Wideband Stacked Square Microstrip Antenna with Slits

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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 antennas 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.

The structure of the stacked MSA is relatively simple because it can be realized by just stacking a parasitic patch, whose geometry is the same as the fed patch, above the fed patch. In the conventional half wavelength stacked MSA, although the radiation peak in the first mode is at high elevation angle, that in the second mode is at low elevation angle [5]. Therefore the bandwidth of the stacked MSA is only enhanced in the frequency band of the first mode.

The authors have proposed a wideband stacked square microstrip antenna (MSA) with two shorting plates [6]. The bandwidth of VSWR ≤ 2 has been achieved in the frequency range between the first and the third resonant frequencies and the bandwidth of VSWR ≤ 2 with gain at $\theta = 0° \geq 0$dBi has been achieved in the frequency range between the first and the second resonant frequencies

In this paper, the improvement of the directivity in the vicinity of the third resonant frequency is examined by installing slits in the patches and changing the width of the shorting plates of the antenna proposed in the reference [6].

2. Antenna Design

Figure 1 shows the structure and the coordinate system of the antenna. 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 have a width $W_p = 14.0\text{mm}$. The upper patch is shorted to the lower square patch at two apexes of the diagonal of the square patch by conducting plates. The widths of two shorting plates are d_{p1} and d_{p2}, respectively. Two slits are installed at the location of the line symmetry for the diagonal in the upper or the lower square patches. The slits length, the slits width and the distance from the apex of the square patch are S_l, S_w and S_p, respectively. The thickness of lower dielectric substrate, the relative dielectric constant and the dielectric loss tangent are $h_2 = 2.4\text{mm}$, $\varepsilon_{r2} = 2.6$ and $\tan\delta = 0.0018$ and the width of lower dielectric substrate is $W_d = 100\text{mm}$. The upper layer is a free space of $h_1 = 10.0\text{mm}$ in thickness. The antenna is excited at the lower patch by a coaxial feed through the lower dielectric substrate at point (x_0, y_0) which lays on the diagonal.

3. Results and Discussion

In the calculations in this paper, the simulation software package FIDELITY, based on the finite difference time domain method is used [7].

Figure 2 shows the calculated input impedance of stacked square MSA without the slits [6]. In the antenna, there are three peaks in the range from 4GHz to 12GHz. In this letter, the peaks of the input resistance are defined as the resonant frequency. The vicinity of the third resonance frequency especially is paid to attention because the directivity at θ = 0° in the vicinity of the third resonance frequency is deteriorated [6].

Figure 3 shows the calculated directivity at θ = 0° of the antennas with the slits in the upper patch or the lower patch. Figure 4 shows the calculated VSWR. In these figures, the calculated result of the antenna without the slits [6] is shown for comparison. The locations of the feed point of the antennas are adjusted so that the best VSWR performance is obtained for each antenna. The directivity 3dBi is improved at 10.5GHz by installing the slits in the upper patch compared with the antenna without the slits. It can be confirmed that the VSWR hardly changes when the slits are installed in the upper patch. On the other hand the both VSWR and gain of the antenna with the slits in the lower patch are deteriorated significantly.

Figure 5 shows the calculated directivity at θ = 0° of the antenna with the slits in the upper patch for changes of the width of one shorting plate. The directivity is improved further in the vicinity of the third resonance frequency(9.8~11.1GHz) by changing the width of one shorting plate. Figure 6 shows the calculated VSWR of the antenna with the slits in the upper patch. The width of the shorting plate doesn't affect the VSWR.

Figure 7 shows the calculated radiation pattern of the electric field at 10.6GHz. Figure 7 also shows the directivities of the stacked square MSA without slits at 10.6GHz for comparison. E and H-planes are shown for $\phi = 45^{\circ}$ and 135°, respectively. It can be confirmed that the directivity at θ = 0° is improved at 10.6GHz by installing the slits in the upper patch and changing the width of shorting plate.

4. Conclusion

In this paper, the wideband stacked square microstrip antenna with slits has been proposed. The directivity at the around third resonant frequency was improved by installing the slits in the upper patch and changing the width of shorting plates. It will be necessary to investigate the geometry of the slits and the width of the shorting plate in more detail so as to improve the directivity further.

References

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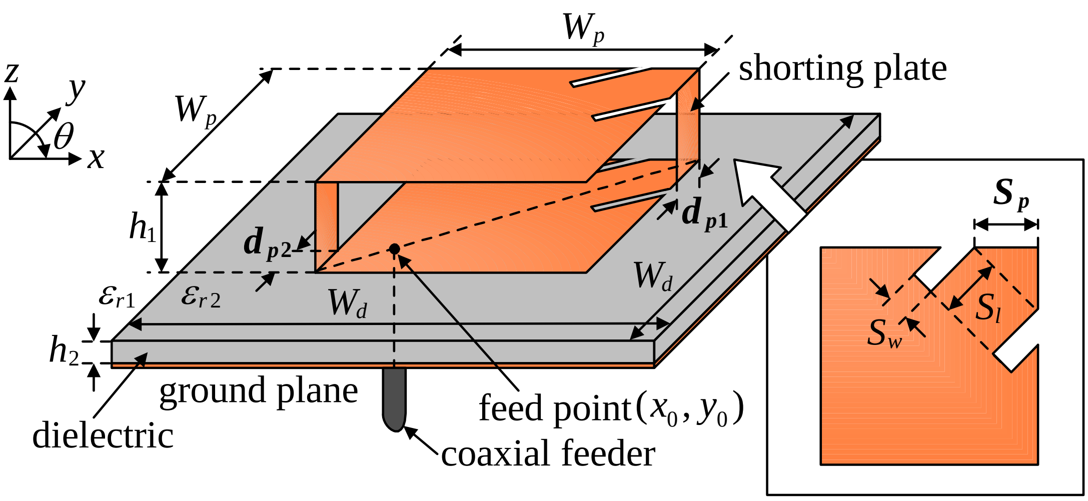

Figure 1: Wideband Stacked Square Microstrip Antenna with Slits

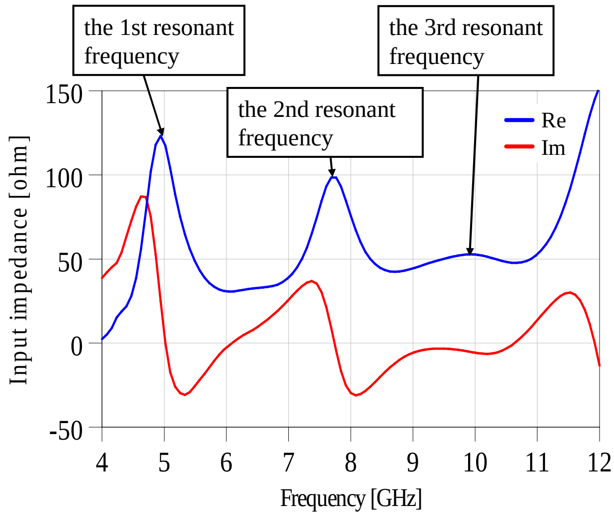

Figure 2: Input impedance $(S_l = 5.65\text{mm},\ S_w = 1.41\text{mm},\ S_p = 3.0\text{mm},\ d_{p1} = d_{p2} = 2.0\text{mm})$

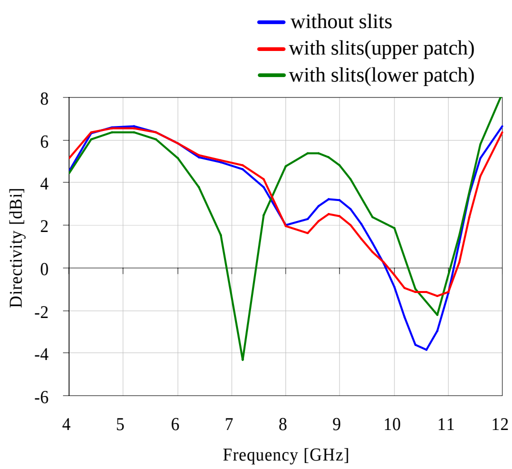

Figure 3: Directivity ($\theta = 0°$, $S_l = 5.65\text{mm}$, $S_w = 1.41\text{mm}$, $S_p = 3.0\text{mm}$, $d_{p1} = d_{p2} = 2.0\text{mm}$)

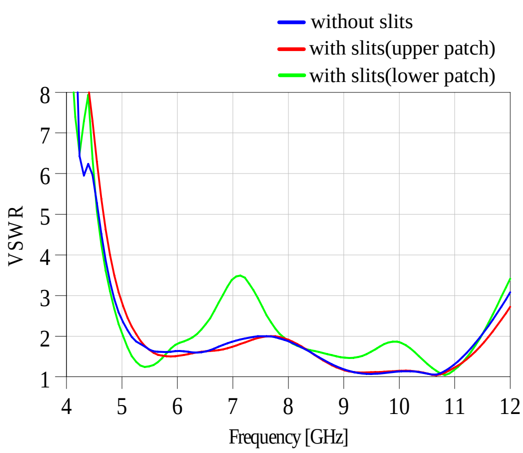

Figure 4: VSWR ($S_l = 5.65\text{mm}$, $S_w = 1.41\text{mm}$, $S_p = 3.0\text{mm}$, $d_{p1} = d_{p2} = 2.0\text{mm}$)

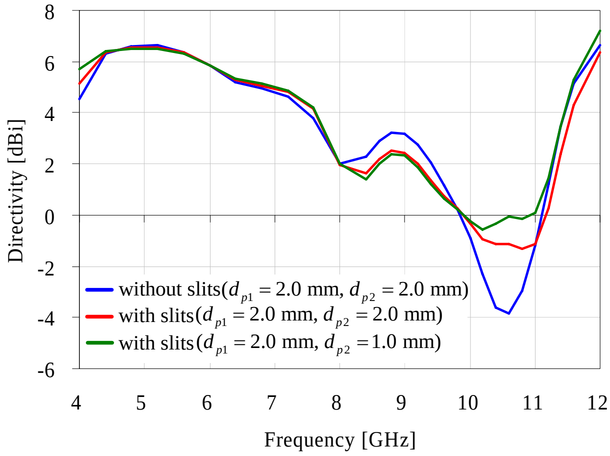

Figure 5: Directivity $(\theta = 0°,\ S_l = 5.65\text{mm},\ S_w = 1.41\text{mm},\ S_p = 3.0\text{mm})$

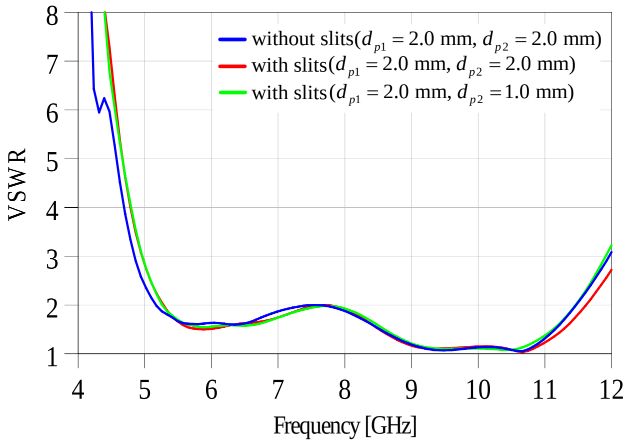

Figure 6: VSWR $(S_l = 5.65\text{mm},\ S_w = 1.41\text{mm},\ S_p = 3.0\text{mm})$

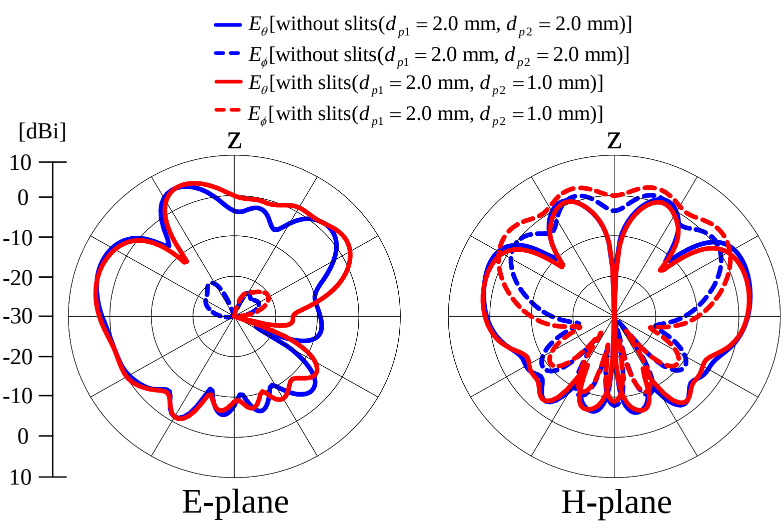

Figure 7: Calculated directivities $(10.6\text{GHz},\ S_l = 5.65\text{mm},\ S_w = 1.41\text{mm},\ S_p = 3.0\text{mm})$