Trends in

Applied Sciences Research

ISSN 1819-3579

Academic
Journals Inc.

www.academicjournals.com

Trends in Applied Sciences Research 6 (9): 1071-1077, 2011
ISSN 1819-3579 / DOI: 10.3923/tasr.2011.1071.1077

A Compact Shorted Wall Patch Antenna for Dual Band Operation

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ABSTRACT

An analysis of a compact patch antenna with a shorted wall is proposed for dual band operation in this study. The proposed antenna covers 2.45 GHz bands with two resonances that are caused by the L slot and the dimension of the shorting wall. In the 2.4 GHz band, the antenna achieves a bandwidth of 150 MHz (2.37-2.52 GHz) or about 6.1% for the center frequency of 2.45 GHz and in the 5 GHz band, antenna shows a bandwidth of 1100 MHz (4.97-6.07 GHz) or about 19.9% for the center frequency of 5.52GHz. The gains across the frequency bands are found to be considerable high in the operating bands. The antenna is prescribed for the multi-band application of Wireless Local Area Network (WLAN) in IEEE 802.11a/b/g.

Key words: Dual band, WLAN, patch antenna, high gain, compact antenna

INTRODUCTION

Evolution towards global wireless communication continues at a stunning rate and the antenna element of the technology is one of the most vital points for the success of the system. The progress in personal communication technologies also demands the integration of more than one communication system into a single compact module. However, the challenge lies in simultaneously locating the multiple antennas and a diplexer into portable devices due to the device's limited space. This indicates that a modern antenna requires not only the function of providing a multi-band operation but also a simple structure, compact size and easy integration with the system circuit.

The development of WLAN technology is seen as a viable and cost-effective high-speed data connectivity solution which can support the pace of the technological development. The IEEE 802.11 b/g standards utilize the license-free 2.4-GHz ISM band for the applications of WLAN system. However, there is another operational universal 5GHz band for the same application. The American IEEE and European ETSI organizations have characterized their respective standards for the 5 GHz band: IEEE802.11a (Draft Supplement to Standard, 1999) and HIPERLAN/2. The IEEE 802.11a standard defines three frequency bands that can be used. A first band extends from 5.15 to 5.25 GHz, the second from 5.25 to 5.35 GHz and the third from 5.725 to 5.825 GHz. HIPERLAN/2 specifies two bands: from 5.15 to 5.35 GHz and from 5.470 to 5.725 GHz (Mobashsher *et al.*, 2010a).

In study, there are numerous antennas reported to achieve dual band characteristics for WLAN bands. However, simple microstrip antennas and coplanar waveguide (CPW)-fed antennas are very promising and suitable for WLAN owing to their low profile, light weight and easy integration with system circuits. However, most of the reported microstrip antennas (Islam *et al*., 2009a; Sarin *et al*., 2009; Hsieh *et al*., 2009; Liu *et al*., 2009) and CPW-fed antenna designs (Liu, 2005; Islam *et al*., 2009b; Gao *et al*., 2006; Augustin *et al*., 2008; Kim and Park, 2005; Kaur *et al*., 2011) are complex and large which makes them unsuitable for practical portable applications. More importantly the gain of the antenna is not high. To achieve high gain in dual band, some antennas were also proposed by Islam *et al*. (2010) and He *et al*. (2009). But they also lag considering the antenna profile. Planar Inverted-Fantennas (PIFAs) also promised considerable gain with low profile (Nepa *et al*., 2005; Chang and Wong, 2009) but the existing PIFAs are very complex for the fabrication. However, antennas with considerably good gain characteristics are vital for the performance improvement of the whole system (Eshanta *et al*., 2009; Saad *et al*., 2008).

In this study, a shorted wall patch antenna is proposed with compact shape. The antenna achieves dual bands that is suitable for the application in WLAN bands. Even though the compact size, the antenna attains a, respectively high gain in both the bands. Details of the antenna design and analytical results are presented and discussed.

ANTENNA DESIGN AND GEOMETRY

The configuration of the proposed antenna is shown in Fig. 1. The antenna consists of a printed patch which is connected with the ground plane by a shorting wall and fed by a simple 50 Ω SMA connector. The radiating patch is printed on Rogers RT/duroid 6006 superstrate with relative permittivity 6.50, tangent loss 0.0027 and thickness t_1 = 1.6 mm. An air of 7 mm thick is used as the substrate of the antenna. It is worth mentioning that the dielectric superstrate can also function as a protecting cover from catastrophic environment (Mobashsher *et al*., 2010b).

The sorting wall is made from a copper strip of w_w = 0.5 mm thickness and l_w = 4 mm in length. The wall stays and makes the connection between the patch and the ground plane. A shorting wall

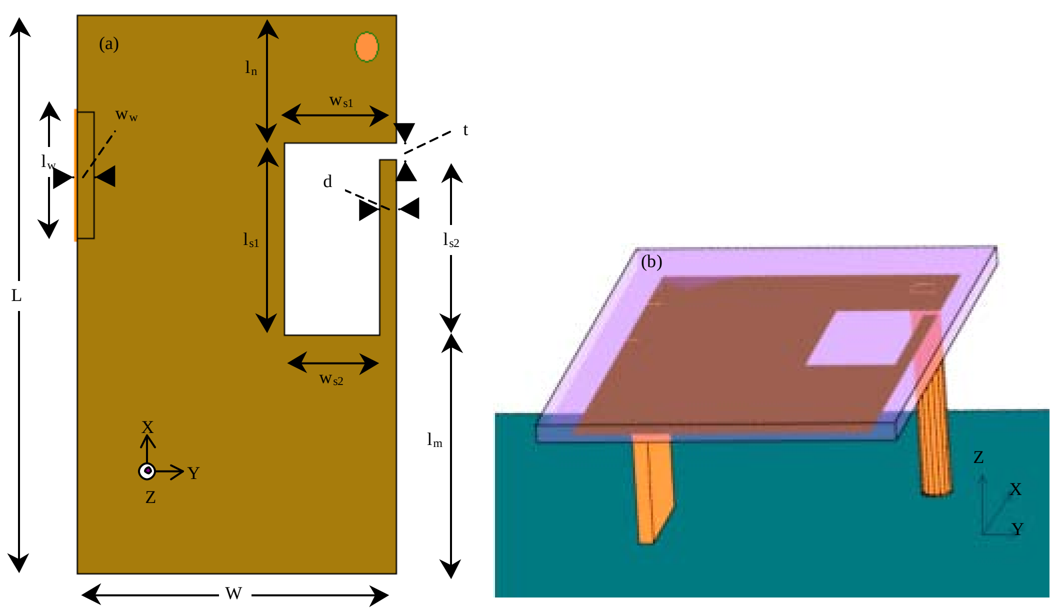

Fig. 1: Geometry of the proposed antenna (a) Top view (b) Perspective view

is mainly used to reduce the overall size of the antenna. The width of the shorting wall also is the key parameter for tuning the lower operating frequency band to the 2.4 GHz band.

The patch of the antenna mainly consists of an L shaped slot with the largest dimensions of w_{s1} = 3.5 mm and l_{s1} = 6 mm. The slot is the primary reason for the dual band characteristic of the antenna. The antenna is fed from the edge of the L slot and the largest current path extends to outer portion of the patch through the shorting wall. This longer path resonates at the lowest frequency and the current path around the L slot up to the end of L slot through l_{s2} is responsible for the higher resonating frequencies. The projection size of the patch size is L×W = 17.5×10 mm^2 which is smaller than other reported dual band antennas.

ANALYSIS AND RESULTS

Analytical parametric studies have been performed to facilitate more elaboration of the design and optimization processes for readers. Various parameters are investigated to examine the effects of the antenna parameters on return loss as well as the impedance bandwidth of the antenna. This study covers the influences of varying length of the patch and the dimensions of the L slot and the shorting wall. For better convenience of the effect on the performance of the antenna upon changing the parameters, only one parameter is changed at a time while keeping others unchanged (Mobashsher *et al.*, 2010c).

Figure 2 depicts the influence of the patch length L on the antenna resonating frequencies. As the length is increased from 15.5 to 19.5 mm, the lower resonance decreases due to an increase in the current path. However, the lower portion of the 5 GHz band is stable in the increment of the patch length; never the less the upper portion of the upper band tends to resonate with more matching which also slightly decreases the operating bandwidth of the 5 GHz band.

The parameters of L slot are also varied to observe the change of the resonating frequencies. As shown in Fig. 3, when the length l_{s2} is varied from 0 to 5.5 mm, the lower resonance remains almost unchanged while the upper resonance changes vigorously. These results confirm the influence of l_{s2} on the upper resonating bandwidth while inactivity on changing the lower resonance. However, as the width of the L slot, w_{s1} is increased, both of the resonances changes which is shown in Fig. 4. This is because of the fact that the feeding is located beside w_{s1} and as w_{s1} is increased the current path of the resonating frequencies increases for both of the operating band. That's why the resonances decrease to the lower value.

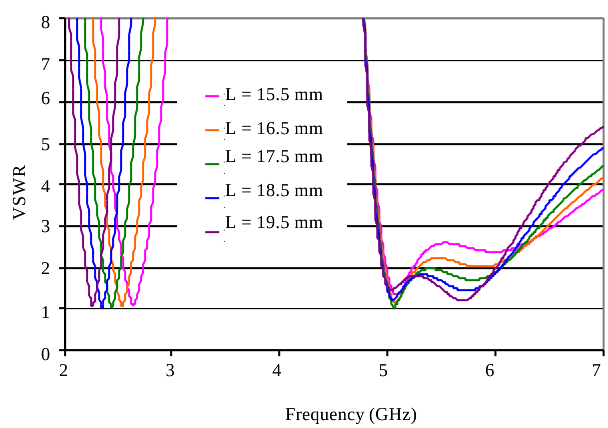

Fig. 2: Return losses for different values of L

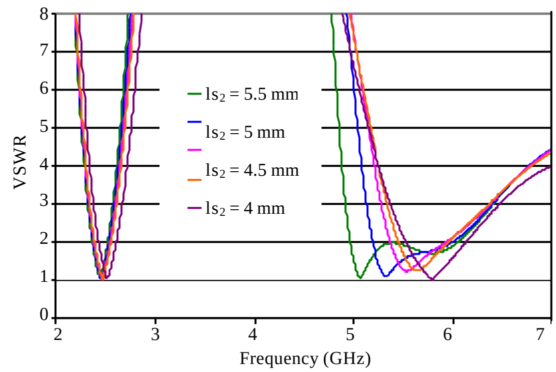

Fig. 3: Return losses for different values of l_{s2}

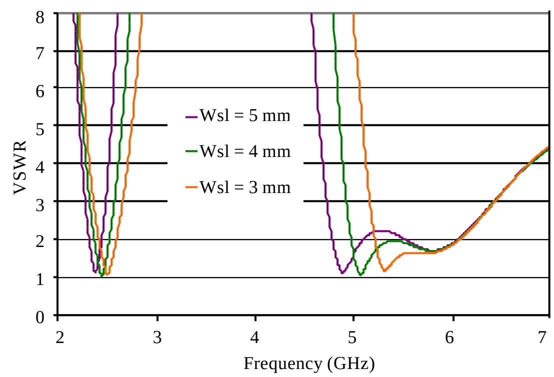

Fig. 4: Return losses for different values of w_{s1}

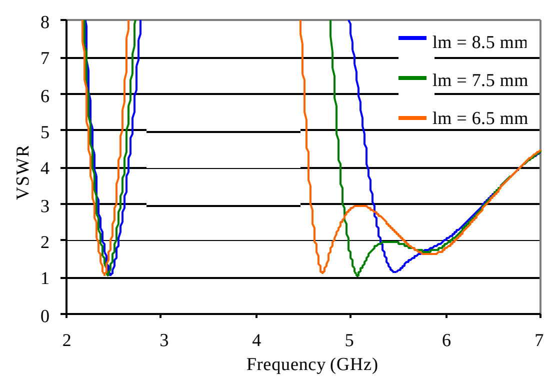

Fig. 5: Return losses for different values of l_m

The distances of the L slot have also some effect on the resonance of the antenna. This parametric study shows the proper position and length of the L slot is very important for the antenna resonances. As shown in Fig. 5 while the distance of the L slot from the lower end, l_m is varied the lower frequency remains almost unchanged. But the upper 5 GHz frequency band changes vitally and rushes to the lower frequencies splitting the whole wideband into two separate small resonating bands. The same effect is seen in Fig. 6, for the fluctuation of the distance of the

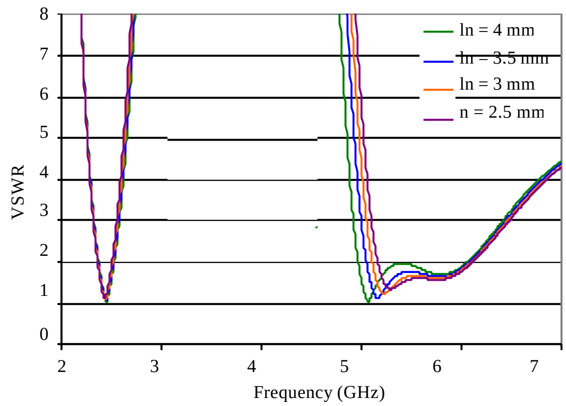

Fig. 6: Return losses for different values of l_n

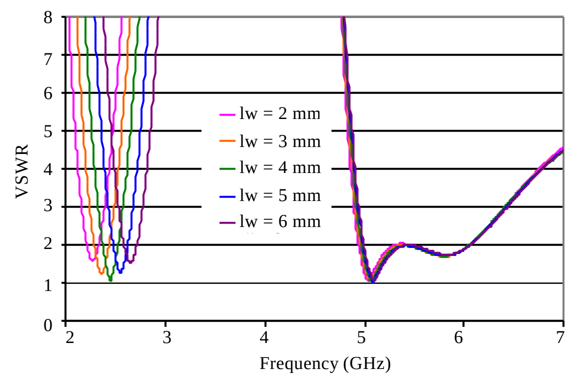

Fig. 7: Return losses for different values of l_w

L slot from the upper side of the patch, l_n. From the graphs, we can conclude that the upper frequency band is very much dependent on the L slot and its position.

Lastly, the influence of the shorting wall on the resonances is observed. As the length of the shorting wall, l_w is increased from 2 to 6mm, the resonances increases from 2.3 to 2.7 GHz. So the relation of the antenna resonance and the length of shorting wall is reciprocal which is shown in Fig. 7. However, there is no effect of the length variation on the upper 5 GHz frequency band of the antenna which suggests that the upper frequencies does not depend on the shorting wall.

The antenna performance was studied by the commercially available full-wave, method-of-moment based electromagnetic simulator Zeland IE3D version 12.0. Figure 8 shows the return losses of the antenna. The central resonance frequencies are 2.45 and 5.52 GHz, respectively. In the 2.4 GHz band, voltage standing wave ratio (VSWR):2 bandwidth is 150 MHz (2.37-2.52 GHz) or about 6.1% for the center frequency of 2.45 GHz which meets the bandwidth requirement for IEEE802.11b/g. In the 5 GHz band, VSWR:2 bandwidth is 1100 MHz (4.97-6.07 GHz) or about 19.9 % for the center frequency of 5.52 GHz which also meet the bandwidth requirement for IEEE 802.11a.

The gain of the antenna is exhibited in Fig. 9. In spite of the small structure of the antenna, it achieves a, respectively high gain than other dual band antennas. With a peak gain of 4.2 dBi at 2.45 Ghz the antenna exhibits gain of more than 3 dBi over the lower frequency band.

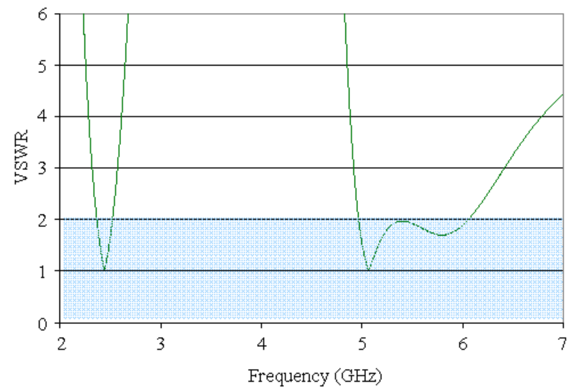

Fig. 8: VSWR of the proposed compact dual band antenna

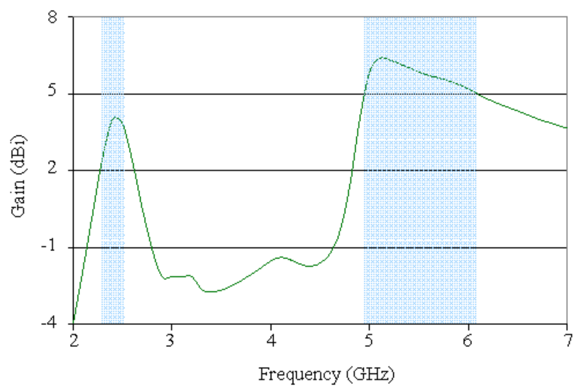

Fig. 9: Gain vs. frequency response of the compact dual band antenna

However, at higher frequency band, with a peak gain of 6.4 dBi at 5.1 GHz, the overall gain of the antenna is distinctly over 5 dBi for the application of universal 5 GHz WLAN.

CONCLUSION

The design of a shorted wall inverted patch antenna with extremely small size, operating in dual bands, has been proposed in this study. The design is simple and compact with very few design parameters. The projects area of the antenna is only 17.5 × 10 mm^2 which is suitable for integration with application specific circuits. The present design stands out as a potential candidate for WLAN applications.

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