Numerical Analysis of Microstrip Antenna by Using Electromagnetic Simulators

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Abstract: The probe-fed truncated square patch microstrip antenna is calculated by using WIPL-D based on the method of moment, Micro-Stripes based on TLM method and Fidelty based on FDTD method. Its input impedance and radiation characteristics are compared and discussed.

Keywords: Microstrip antenna, method of moment, WIPL-D, FDTD method. TLM method

1. Introduction

With the development of numerical analysis method, the many kind of electromagnetic simulators are used for the analysis of antennas. Authors have calculated the center-fed hollow cylindrical dipole antenna and the center-fed solid dipole antenna by using the electromagnetic simulators WIPL-D and AWAS based on the method of moment [1]. The relative error of feed point current and the root mean square error of current have been compared. As the criterion for comparison, Pocklington's integral equation for the surface current formulated from the boundary condition on the antenna surface is numerically solved. The current of this reference solution is expanded by the piecewise sinusoidal function and the function satisfying the edge condition at antenna ends.

In this paper, the probe-fed truncated square patch microstrip antenna for circular polarization is calculated by using the electromagnetic simulators WIPL-D based on the Method of Moment, Micro-Stripes based on the TLM (Transmission Line Matrix) method and Fidelity based on the FDTD method [2]-[4]. These simulators are applicable to the antenna consisting of conducting and dielectric materials with finite size. The input impedance and the radiation characteristics of the antenna are calculated and compared with the measured data.

2. Analytical model and numerical calculation

Figure 1 shows the probe-fed truncated square patch microstrip antenna for circular polarization (MSA-3) [5]. The thickness, the relative dielectric constant and loss tangent of dielectric substrate are 1.2 mm, 2.6 and 0.0018, respectively. The thickness of patch conductor is 0.035 mm.

In the numerical calculation by WIPL-D, the patch conductor is modeled as the rectangular parallelepiped with thickness 0.035 mm. Figure 2 shows the geometrical model of microstrip antenna. The total number of unknown electric current and magnetic currents are 1,092 and 288, respectively.

In the numerical calculation by Micro-Stripes and Fidelity, the calculation region is set as 120 mm by 120 mm (x and y direction) by 60 mm (z direction). The minimum cell size in the calculation by Micro-Stripes is 0.1 mm in x and y direction and 0.035 mm in z direction. The maximum cell size is 3 mm in x and y direction and 3.12 mm in z direction. The minimum cell size 0.1 mm in x and y direction is 1/600 wavelength at the center frequency 5 GHz. In the numerical calculation by Fidelity, the minimum and maximum cell size are

0.1 mm and 1 mm in all directions, respectively.

3. Numerical results and discussion

Figure 3 shows the return loss characteristics calculated by Micro-Stripes for different minimum cell sizes. The return loss characteristics converges when the minimum cell size is less than 0.25mm, that is, 1/200 wavelength at the center frequency 5 GHz. Figure 4 shows the return loss characteristics calculated by Fidelity for different minimum cell sizes. The calculated result does not converge when the minimum cell size becomes small to 0.1 mm, that is, 1/600 wavelength.

Figure 5 shows the comparison of input impedance calculated by WIPL-D, Micro-Stripes and Fidelity and measured result. In the figures, the calculated result by IE3D based on the method of moment is also shown for the comparison [5]. In the calculation by IE3D, the infinite dielectric substrate is assumed. The resonant frequency calculated by WIPL-D agrees well with that by IE3D and measured result.

Figure 6 show the electric field radiation patterns calculated by WIPL-D, Micro-Stripes and Fidelity, respectively. The radiation patterns are calculated at the center frequency of circular polarization. The calculated directivities at the circular polarization are 8.04 dBi (WIPL-D), 7.875 dBi (Micro-Stripes) and 7.906 dBi (Fidelity). On the other hand, the calculated directivity by IE3D is 6.33 dBi. The diffrence of directivity is due to the difference of size of dielectric substrate. Figure 7 shows the frequency characteristics of axial ratio. The axial ratio calculated by WIPL-D agrees well with that by IE3D.

4. Conclusion

The probe-fed truncated square patch microstrip antenna for circular polarization is calculated by using WIPL-D, Micro-Stripes and Fidelity. The calculated results by using Micro-Stripes and Fidelity agree well with the calculated result by WIPL-D and the measured result when the minimum cell size is 1/600 wavelength in the center frequency. This is much smaller than the minimum cell size in the ordinary antenna analysis.

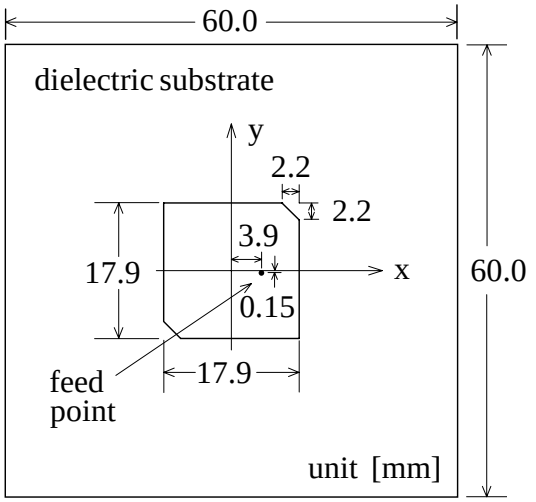

Figure 1 Probe-fed truncated square patch microstrip antenna for circular polarization.

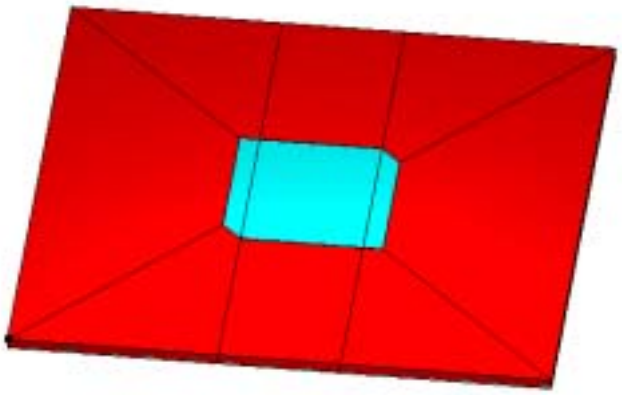

Figure 2 Geometrical model of microstrip antenna in analysis by WIPL-D.

References

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[5] M. Taguchi, H. Morishita, M. Hirose and M. Haneishi: "Analysis of rectangular microstrip antenna for circular polarization by using electromagnetic simulators", Technical Report of IEICE, AP2001-185, Jan. 2002 (*in Japanese*).

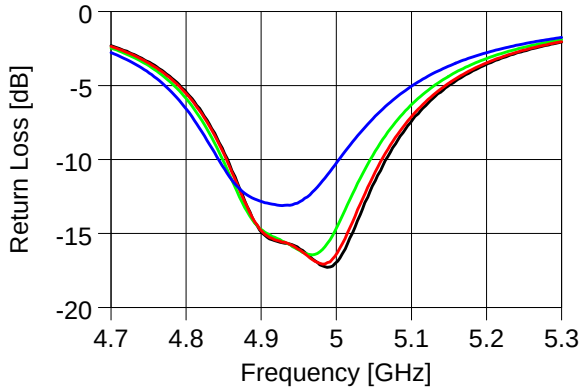


Figure 3 Return loss characteristics calculated by Micro-Stripes.

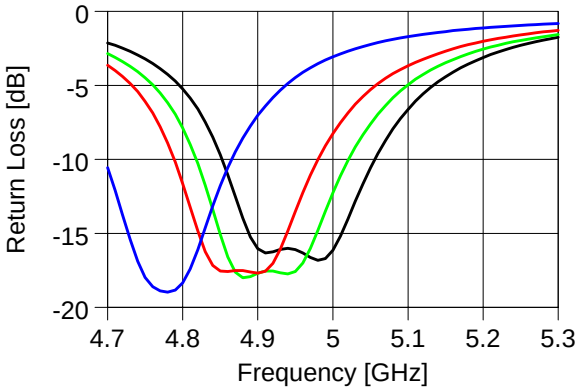
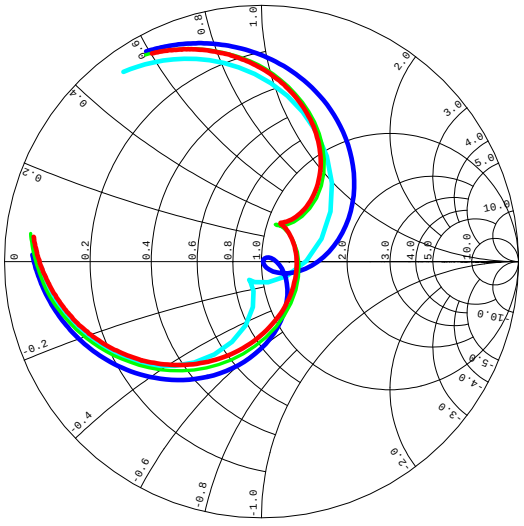
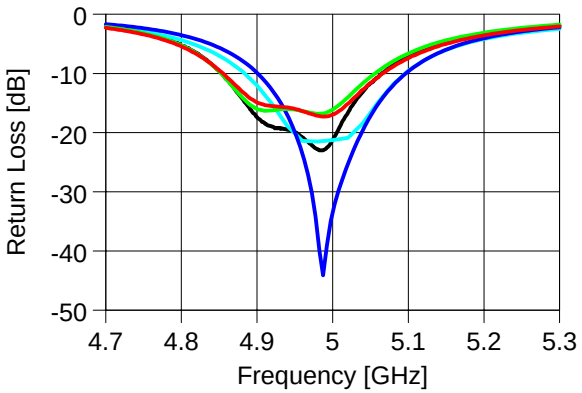


Figure 4 Return loss characteristics calculated by Fidelity.

Minimum cell size — 0.425 mm — 0.25 mm — 0.157 mm — 0.1 mm



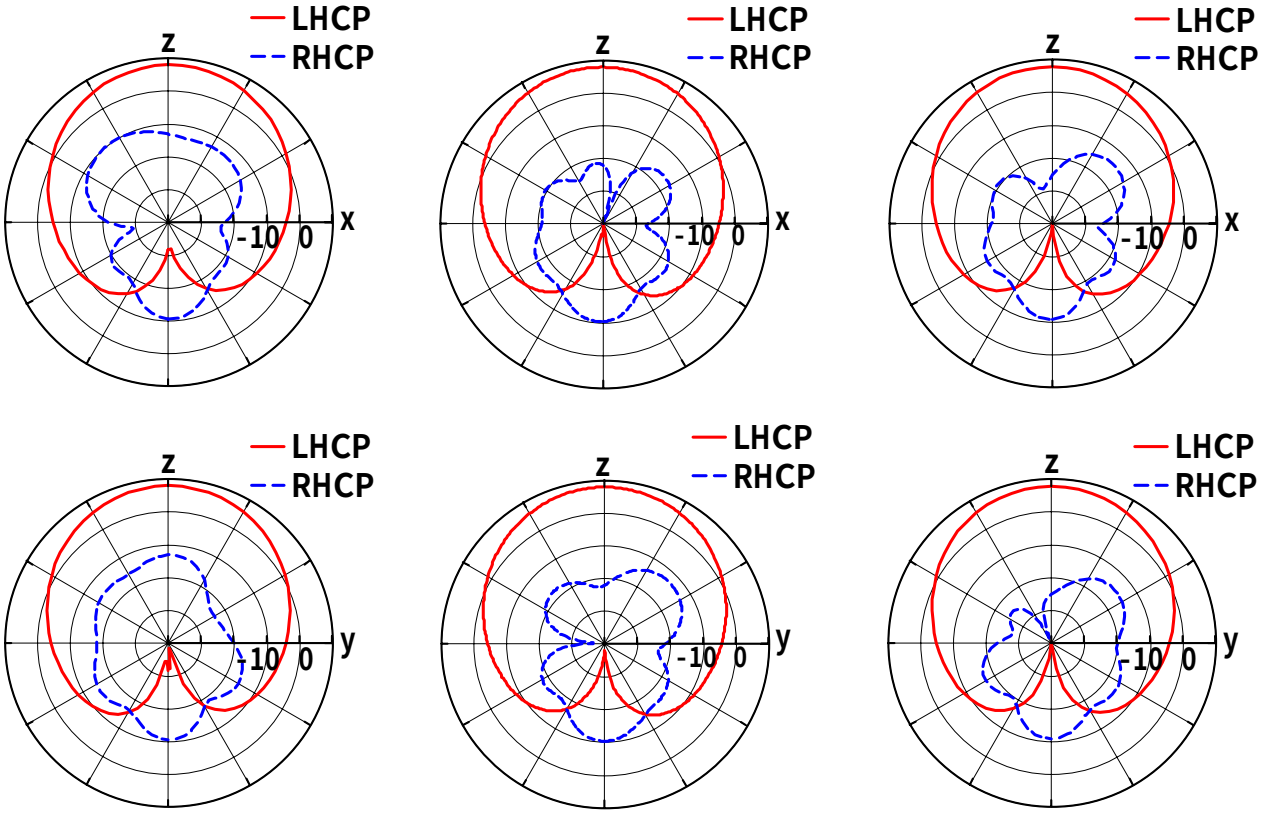
(a) Smith chart



(b) Return loss characteristics

WIPL-D — IE3D — measured
Micro-Stripes — Fidelity

Figure 5 Input impedance characteristics



(a) WIPL-D (4.994 GHz) (b) Micro-Stripes (4.92GHz) (c) Fidelity (4.92 GHz)

Figure 6 Calculated electric field radiation patterns.

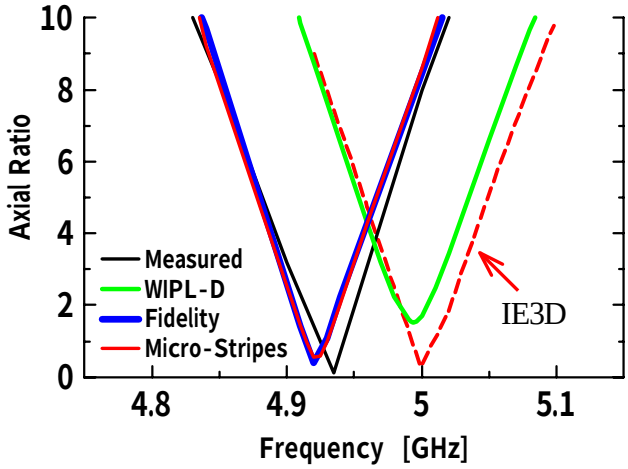


Figure 7 Calculated axial ratio.

