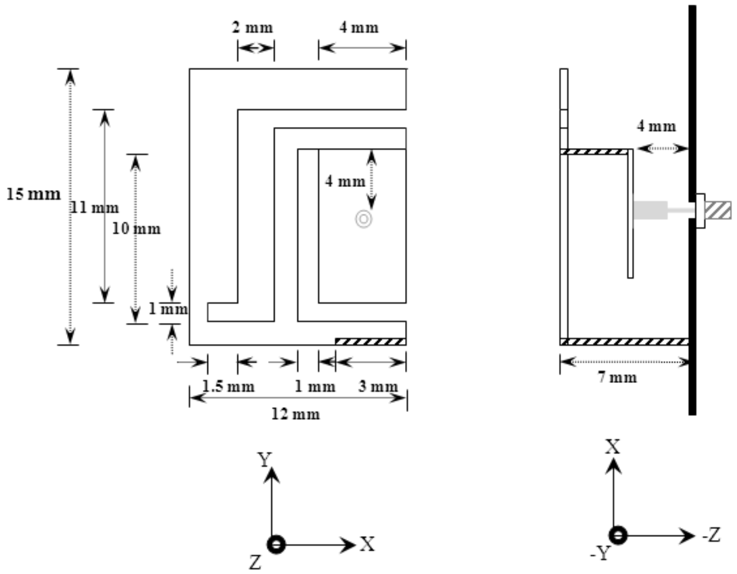


(a)



(b) (c)

Fig. 1. Geometry of the proposed antenna 3D-view (b) Top view (c) Side view.

III. Results and Discussions

The simulated antenna performance is analyzed using CST Microwave Studio Suite and measured using Agilent Network Analyzer E8362C. Fig. 2 depicts the comparison results between the simulated and measured return losses of the proposed antenna. The solid and the dashed line denote the simulated and measured return losses respectively. The measured return loss curve shows that the proposed antenna is excited at 2.45 GHz with a -10 dB return loss bandwidth of 80 MHz (2.39-2.48 GHz) and at 5.5 GHz with an impedance bandwidth of 1425 MHz (5.03-6.45 GHz). The obtained bandwidths can sufficiently cover the bandwidth requirement for WLAN standards IEEE 802.11a (5.15-5.35 GHz and 5.47-5.825 GHz), IEEE 802.11b/g (2.4-2.484 GHz) and IEEE 802.11n (2.4-2.484 GHz, 5.15 -5.35 GHz and 5.47-5.825 GHz). The maximum return loss of -22.9 dB and -17.89 dB are obtained at the resonant frequencies of 2.4 GHz and 5.5 GHz respectively. It is clearly seen that the measured impedance matching of upper resonant frequency has been decreased from -34.2 dB of simulated impedance matching. This discrepancy is due to the cable losses and tolerances in fabrication process.

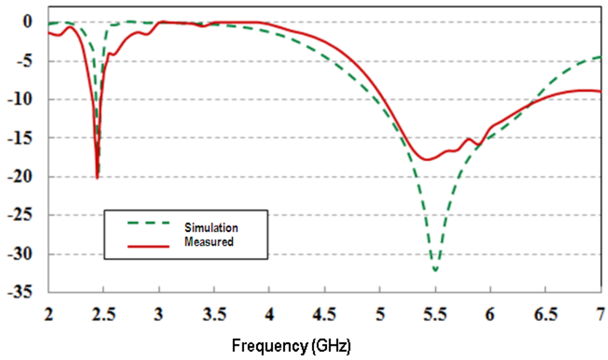
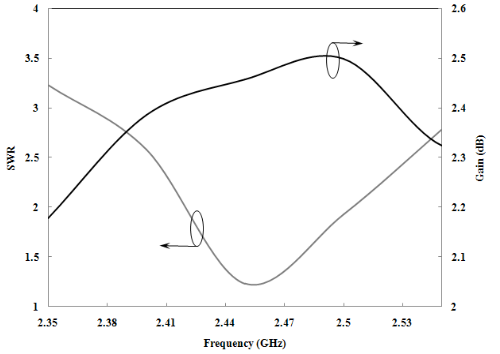
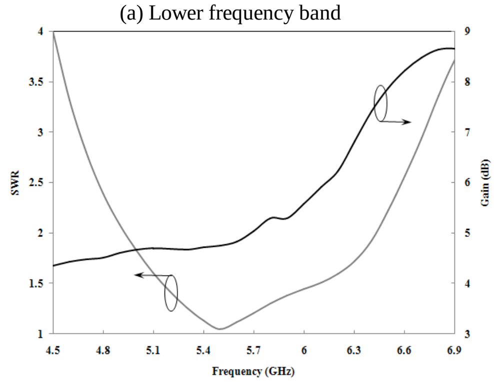


Fig. 2. Comparison between simulated and measured return losses of the proposed antenna.

Fig. 3(a) and (b) illustrates the SWR and maximum antenna gain for frequencies across both of the operating bands. The maximum 7dB gain is achieved in higher frequency band with SWR 1.0467, which is nearly 1 (absolute impedance matching). This shows almost all input power has been transmitted to the patch. In the 2.4 GHz band, the peak gain reaches about 2.507 dB. The low gain in the 2.4 GHz is mainly caused by the cancellation of the current by the meandering structure to reduce the dimension of the proposed antenna.



(a) Lower frequency band



(b) upper frequency band

Fig. 3. SWR and gain of the proposed antenna.

Measured results of E and H plane of radiation pattern patterns of the proposed antenna at 2.45GHz and 5.5GHz has been shown in Figure 4. It can be seen that the patterns are nearly Omni directional, and in the H plane symmetrical radiation patterns are clearly seen due to the structural symmetry. The advantage of symmetrical radiation pattern is that the maximum power direction would always be at the bore sight direction and would not shift to any different direction across the frequencies [1]. Low cross polarization of more than 5dB also has been achieved for both desired frequencies. The discrepancy in intensities between co and cross polarization will reduce the multipath fading problem thus enhance the system performance.

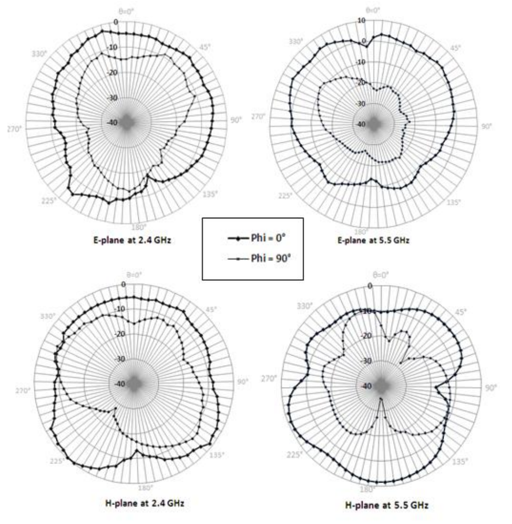


Fig. 4. Measured radiation pattern of the proposed antenna.

IV. Conclusion

A novel dual band planar antenna for WLAN/Bluetooth application is presented in this paper. By using a double-L slot and folded feeding structure with air as substrate, the antenna attains a -10dB impedance bandwidth of 80MHz (from 2.39-2.48 GHz) in the lower frequency and 1425 MHz (5.03-6.45 GHz) in the higher band which fulfil the requirements of IEEE802.11a/b/g bands 2.45GHz and 5.8GHz for WLAN applications. When tested the antenna prototype exhibits maximum gain of more than 7dBi with a good radiation pattern in the lower and higher frequency bands, respectively. Moreover, the proposed antenna is compact in size, low cost and easy to manufacture. These features are very useful for worldwide portability of wireless communication applications.

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