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COMPACT M-SLOT FOLDED PATCH ANTENNA FOR WLAN

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Abstract—This paper presents a very small size microstrip antenna suitable for WLAN application. The main patch antenna consists of an M-shaped slot with shorting wall. With a shorted triangular parasitic patch and a folded patch overall antenna size is reduced. The simulated and measured results show that by selecting a proper shorting wall width, the proposed antenna can provide an impedance bandwidth of 21.17% covering the 4.93–6.09 GHz band. The antenna size is of order $0.1094\lambda_o \times 0.1094\lambda_o \times 0.0544\lambda_o$ ($6 \times 6 \times 3\,\text{mm}^3$). The proposed antenna has 75% surface size reduction compared to a conventional patch antenna operating at the same centre frequency. The E- and H-plane radiation pattern across the entire operating bandwidth is provided.

1. INTRODUCTION

The microstrip patch antenna is an excellent candidate for portable wireless devices. Personal mobile communication requires small size and lightweight antenna with wideband performance. As such, many researchers are focusing on the development of impedance bandwidth enhancement techniques for patch antennas. Bandwidth enhancement techniques that have been studied thus far for microstrip antennas include the use of a thick substrates [1], parasitic patches [2], E-slot patch [3], H-shaped patch [4, 5], U-shaped slot patch [6, 7], T-shaped parasitic strip [8], meandered slot and slit loaded [9], L-probe feed [10], fed by a circular open ended microstrip line [11], and shorting pins [12]. Recently, a new feeding method that can dramatically improve the impedance bandwidth of a patch antenna has been proposed, namely, the folded patch feed. The rectangular U-slot patch antenna with a folded patch feed [13] and folded patch feed to an E-shape patch antenna [14]. Wideband and small size patch antenna have been developed by using shorting wall technique, [15]. Recently, [16] investigated the application of the E-shaped patch antenna to wireless local area networks operating in the 5–6 GHz. The antenna size in that paper is 23.6 mm × 32 mm × 3.5 mm thick.

In this paper, a compact M-shape slot microstrip antenna that is significantly smaller than the conventional patch antenna or any other modified structure reported in the open literature is presented. The size of the proposed patch antenna covering the 4.93–6.09 GHz band is $6 \times 6 \times 3\,\text{mm}^3$. The small size is achieved by using folded patch shorted to ground electromagnetically coupled to a parasitic shorted patch.

2. ANTENNA GEOMETRY AND DESIGN

It is well known that a microstrip patch antenna that is fed by a coaxial probe has narrow impedance bandwidth. The impedance bandwidth can be improved by simply increasing the thickness of the substrate. Due to the probe inductance the impedance bandwidth of a patch antenna with a thick substrate would be limited. The folded patch feed with air substrate is a desirable technique to broaden the impedance bandwidth. By this method the probe inductance can be reduced as a shorter coaxial probe is required, [14].

Figure 1. Geometry of the proposed M-slot folded patch antenna.

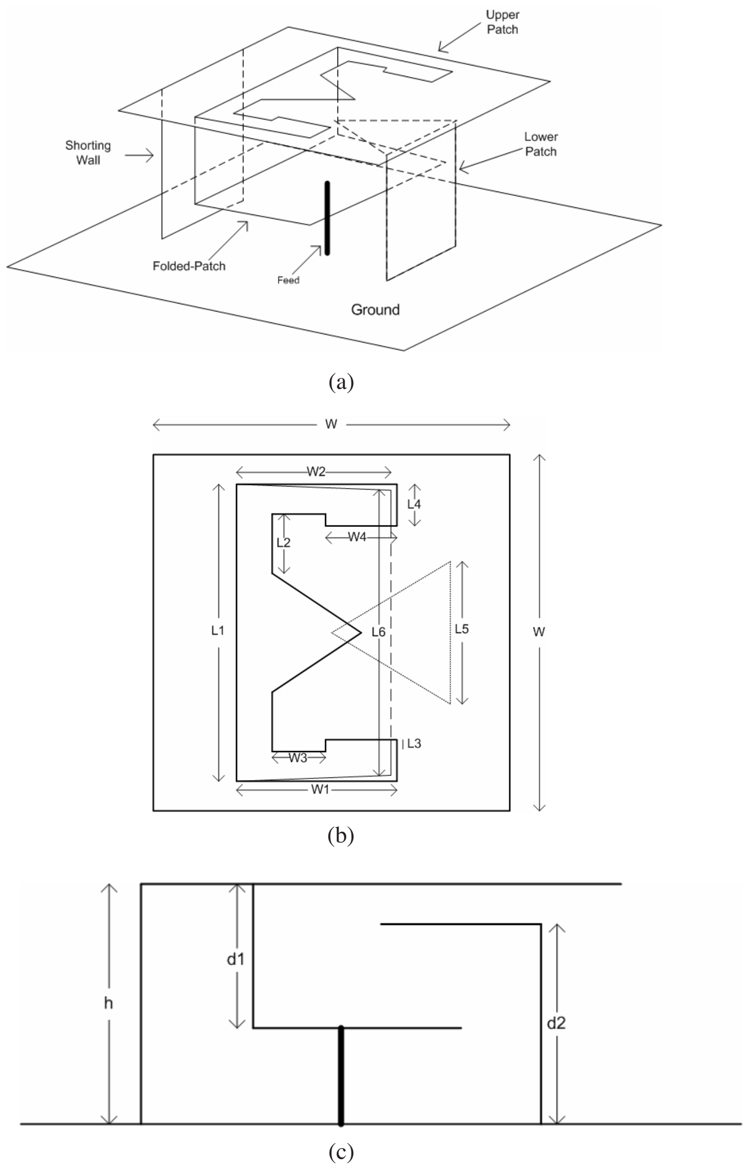

Figure 2. Schematic diagram, (a) 3D view, (b) Top view, (c) Side view, $L1 = 5\,\text{mm}$, $L2 = 1\,\text{mm}$, $L3 = 0.2\,\text{mm}$ $L4 = 0.7\,\text{mm}$, $L5 = 2.4\,\text{mm}$, $L6 = 4.8\,\text{mm}$, $W = 6\,\text{mm}$, $W1 = 2.7\,\text{mm}$ $W2 = 2.6\,\text{mm}$, $W3 = 0.9\,\text{mm}$, $W4 = 1.2\,\text{mm}$, $h = 3\,\text{mm}$, $d1 = 1.8\,\text{mm}$, $d2 = 2.5\,\text{mm}$.

The present design is based on slot loading a patch antenna. The proposed antenna uses an air substrate of thickness $h = 3\,\text{mm}$ and dimensions as shown in Fig. 2. A shorting wall to reduce the overall size of the antenna is connected between the main patch (upper level) and the main ground. The ground plane size is selected as $9 \times 9\,\text{mm}^2$ and the initial width of the shorting wall is 2.8 mm. The main patch is loaded by an M-slot (a modified E-shaped slot). The M-slot provides a larger bandwidth with a better impedance matching level. Along the edge of the M-slot a folded patch that is fed by a coaxial probe is located. This folded patch results in wider bandwidth as well as reduction in size of the antenna. To further reduce the size of the overall antenna, an isosceles triangular patch shorted to ground is located under the main patch and parasitically coupled to it. Also, it was noticed that the presence of this triangular patch results in almost 1 GHz downward shift of the bandwidth in frequency range. The width of the shorting wall between the main patch and ground is a key parameter for tuning the lower operating frequency.

3. SIMULATED AND MEASURED RESULTS

With the dimensions of the antenna as given in Fig. 2 the proposed M-Slot antenna is fabricated and tested. For a shorting wall width of 2.8 mm the measured return loss of the proposed antenna along with the simulated results obtained from a commercially available Finite Element package, HFSS are shown in Fig. 3 Good agreement is observed between the measured and simulated results although the measured bandwidth is slightly smaller. The bandwidth of the antenna covers the range 4.93–6.09 GHz. The length and width of

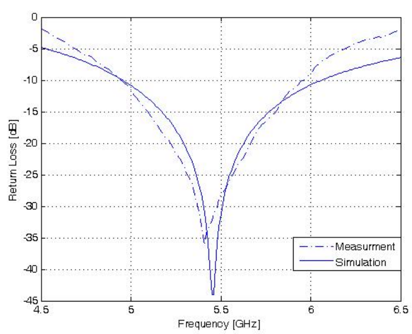

Figure 3. Simulated and measured return loss for the antenna shown in Fig. 2.

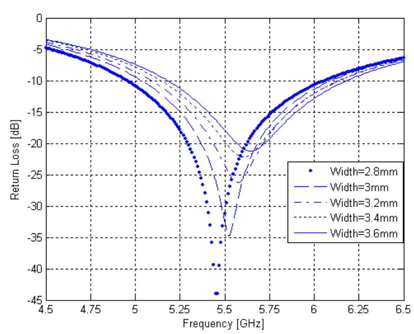

Figure 4. Simulated return loss for the antenna with different shorted wall widths.

the upper patch is $0.1094\lambda_o$, whereas the height of the probe and the overall height of the antenna are $0.0544\lambda_o$ and $0.0224\lambda_o$. A conventional microstrip patch antenna operating at the same centre frequency as that of the proposed antenna is obtained with a patch size of $24 \times 24 \times 3\,\text{mm}^3$. This shows that some 75% reduction in patch size is achievable.

Figure 4 shows the variation of the simulated return loss for different widths of the shorting wall. As the width of the shorting wall increases, the resonance frequency shifts upward. The width of 2.8 mm results in a very low return loss, at least 35 dB.

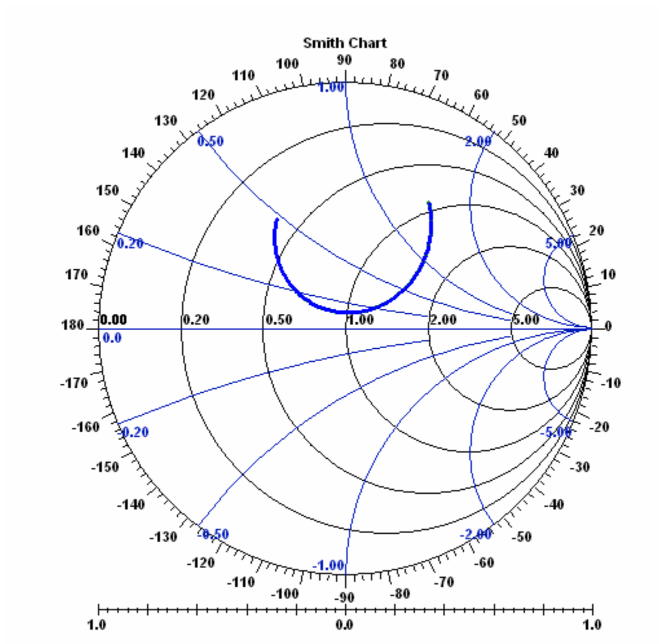

Figure 5. The simulated input impedance on a Smith chart of the M-slot antenna.

Figure 6 shows typical far-field radiation patterns of the proposed antenna in both the E and H-planes, including the co-polarized and the cross-polarized components at the center frequency of the band, 5.4 GHz. Although not shown, almost the same patterns are obtained at other frequencies over the band. It is clear that the E-plane co-polar pattern is very similar to an Omni directional pattern. The measured results are in good agreement with the simulated ones.

Figure 7 indicates concentrated current next to the fin sections. However, the current is uniformly distributed elsewhere.

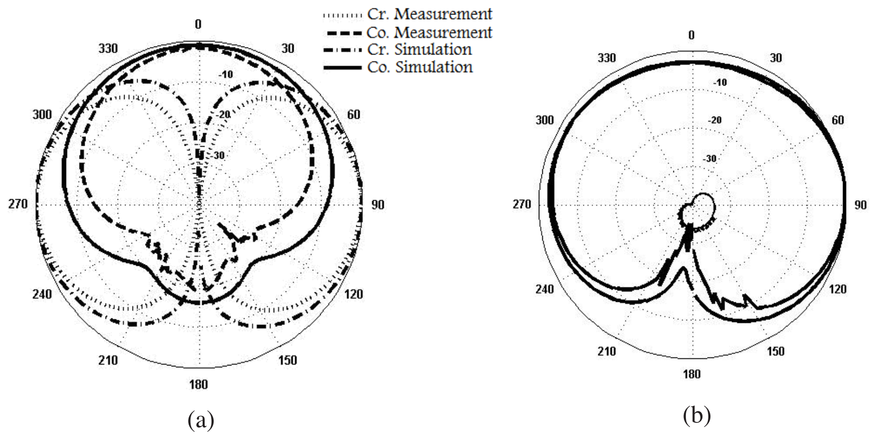

Figure 6. Simulated and Measured radiation pattern at 5.4 GHz (a) *H*-plane (b) *E*-plane.

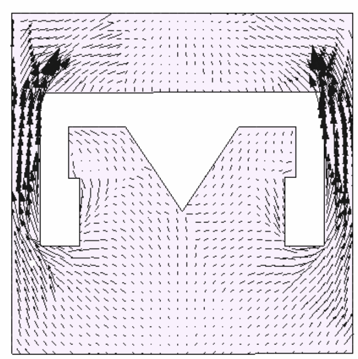

Figure 7. Distribution of current on main patch.

4. CONCLUSION

A new small and compact size patch antenna suitable for WLAN application covering 4.93–6.09 GHz is proposed. The antenna comprises an M-slot loaded patch, a triangular parasitic patch, a coaxially fed folded patch and shorting walls to provide the required bandwidth as well as reducing the overall antenna size. The overall size of the proposed patch antenna is $6 \times 6\,\text{mm}^2$ with thickness of 3 mm. This is some 75% smaller than a conventional patch antenna. The return loss as well as the radiation properties of the antenna has been studied.

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