Research of The Indoor Reflection Wave Control with Phase Control Wall

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1. Introduction

In recent years, the uses of wireless communications technology are extending to everywhere and every scene. Almost all people are using radio frequency identification (RFID), digital terrestrial television broadcasting or wireless local-area networks (WLANs) everyday. As for television broadcasting, many countries are replacing to digital terrestrial television broadcasting. These digital television systems have the high ghost cancellation and the Doppler phase-shift compensation function.

However, because the spectacle in the house deteriorates, it is disliked to install the high gain antenna for TV on the roof. And, the demand for the technology that receives TV broadcasting only with installing an indoor small antenna is increasing. In general, because electric field strength of the TV signal in the room is slight, the performance of high gain is expected of the indoor antenna. On the other hand, low antenna gain is supplemented if the reflection wave from the wall is concentrated on the indoor small antenna. It is actually impossible to transform the wall of an existing room into the parabolic surface. .

In this paper, the effect when the reflector that can control the reflection wave phase is installed on the room wall is reported though it is a planar shape. Concretely, it is thought that the wall approximate to the parabolic surface if the phase of the reflection wave is delayed near the center of the wall. Hence, the planar phase delay element loading to room wall is proposed in this paper.

Moreover, diffusion is also possible if concentrating is possible. It is thought that the problems of an indoor microwave fading are also solvable by this technique. The following chapter explains these concepts in detail.

2. Basic concept

In case of a plane wave normal incidence to moralized room wall, the phase of reflected wave with room wall is the same anywhere. Therefore, the reflected wave is also plane wave as shown in Fig. 1(a), and the focal point is not formed. If the room wall has curved as shown in Fig. 1(b), the reflected wave's phase is different according to the reflected position. In this case, the phase delay of the reflected wave increases while approaching the centre of the wall, and focal point is formed on the normal direction of wall. It is predicted that the same effect as the curved wall is obtained, if the reflected wave phase delay on the wall is gradually increased toward centre as shown in Fig. 1(c). The frequency selective surfaces (FSS) are general as planar reflection wave phase control equipment [1]-[3]. However, it is not easy to change the phase depending on the position when FSS is used. Accordingly, it is attempted to use the patch antenna array with different resonance frequency (see Fig.2 (a)). Interaction of reflector and patch element acts as parallel LC circuit, as shown in Fig.2 (b). The parallel LC circuit behaves as inductive reactance at frequency below resonance, and behaves as capacitive reactance above the resonant frequency, as shown in Fig.2 (c). It is thought that the extension of shorted transmission line and the inductive reactance loadings to the transmission line terminal are equivalent. Moreover, it is thought that the opposite are also correct. This is equivalent to the electrical shift of the reflector. It is guessed that the reflector that forms focal point can be achieved though it is plane shape if the patch element with different shape and size is located one by one.

3. Configuration of reflected wave phase control surface

The calculation results about dependency of input reactance to the patch element's shape parameter are shown in Fig. 3. The transition of Z_{in}'s reactance only by the reflector shift is shown for the comparison. The finite difference time domain (FDTD) method is used to analyze the patch element's shape parameters [4],[5]. The analysing region is enclosed by a periodic boundary consisting of a perfect electric conductor wall and a perfect magnetic conductor wall. The FDTD cell length is 1.0 mm and the time step is 0.001926 ns. The space of the patch element and the reflector is fixed by 5 mm. In this figure, the equivalent reflection position shift distance is calculated from the comparison of equivalent reactance $\mathrm{Im}\{Z_{in}\}$ of the patch element loadings case and the non loadings case. As a result, the input reactance with patch element loadings can be approximated to positional movement of the reflector within 0.47 to 0.53 GHz.

Fig. 4 shows the size of the patch element as the function of equivalent reflection position shift distance. Fig. 5 shows the result of verifying whether the patch array designed based on the result of Fig. 4 demonstrates the requirement effect. This figure shows the reflection electric field distribution with the wall (height x width =3 m x 3 m) of patch array loading. Focusing of the reflection wave was confirmed by phase control plate though it was inferior to the actual parabolic reflector.

4. Conclusion

In this report, it was described that the reflector that forms focal point can be achieved though it is plane shape if the patch element with different shape and size is located one by one. Fixed to 5mm thickness of the patch element, the patch size were varied. In this case, it was confirmed that the input reactance with patch element loadings can be approximated to positional movement of the reflector within 0.47 to 0.53 GHz. As a future, we are going to carry out the amount of a advance expand when change the shape of the patch element.

References

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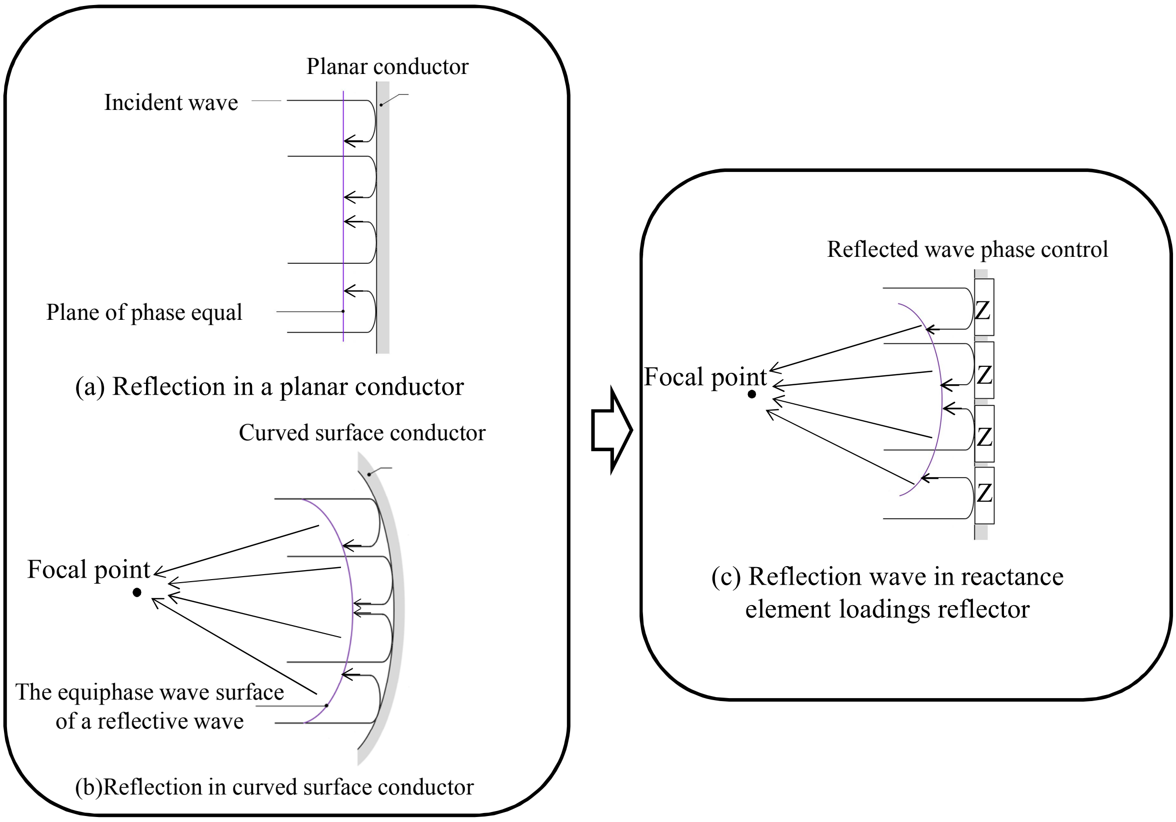
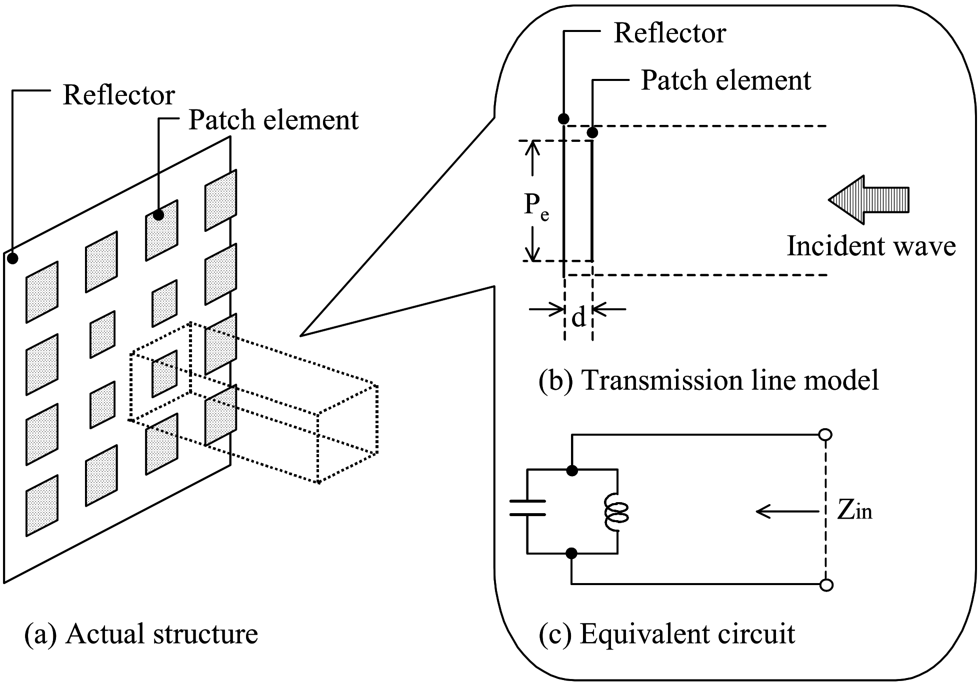


(a) Reflection in a planar conductor

(b)Reflection in curved surface conductor

(c) Reflection wave in reactance element loadings reflector

Fig.1 Basic concept of reflected wave phase control plate



(a) Actual structure

(b) Transmission line model

(c) Equivalent circuit

Fig.2 Behaviors analysis of patch element using equivalent circuits

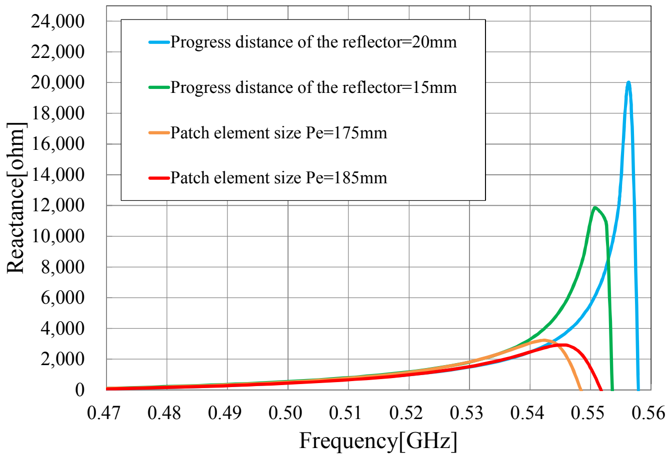


Fig.3 Comparison between the reactance transitions for case of patch element's size change and for case of reflector's position change

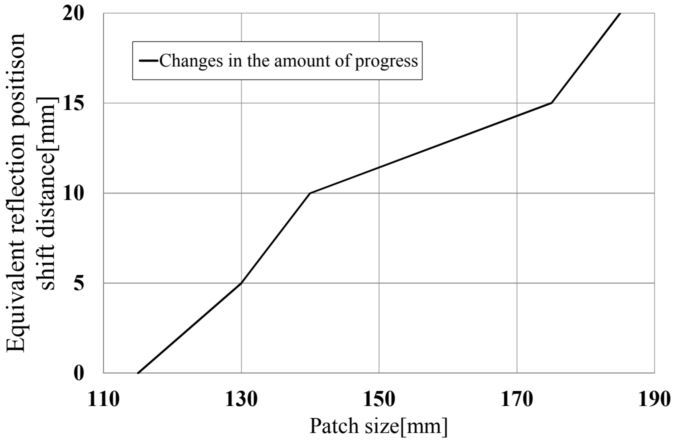
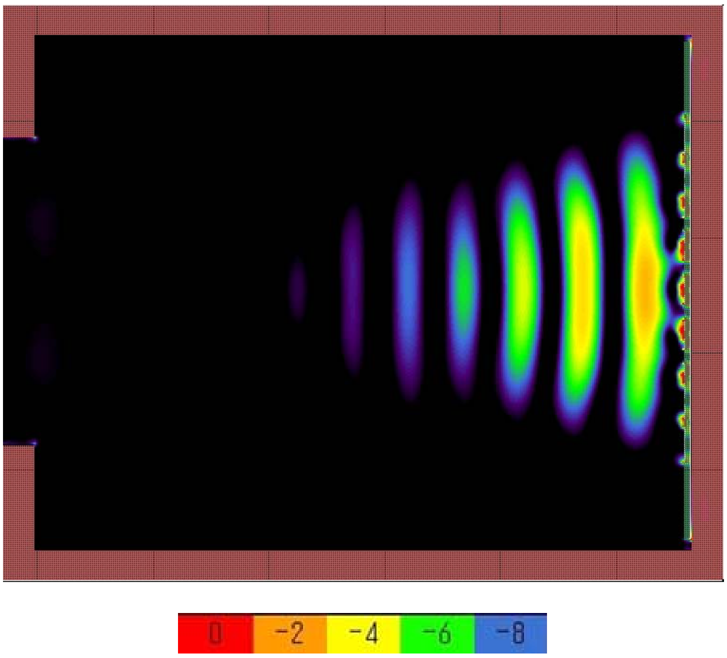


Fig.4 Equivalent reflection position shift distance as function of patch size



0dB =4.41e+000V/m

Fig.5 Reflected wave by the patch element planar array of different sizes