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WIDEBAND STACKED SQUARE MICROSTRIP ANTENNA WITH SHORTING PLATES

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1. Introduction

An impedance bandwidth of a microstrip antenna (MSA) is narrow inherently. Therefore, many approaches to increase the bandwidth such as using additional microstrip resonators [1], stacking parasitic patches above a fed patch (stacked MSA) [2], embedding a U–shaped slot in the radiating patch [3] and using an L–probe feed [4], have been proposed. It is desirable for wideband MSAs that the frequency characteristic of the VSWR (voltage standing wave ratio) is wide and the direction of the radiation peaks is the same in the frequency range.

In this paper, a wideband stacked square MSA with shorting plates is proposed. In the conventional stacked MSA, although the radiation peak in the primary mode is at high elevation angles, that in the secondary mode is at low elevation angles. The bandwidth of the stacked MSA is only enhanced in the frequency band of the primary mode. In the proposed stacked MSA, the direction of the radiation peak for the secondary mode is changed to high elevation angles by controlling the electric current distributions at the secondary mode using shorting plates. The characteristic of the VSWR is also improved in the frequency band of the secondary mode.

2. Antenna Design

Figure 1 shows a stacked square MSA with two shorting plates. The antenna consists of a dielectric substrate and an air layer with a square patch. The upper and lower square patches are the same size and their width is W=15.0mm. The upper patch is shorted to the lower patch at two apexes on the diagonal of the square patch by a conducting plate. The width of the shorting plates is d_p=1.0mm. The relative dielectric constant and the thickness of the upper and lower layers are ε_{r1}=1.0, h_1 and ε_{r2}=2.6, h_2=2.4mm, respectively. The antenna is excited at x_0, y_0 ($x_0 = y_0$) on the diagonal of the lower patch by a coaxial feeder through the lower dielectric substrate.

3. Results and Discussion

In the calculations in this paper, the simulation software package IE3D 10.2, based on the method of moments in the spectral domain (SD–MoM) is used [5]. In SD–MoM, Green's functions in a layered medium are used [6]. Therefore, IE3D is efficient for analyzing the stacked MSAs.

Figure 2 (a) and (b) show the VSWR and gain at θ=0° of the stacked square MSA with the shorting plates. Those of the stacked square MSA without the shorting plates are also shown for comparison. The locations of the feed point are adjusted so that the best performance of the VSWR is obtained in each antenna. The VSWR is improved in the range from 9GHz to 11GHz by loading the shorting plates at the edges. Moreover, the gain increases significantly in the range from 8GHz to 10GHz. However, the VSWR from 5GHz to 8GHz is larger than 2.0 ($\simeq$ 2.1) and the gain at 8 GHz is less than 0.0 dBi (=-1.83 dBi).

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Figure 3 (a) and (b) show the VSWR and gain at θ=0° for the stacked square MSA with the shorting plates for changes of the length of the shorting plates h_1. As the length of the shorting plates (the thickness of the upper layer) increases, the VSWR in the range from 5GHz to 8GHz becomes less than 2.0 and the gain at 8GHz increases. In the case of h_1=6.0mm, the bandwidth of VSWR $\leqq$ 2.0 with gain $\geqq$ 0dBi is 62.1% (5.18GHz–9.84GHz). The bandwidth is approximately 1.8 times of that without the shorting plates with h_1=4.0mm.

Figure 4(a)–(f) show the radiation patterns of the stacked square MSAs with and without the shorting plates at 6GHz, 8GHz and 10GHz. E and H–planes are shown for ϕ=45° and 135°, respectively. At 6GHz, the radiation patterns of the stacked MSA with the shorting plates are nearly the same as those without the shorting plates. At 8GHz, in the case without the shorting plates, a null exists at around θ=0°. However, the null moves from θ=0° to θ=15° by loading the shorting plates. Therefore, the gain at θ=0° of the stacked MSA with the shorting plates increases. At 10GHz, the radiation patterns of the stacked MSA without the shorting plates are those of a secondary mode with low elevation angles [7]. However, the radiation patterns of the stacked MSA with the shorting plates is similar to those of the primary mode, the radiation patterns at 6GHz.

Figure 5(a)–(d) show the electric current distributions of the stacked MSAs with and without the shorting plates at 10GHz, when the differences in the radiation pattern are the biggest. In the stacked MSA without the shorting plates, the intensities of the electric current around the center on the upper and lower patches are approximately zero. However, the intensities of the electric current around the center on the upper and lower patches become large in the stacked MSA with the shorting plates. The radiation peak at 10GHz is at high elevation angles due to these electric currents on the center of the patches.

4. Conclusion

A wideband stacked square MSA has been proposed. The wideband operation, the VSWR less than 2.0 with the gain more than 0.0dBi, has been achieved by loading the two shorting plates at the edges of the square patches.

References

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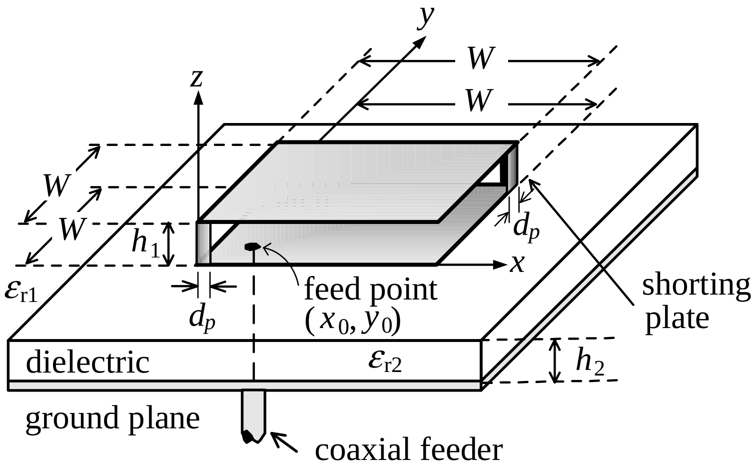
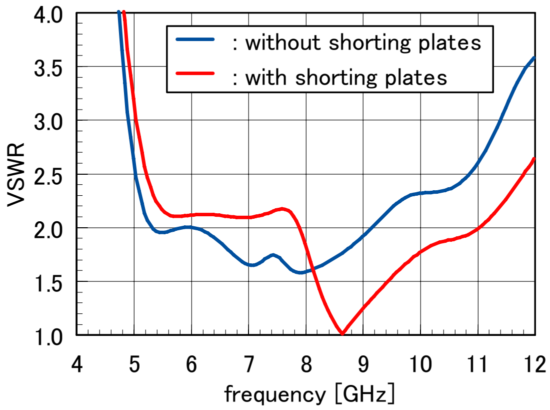
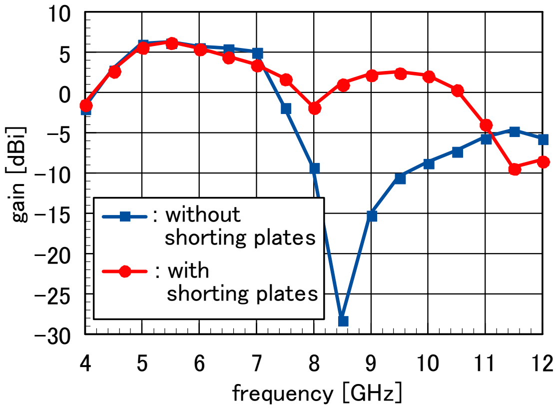


Figure 1: Geometry of a stacked square MSA with shorting plates

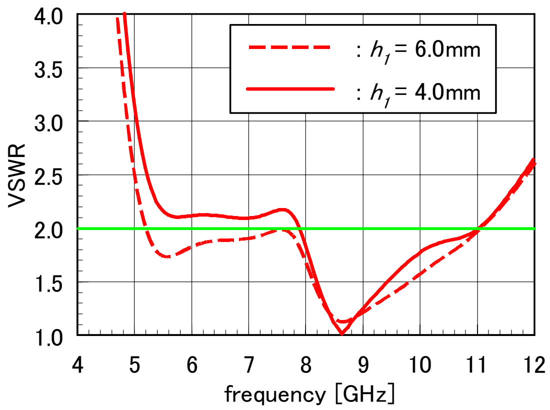


(a) VSWR

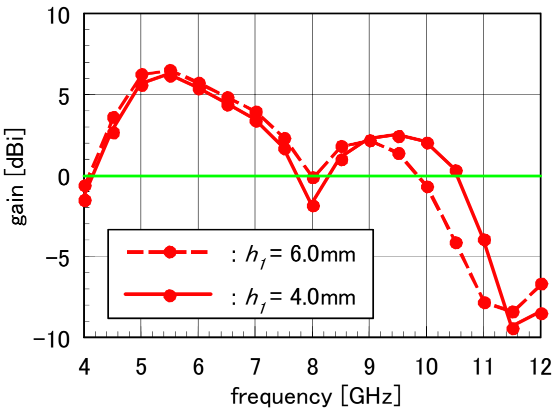


(b) Gain

Figure 2: Comparison of stacked MSAs with and without shorting plates (h_1=4.0mm)

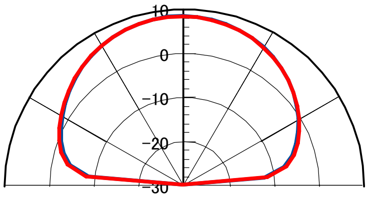


(a) VSWR

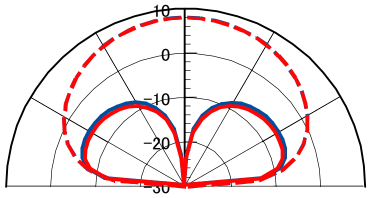


(b) Gain

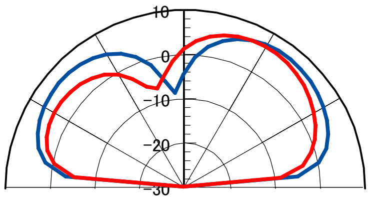
Figure 3: Characteristics for changes of the length of the shorting plates



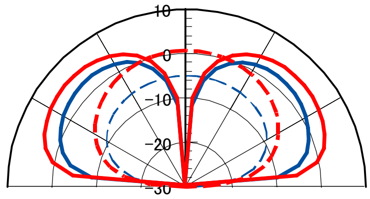
(a) E-plane (6.0GHz)



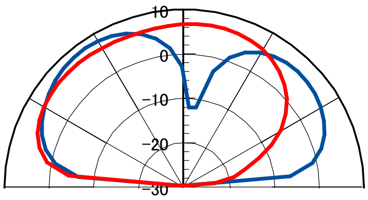
(b) H-plane (6.0GHz)



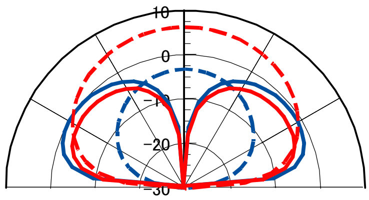
(c) E-plane (8.0GHz)



(d) H-plane (8.0GHz)

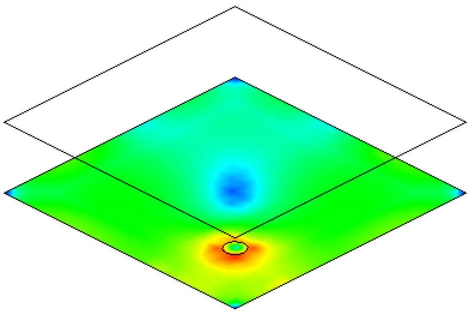


(e) E-plane (10.0GHz)

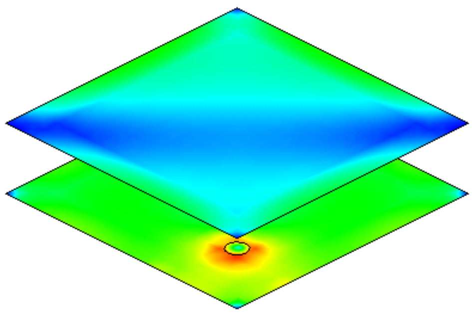


(f) H-plane (10.0GHz)

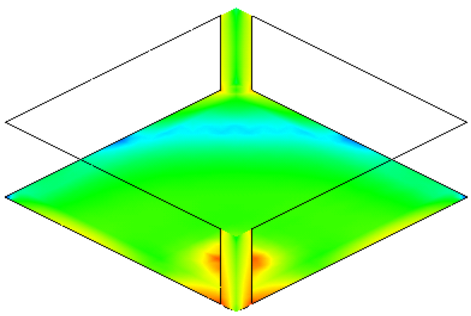
Figure 4: Radiation patterns of stacked MSAs with and without shorting plates (h_1=4.0mm)



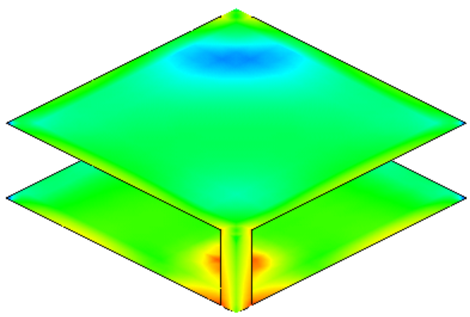
(a) Lower patch (without shorting plates)



(b) Upper patch (without shorting plates)



(c) Lower patch (with shorting plates)



(d) Upper patch (with shorting plates)

Figure 5: Electric current distributions (10GHz, h_1=4.0mm)