Design of a Planer Antenna Cover for Optimal Antenna Characteristics

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Abstract

For the protection of antenna elements and other design reasons, an antenna generally has a cover which is made of resin. However, the characteristics of an antenna are influenced by different kinds of resin, the design of the antenna cover, and the location of antenna elements and cover. In this paper, we investigate the influence on antenna characteristics by a cover and propose a design of a planer antenna cover for optimal antenna characteristics.

1. Introduction

Antennas can be divided into two categories: outdoor and indoor. Outdoor antennas, which are usually large due to the fact they are often array antennas, have a strong radome for protection against ultraviolet rays, wind and rain for long-term use. Indoor antennas, on the other hand, need a good design for both durability and installation in a conspicuous place. The influence of a cylindrical radome, which is normally used in outdoor antennas, has been investigated before using the FDTD method[1], [2].

In this paper, for the ease of experimentation, we study the design of a planer antenna cover for indoor use in the 5 GHz band. To simulate the antenna performance, we use the electromagnetic simulator MW-STUDIO (CST). This paper proposes a design of a planer antenna cover for optimal antenna characteristics, and compares the effect of the proposed cover design on a prototype antenna.

2. Antenna Model and Measurement Result

Figure 1 shows the geometry of a circular microstrip patch antenna with a parasitic element. The circular microstrip patch antenna has a diameter of 18 mm printed on a dielectric substrate 1.0 mm thick and 60 mm diameter with a relative permittivity of 3.47. This patch antenna is fed by 50Ω microstrip line. There is a circular parasitic element of 25 mm diameter and 4.5 mm above the patch antenna for the purpose of obtaining wider input impedance characteristics. This parasitic element is 0.5 mm thick and made of chalcopyrite plate.

To confirm the confidence of the simulation, we compare the results of the simulation with actual measurement data, as shown in Fig. 2.

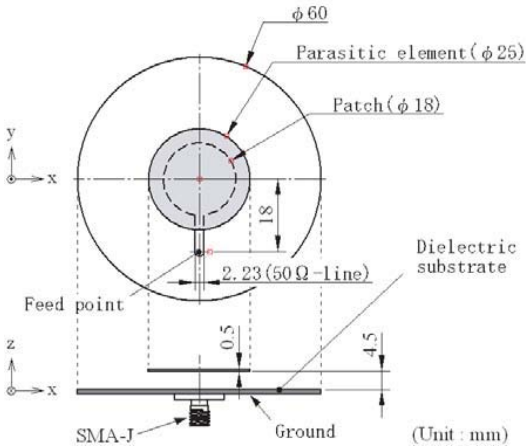

Fig. 1: Geometry of a circular microstrip patch antenna.

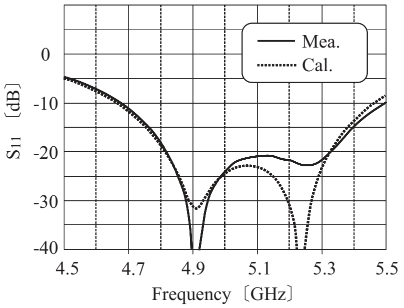

Fig. 2: Comparison of the measured and the calculated data for the S_{11}.

For the bandwidth in which the $S_{11} \leq -13.97$ dB (VSWR≤ 1.5), there is agreement between the measured data and simulation results.

3. Influence of the Antenna Cover

We simulate the antenna characteristics in order to confirm the behavior of the antenna characteristics when the structural parameters of a basic antenna cover design are varied, as shown in Fig. 3, where the relative permittivity of the cover is ϵ_r, the distance between the patch antenna and the inner-wall of the cover is Dco, the thickness of the top of the cover is

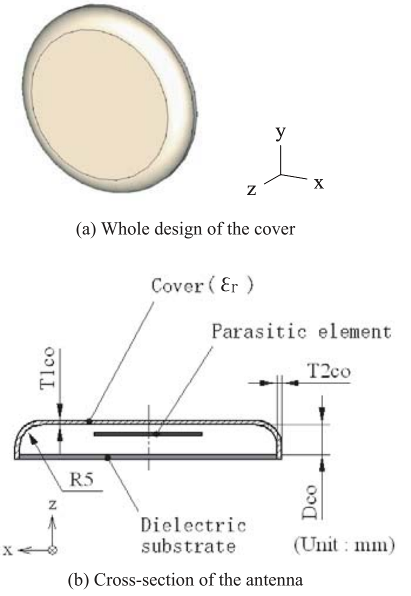

Fig. 3: Basic structure of antenna cover.

$T1co$ and the thickness of side-wall of the cover is $T2co$. The fillet on the inside of the cover is 5.0 mm fixed.

Figure 4 shows the S_{11} characteristics when the structural parameters of a basic antenna cover design are varied.

The S_{11} characteristics are shown in Fig. 4 (a) when the relative permittivity ϵ_r is varied. It can also be recognized that the S_{11} characteristics become worse when ϵ_r is increased.

Figure 4 (b) shows the S_{11} characteristics when the Dco is varied. It can be observed from Fig. 4 (b) that the S_{11} characteristics are improved when Dco is increased, and that the S_{11} characteristics between Dco = 9 mm and 11 mm do not change that much for the bandwidth in which the S_{11} ≤ -13.97 dB (VSWR$\leq$ 1.5).

The S_{11} characteristics are shown in Fig. 4 (c) and Fig. 4 (d) when the thickness either $T1co$ or $T2co$ is varied. It can be observed from these figure that $T1co$ influences the S_{11} characteristics while $T2co$ does not.

It can be observed from Fig. 4 (a), Fig. 4 (b) and Fig. 4 (c) that the S_{11} characteristics are worse with the cover than without the cover. In particular, the bandwidth is narrower because the curve of the high frequency region becomes worse.

4. Optimal design of the antenna cover

It can be recognized from section three that the influence of the cover is smaller when the relative permittivity of the cover (ϵ_r) is decreased, the distance between the patch antenna and the inner-wall cover (Dco) is large, and the thickness of the top of the cover ($T1co$) is thinner. However, because the cover with a thickness ($T1co$) of 0.5 mm is too fragile, we decide to design the antenna cover with the parameters indicated below.

Model-A:

- ϵ_r = 2.8
- Dco =7mm
- $T1co$ = $T2co$ =1.5mm

A. E-field distribution around the patch antenna

To prove the optimization of the antenna cover design, we confirm the E-field distribution around the patch antenna, as shown in Fig. 5. It is well known and can be observed from Fig. 5 that the E-field is strong at the edge of the parasitic element along the y-axis. Thus, for optimal antenna characteristics, we should make the cover thinner around the strong E-field region.

B. Design of the proposed cover

Figure 6 shows the process of the optimization of the antenna cover design.

First, we consider a cover with a top thickness of 0.5 mm, as shown in Fig. 6 (a), where the diameter of the thin region is $D1co$. It can be observed from this figure that the S_{11} characteristics are improved when $D1co$ is increased, and that the S_{11} characteristics do not change for $D1co$ between 40mm and 50 mm. Due to this behavior, $D1co$ if fixed at 40 mm.

Next, because the E-field of the center region is weak, we consider the cover design with a top region 1.5 mm thick and a diameter of $D2co$, as shown in Fig. 6 (b). It can be observed from Fig. 6 (b) that the improvement in the S_{11} characteristics do not change on the condition that $D2co$ is under 20 mm. Due to this behavior, we fix the parameter $D2co$ at 20 mm.

Finally, because the E-field along the x-axis is weak, we consider a cover design with a belt-shaped top 1.5 mm thick and a width of $WBco$, as shown in Fig. 6 (c). Note that this belt also serves as a method for increasing the durability. It can be observed from Fig. 6 (c) that the S_{11} characteristics are improved little by little when $WBco$ is decreased. Therefore, the prototype antenna cover is made with a belt width of 10 mm.

C. Measurement results

Figure 7 is a photograph of the prototype antenna model with the proposed cover, and Fig. 8 shows the measurement results of the S_{11}. The proposed antenna cover is made of resin ABS which has a relative permittivity (ϵ_r) ranging from 2.44 to 3.11 (at 1 MHz) [3]. It can be observed that the S_{11} characteristics are improved for the new design versus Model-A. The measurement results of the radiation pattern are shown in Fig. 9. It can be observed from this figure that the measurement results of the prototype with a cover do not change when compared with an antenna without a cover.

5. Conclusion

This paper analyzed the influence of the design of a cover by using MW-STUDIO (CST) simulator, and proposed the optimal design of a cover. From the measurement results of the prototype antenna, the proposed design of the cover is proved to be effective in optimizing the antenna characteristics.

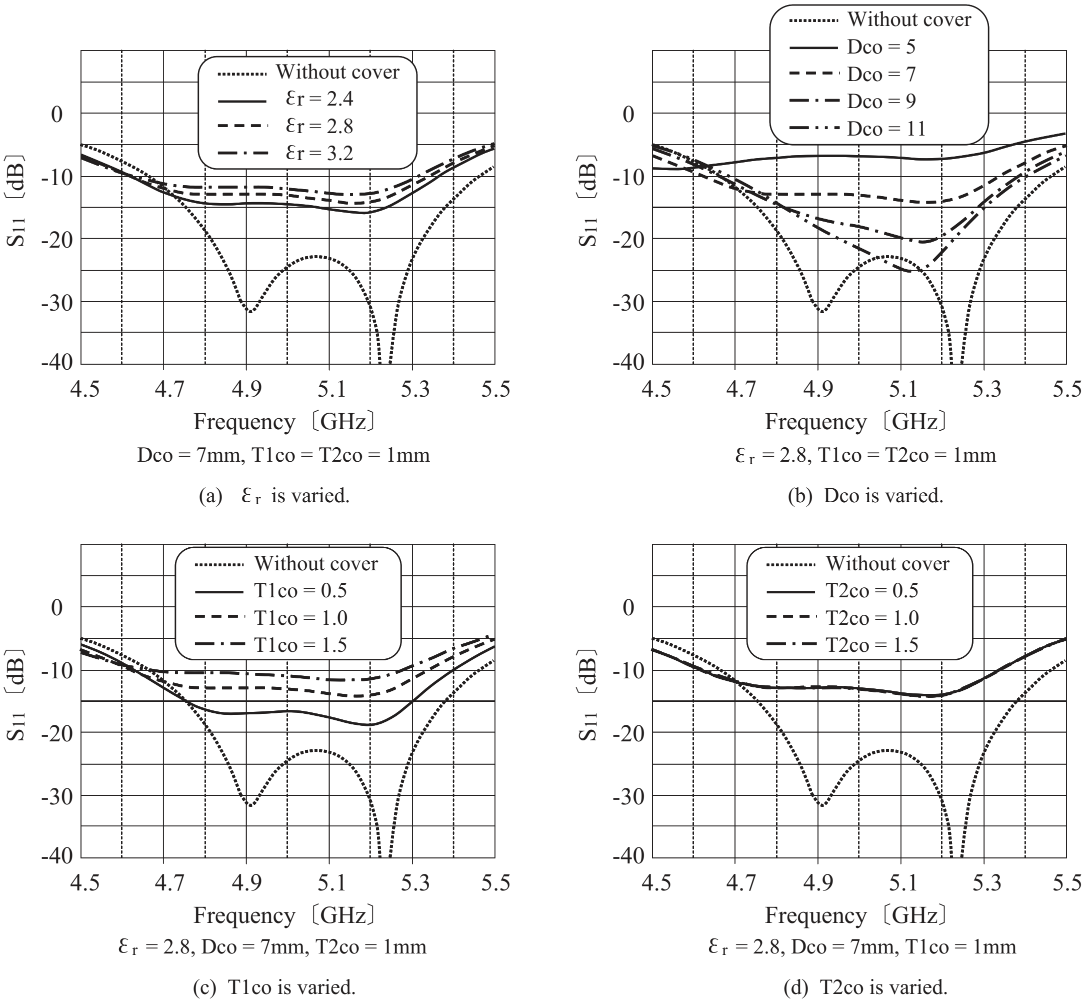

Fig. 4: S_{11} characteristics when structural parameters are varied.

ACKNOWLEDGMENTS

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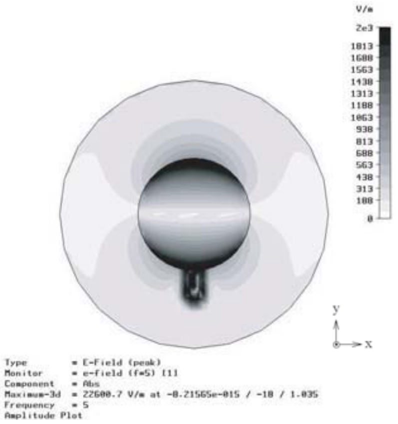


Fig. 5: E-field distribution around the patch antenna.

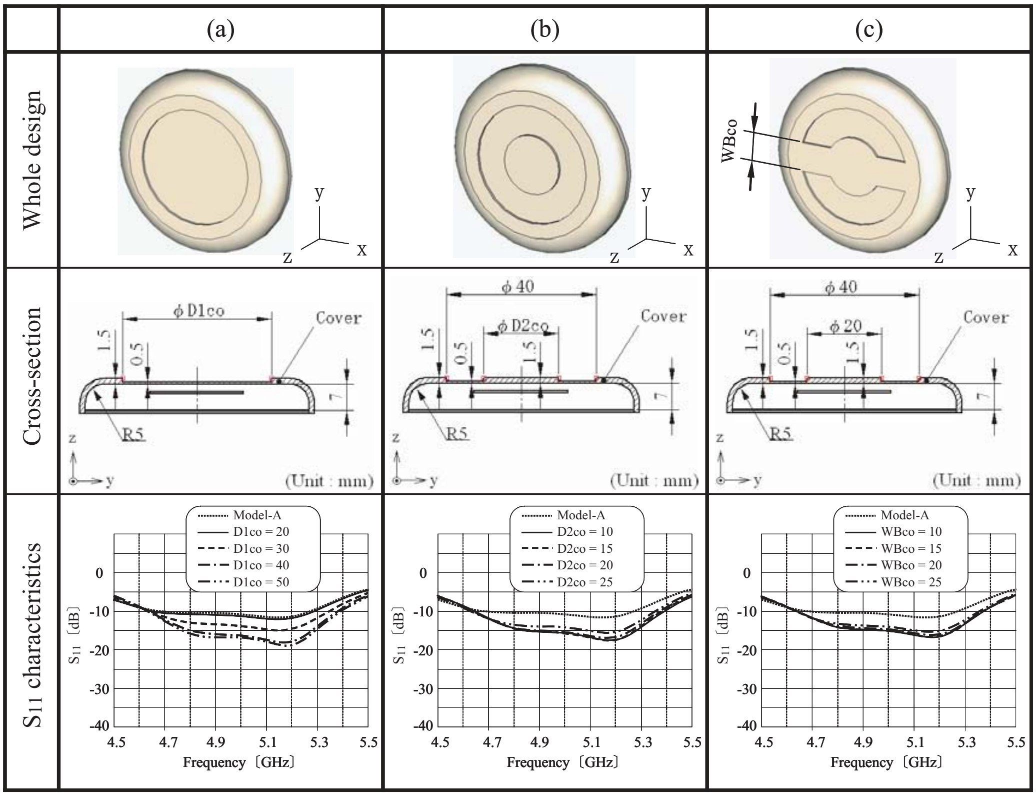


Fig. 6: Process of the optimization of the antenna cover design.

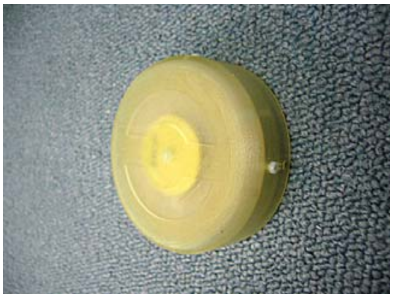


Fig. 7: Prototype antenna model with the proposed cover.

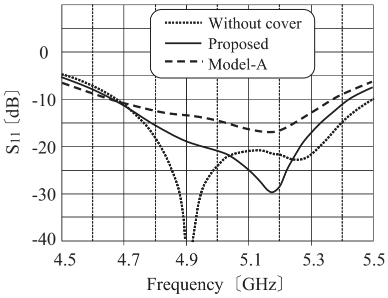
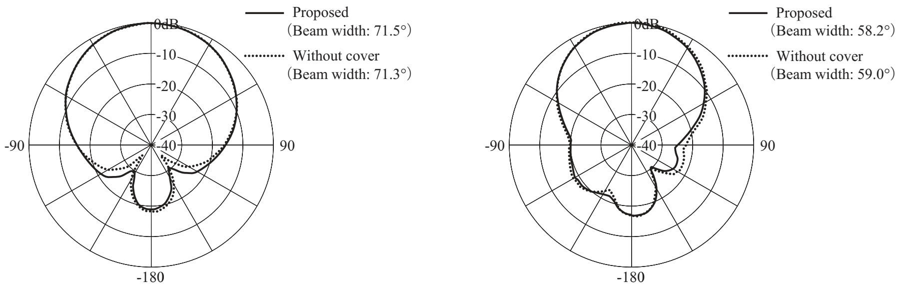


Fig. 8: Measured S_{11} characteristics with the proposed cover.



(a) H-plane pattern (zx - plane)

(b) E-plane pattern (yz - plane)

Fig. 9: Measured radiation patterns.