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Stacked Square Microstrip Antenna with a Shorting Post for Dual Band Operation in WLAN Applications

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Abstract — **A small and wideband antenna for dual band (2.4/5.2 GHz bands) operation is presented. The proposed antenna has a shorting post and slits to miniaturize the size of patch. The bandwidth in the low frequency band (the 2.4GHz band) increases as the length of the shorting post between the upper and lower patches increases. The lengths of the square patch of the proposed antenna are around $0.10\lambda_{2.45GHz}$ and $0.21\lambda_{5.25GHz}$. The bandwidths are 5.2% and 11.0% in the 2.4GHz and 5.2GHz bands, respectively.**

I. Introduction

Recently, wireless local area networks (WLANs) in the 2.4GHz (2400MHz–2484MHz) and 5.2GHz (5150MHz–5350MHz) bands and Wireless personal area networks (WPANs) such as Bluetooth (2402MHz–2480MHz) have received much attention and have spread rapidly. Mobile communication terminals such as antennas for WLAN and WPAN are required to be as small as possible and to operate in dual frequency bands.

The authors have proposed a stacked square microstrip antenna (MSA) with a shorting post and slits for VICS/ETC dual–band operation [1]. The lengths of the square patch of the proposed antenna are around 0.09λ referenced to 2.5GHz, the center frequency in VICS band and 0.21λ referenced to 5.8GHz, the center frequency in ETC band. The calculated bandwidth of the return loss of less than -10dB is 5.17% in the VICS band. The bandwidth of the return loss of less than -10dB and the axial ratio of less than 3dB is 6.45% in the ETC band. The proposed antenna is small and wideband.

In this paper, the stacked square MSA with a shorting post for dual band operation is applied to 2.4/5.2GHz dual band operation.

II. Antenna Design

Figure 1 shows a stacked square MSA with a shorting post. The antenna consists of two dielectric substrates with a square patch. The square patches have slits to miniaturize the patch size. The upper and lower square patches are the same size and have a width W. The length and width of the slits along the diagonal are l_s and d_s, respectively. The upper patch is shorted to the lower patch at x_p, y_p around the apex of the square patch. The diameter of the shorting post is d_p.

The relative dielectric constant and thickness of the lower and upper dielectric layers are ε_{r1}, h_1 and ε_{r2}, h_2, respectively. Both ε_{r1} and ε_{r2} are 2.60. The antenna is excited at x_0, y_0 on the diagonal on the lower patch by a coaxial feeder through the lower dielectric substrate.

III. Results and Discussion

The calculated results are obtained by a simulator software package IE3D 10.0 based on the method of moments in the spectral domain [2].

Figure 2 shows the bandwidth for changes of the length of the shorting post h_2 in the 2.4GHz band. The location of the upper patch is fixed

($h_t = h_1 + h_2$=5.6 and 6.4mm). In figure 2, the geometry of the patch is the square without the slits ($l_s = d_s = 0$) and the width of the square patch is W =12mm. The location of the shorting point in the square patches is adjusted so that the center frequency is 2.45GHz. The bandwidth increases as the length of the shorting post (the thickness of the upper dielectric) increases.

MSAs for 2.4GHz/5.2GHz dual band operation have been designed for the widest bandwidth in the 2.4GHz band using the dielectric substrates h_1=1.6mm and h_2=4.8mm. In [1], two pairs of slits are cut at the center of the sides in the square patches to achieve circular polarization for the ETC band (the high frequency band) and miniaturize the size of the square patch. In this paper, however, the proposed antenna has one pair of slits along the diagonal because linear polarization is used in the high frequency band, the 5.2 GHz band, for WLAN application.

Figure 3 shows the return loss in the 2.4GHz and 5.2GHz bands. In each square, the lengths l_s and width d_s of the slits and the position of the shorting point (x_p, y_p) are adjusted. In the case of W =11mm(=0.09$\lambda_{2.45}$=0.19$\lambda_{5.25}$), the bandwidths of the 2.4GHz and 5.2GHz bands are 4.8% and 7.0% and in the case of W =12mm(=0.10$\lambda_{2.45}$=0.19$\lambda_{5.25}$), the bandwidths are 5.2% and 11.0%, respectively. (λ_f : the wave length at fGHz)

Figures 4(a)–(d) show the electric current distributions on the upper and lower patches of W=12mm. The calculation frequencies are the center frequencies of the 2.4GHz and 5.2GHz bands, 2.45GHz and 5.25GHz, respectively. The intensities of the electric current around the shorting post at 2.45GHz are maximum and those on the opposite apexes to the shorting point are approximately zero on the upper and lower patches. The sum of the lengths of the diagonal of the upper and lower patches and the shorting post approximately becomes a half wavelength at 2.45GHz. The intensity of the electric current on the lower patch at 5.25GHz is maximum around the edge of the slits and zero around the two apexes of the patches, demonstrating that the electric current path is lengthened by the slits. The intensity of the electric current on the upper patch is much smaller than that on the lower patch.

Figures 5(a)–(d) show the radiation patterns at 2.45GHz and 5.25GHz, respectively. At 2.45GHz, the intensities of the radiation fields at the low–elevation angles in the xz and yz planes are large compared with those at the high–elevation angles. At 5.25GHz, the antenna has a radiation peak around the high–elevation angles. These are due to the fact that the electric current on the shorting post contributes to the radiation field at 2.45GHz and that the electric current on the patches contributes to the radiation field at 5.25GHz. The radiation pattern in the azimuth (xy-plane) is a nondirectional pattern in both 2.45 and 5.25GHz.

IV. Conclusion

A stacked square MSA with a shorting post for dual band operation in WLAN applications has been proposed. The wideband operation has been achieved by enlarging the length of the shorting post between the upper and lower patches. Moreover, the antenna size has been reduced by inserting slits in the square patches.

Acknowledgments

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References

[1] T. Fujimoto and K. Tanaka, "Stacked square microstrip antenna with a shorting post for dual band operation," Proc. of 2006 IEEE AP-S. Int. Symp., in CD, pp.3585–3588, July 2006.

[2] "IE3D User's Manual," Zeland Software, Inc., Dec. 1999.

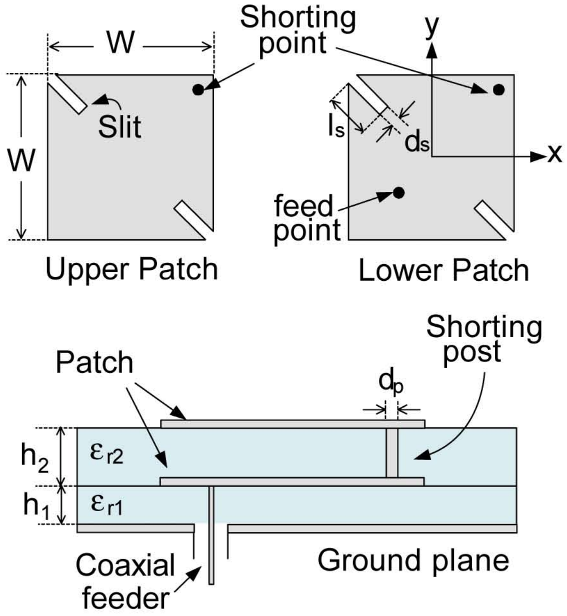


Fig. 1 Geometry of a stacked square MSA with shorting post

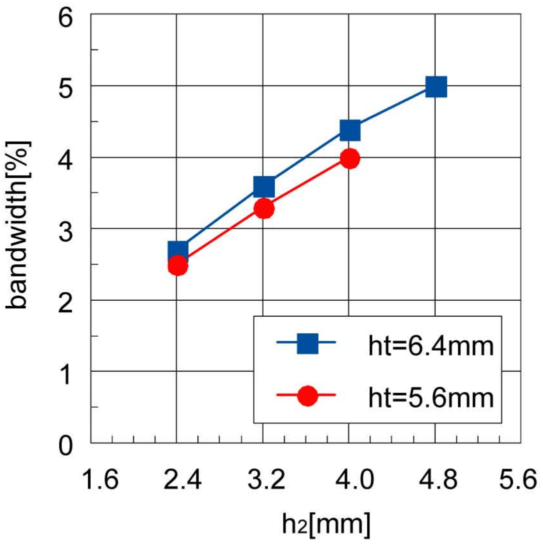


Fig. 2 Bandwidth as a function of the length of the shorting post

(W=12mm, ε_{r1}=ε_{r2}=2.6, d_p=1.3mm, without slits)

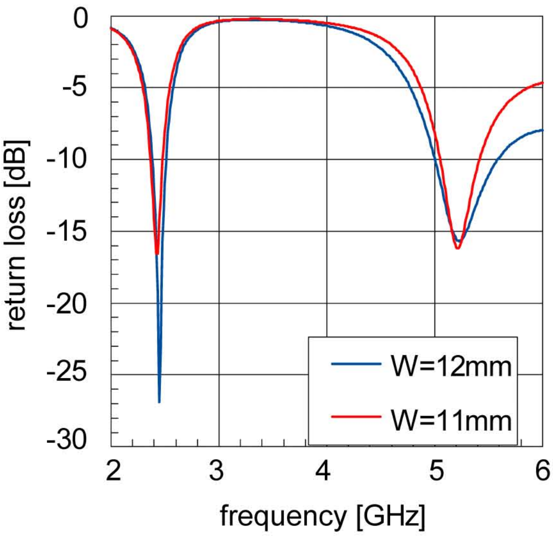
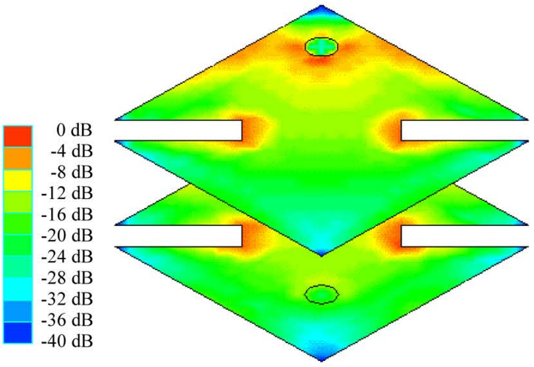
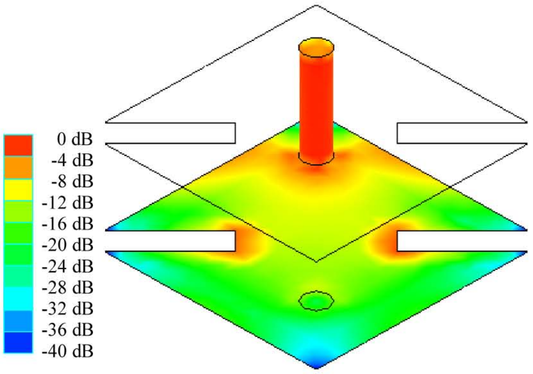


Fig. 3 Return loss

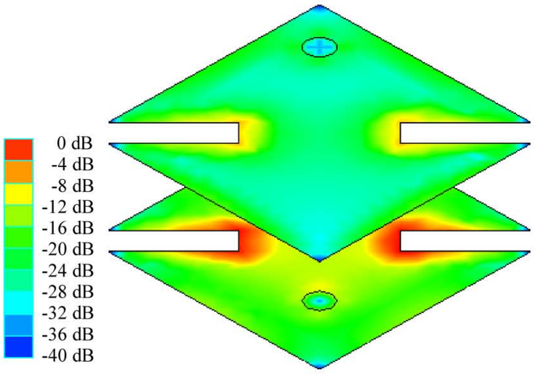
(l_s=5.52mm, d_s=1.42mm, $x_0 = y_0$=3.2mm, $x_p = y_p$=10.0mm, d_p=1.3mm, ε_{r1}=ε_{r2}=2.6, h_1 = 1.6mm, h_2 = 4.8mm)



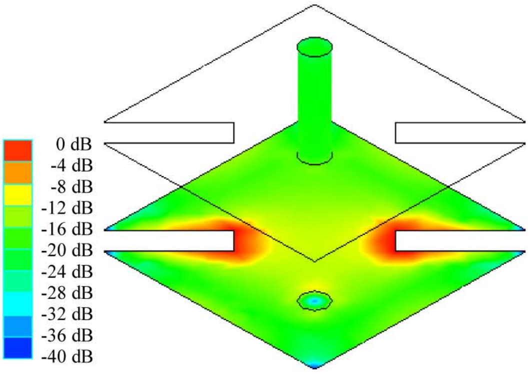
(a) Upper patch (2.45GHz)



(b) Lower patch (2.45GHz)



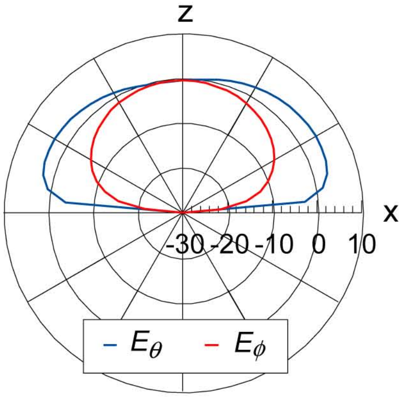
(c) Upper patch (5.25GHz)



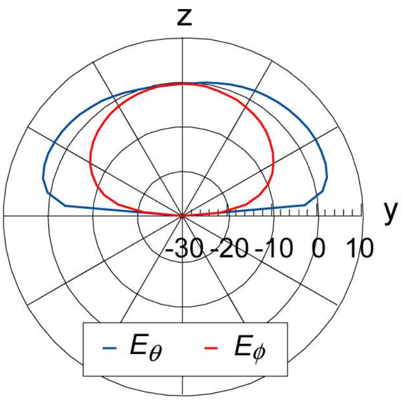
(d) Lower patch (5.25GHz)

Fig. 4 Electric current distribution

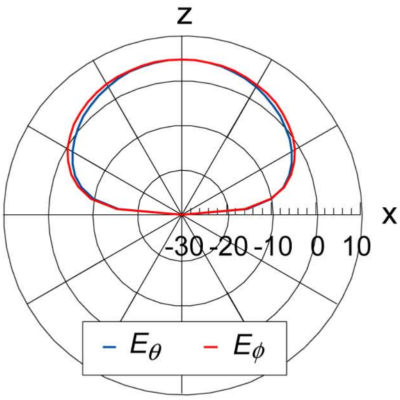
(W=12.0mm, l_s=5.52mm, d_s=1.42mm,
$x_0 = y_0$=3.2mm, $x_p = y_p$=10.0mm, d_p=1.3mm,
ε_{r1}=ε_{r2}=2.6, h_1 = 1.6mm, h_2 = 4.8mm)



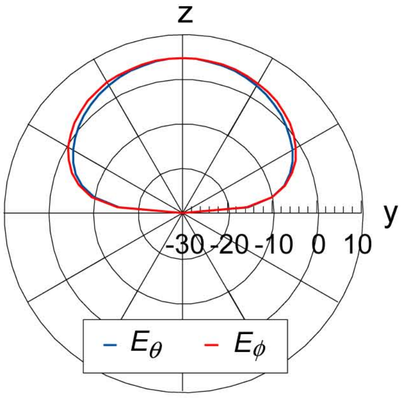
(a) xz plane (2.45GHz)



(b) yz plane (2.45GHz)



(c) xz plane (5.25GHz)



(d) yz plane (5.25GHz)

Fig. 5 Radiation patterns

(W=12.0mm, l_s=5.52mm, d_s=1.42mm,
$x_0 = y_0$=3.2mm, $x_p = y_p$=10.0mm, d_p=1.3mm,
ε_{r1}=ε_{r2}=2.6, h_1 = 1.6mm, h_2 = 4.8mm)