Shorted Rectangular Microstrip Antenna on Dielectric Chip for 5.2 GHz Wireless LAN

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Introduction

The authors were reported on the rectangular patch microstrip antenna printed on the parallelepiped dielectric chip for the Bluetooth system from from 2400 MHz to 2483.5 MHz [1]. This antenna is excited by the monopole antenna printed on the sidewall of dielectric chip. The relative permittivity of chip is 37. Since the size of dielectric chip is 12mm by 12 mm by 4 mm, this antenna is compact.

In this paper, the shorted rectangular patch microstrip antenna printed on the parallelepiped dielectric chip for the wireless LAN is numerically and experimentally analyzed. This antenna is electromagnetically coupled and excited by the three monopole antennas composed of through holes within the chip.

In the numerical analysis, the electromagnetic simulator "Fidelity" based on FDTD method is used [2].

Analytical model

Figure 1(a) and (b) show the structure of shorted rectangular patch microstrip antenna on the rectangular parallelepiped dielectric chip. The patch microstrip antenna is short-circuited at the opposite side to the feed point. The dielectric chip of 8 mm by 6 mm by 2 mm is located on the lower dielectric substrate of 20 mm by 48 mm in dimensions. The dielectric chip antenna is excited by three monopole antennas connected to the microstrip line on the lower substrate. The relative permittivity of upper dielectric chip is $\varepsilon_{r1} = 4.4$ and that of lower one is $\varepsilon_{r2} = 3.9$. In the practical application, the transceiver circuit is located close to the antenna on the lower dielectric substrate.

In the numerical analysis with FDTD method, the perfectly matched layer of six-layer and fourth-order is used as the absorbing boundary condition. The space steps are from 0.1 mm to 1 mm (non-uniform mesh). The time step is 1.83×10^{-13} sec. The calculation region is 80 mm by 60 mm by 60 mm in dimensions. In the analysis, the existence of the transceiver circuit is not considered.

Numerical and measured results and Discussion

Figure 2 shows the calculated return loss characteristics for different length of patch conductor L. Figure 3 shows the calculated and measured return loss characteristics for L = 6 mm. In the measurement, the size of lower dielectric substrate is 40 mm by 47 mm. The calculated resonant frequency is lower than the measured one. Since, in general, the calculated resonant frequency by FDTD method becomes lower than the measured one, the difference between the calculated and measured resonant frequencies seems to be acceptable [3]. Figure 4 show the calculated electric field radiation patterns at the resonant frequency 5.17 GHz. The

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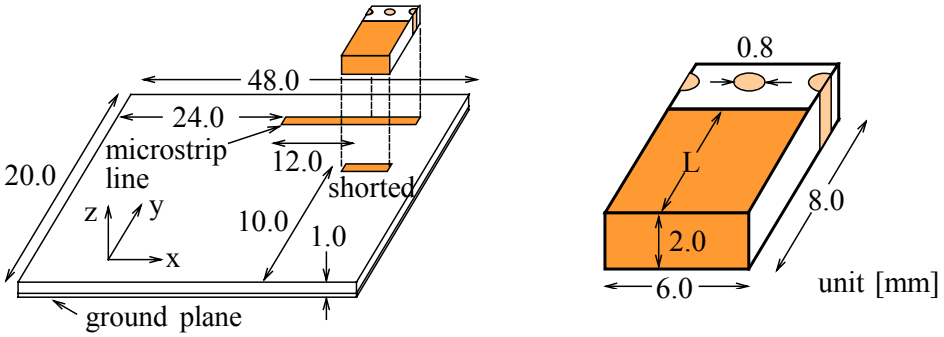

(a) Structure of chip and lower dielectric substrata (b) Enlargement of chip

Figure 1 Shorted rectangular microstrip antenna on chip.

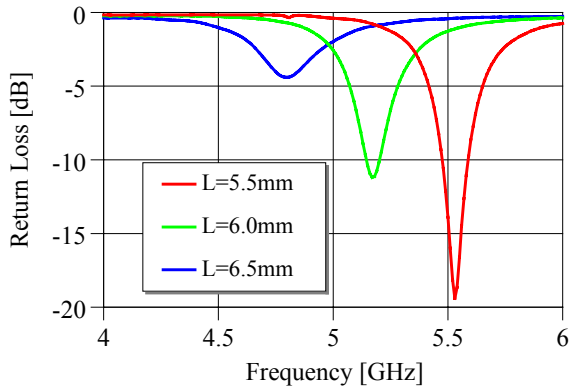

Figure 2 Calculated return loss characteristics.

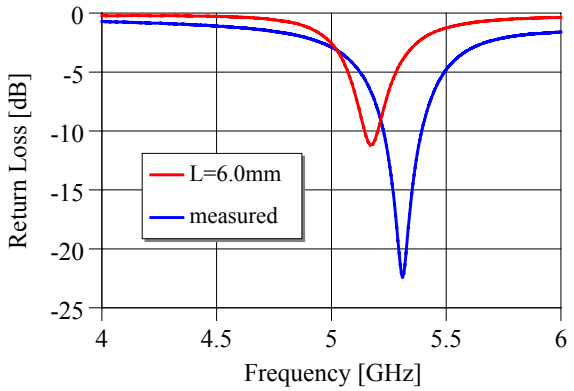

Figure 3 Comparison of calculated and measured return loss.

directivity of this antenna is 3.4 dBi at the resonant frequency. For comparison, the probe-fed shorted rectangular microstrip antenna is also calculated. Figure 5 shows the structure of probe-fed shorted microstrip antenna on the dielectric chip. The size of patch is same as one of dielectric chip. Figure 6 shows the calculated return loss of this antenna. From Figures 2 and 6, the antenna electromagnetically excited by three monopoles is smaller than the shorted

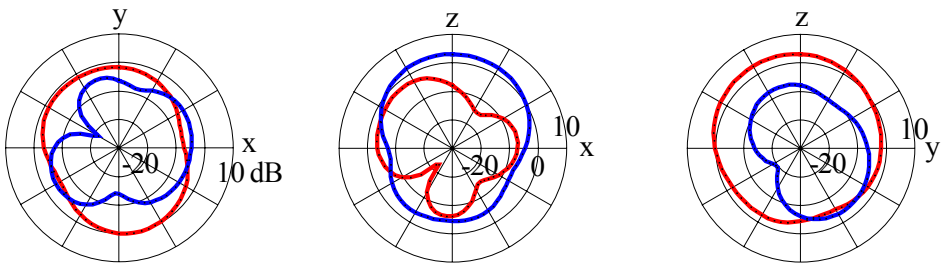

Figure 4 Calculated radiation patterns. L = 6 mm, 5.17 GHz

E_θ E_ϕ

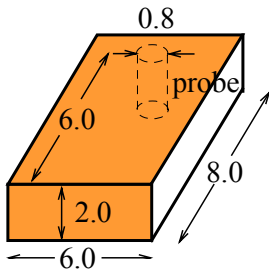

Figure 5 Shorted microstrip antenna

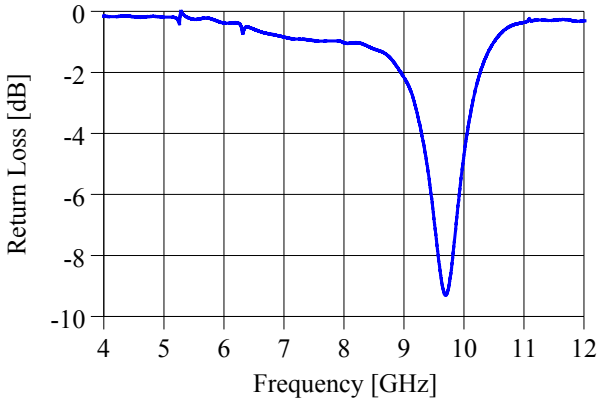

Figure 6 Return loss characteristics of shorted microstrip antenna

rectangular patch microstrip antenna on the dielectric chip with same size. Figure 7 show the electric field distribution on the surface of the chip antenna drawn in Figure 1. Figure 8 shows the electric field distribution within the yz-plane including the central monopole antenna. Between the monopole antennas and the patch end, the electric field is excited strongly. Therefore the size of proposed antenna becomes compact.

Conclusion

The shorted rectangular microstrip antenna on the dielectric chip for the wireless LAN has been analyzed by using the electromagnetic simulator "Fidelity" based on FDTD method. This antenna is electromagnetically excited by the three monopole antennas mounted on the microstrip line on the lower dielectric substrate. This antenna is very small compared with the probe-fed shorted rectangular microstrip antenna.

References

[1] M. Taguchi , R. Nakamura, H. Shimoda and K. Tanaka, "Rectangular microstrip antenna excited by monopole antenna on finite dielectric substrate", Proc. of 2002 Interim International Symposium on Antennas and Propagation, 2A2-2, Nov. 2002.

[2] "Fidelity User's manual", Zeland Software, Inc., April 2000.

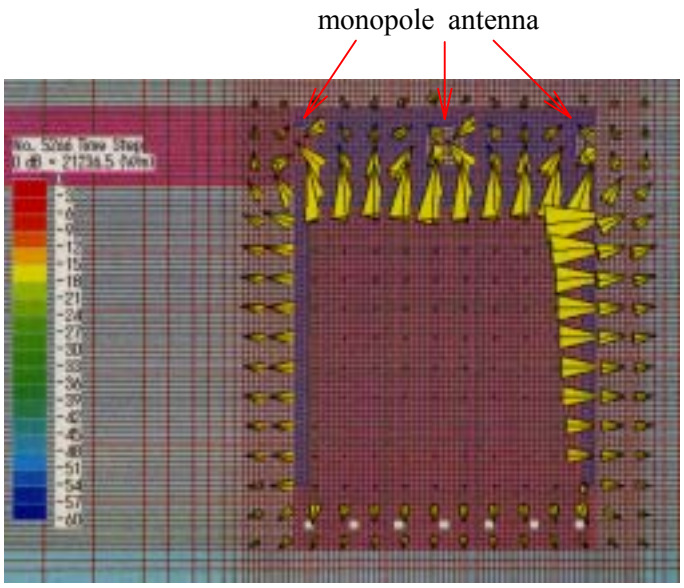

Figure 7 Electric field distribution on surface of chip.
L = 6 mm, frequency = 5.17 GHz

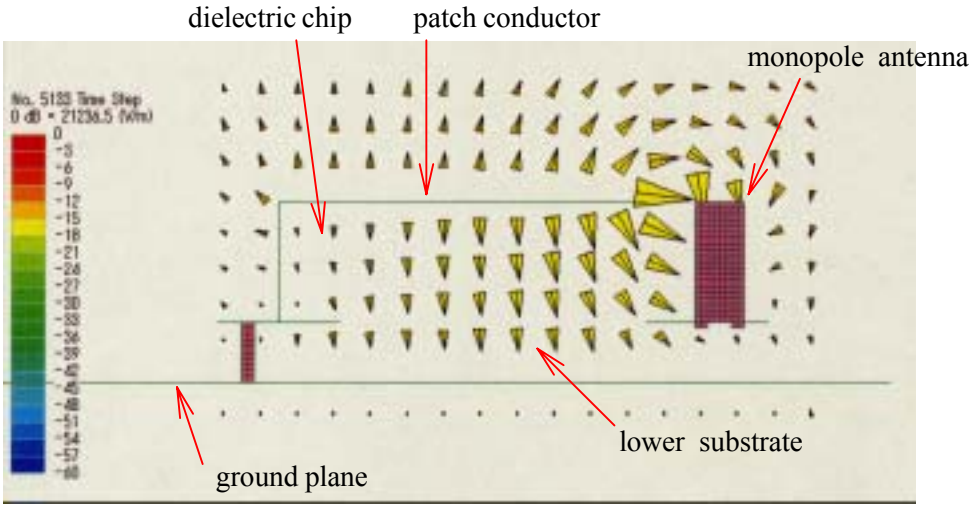

Figure 8 Electric field distribution in vertical plane including central monopole.
L = 6 mm, frequency = 5.17 GHz

[3] M. Taguchi, K. Ichikawa and K. Tanaka, "Numerical analysis of microstrip antenna by using electromagnetic simulators", Proc. of 19th Annual Review of Progress in Applied Computational Electromagnetics, April 2004 (to be published).