Evaluation of Antenna Isolation for MIMO Repeater in 800MHz Band

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Abstract

In this paper, antenna isolations for MIMO repeater system using orthogonal polarization is evaluated by the computer simulation. From the results, the isolation of the orthogonal polarization is higher than that of the co-polarization. Therefore, the MIMO repeater using orthogonal polarization technique expects to have cost effective and high performance.

Keywords： Isolation, Repeater, Polarization, MIMO

1. Introduction

In recent years, new broadband wireless systems such as WiMAX and LTE (Long Term Evolution) have been introduced. These wireless systems adopt MIMO (Multiple Input Multiple Output) technology in order to obtain higher speed data communications. In the initial stage, these systems were deployed in high traffic areas such as in the urban environment, and then expanded to include suburban areas. In the final stage, the service area will be extended to include rural areas. From the viewpoint of infrastructure costs, it is more effective to adopt repeater systems than base stations for suburban and rural areas. However, for MIMO communication, the amount of equipment needed for the repeater system is more than doubled because MIMO transmission and receiving needs more than two radio channels. Figure 1(a) and (b) show a conventional repeater and the MIMO repeater, respectively. In figure 1(a), there is a single radio echo in the downlink. On the other hand, there are 4 radio echoes for the MIMO repeater as shown in figure 1(b). In general, it is considered that the distance between the donor antenna toward the base station direction and the service antenna toward the mobile station area must be great enough to reduce the radio echoes. Additionally, the distance between the pair of donor antennas should be extended to obtain the MIMO effect by reducing the correlation coefficient of radio paths for the MIMO repeater. In the above case, the construction cost of four separate antennas is considerable. Therefore, a radio repeater for MIMO systems may appear to be less attractive in an actual working environment.

To solve the problem of higher cost for the MIMO repeater, in this paper, an orthogonal polarization technique for repeater systems is employed. An orthogonal polarization antenna can integrate two polarization antennas underneath a single radome without increasing the mutual coupling between a pair of MIMO antennas. Furthermore, the radome can be compact as shown in figure1 (c).

Conventionally, the repeater has a single vertical polarization antenna and the antenna isolation between the donor antenna and service antenna would be evaluated in the case of single vertical polarization [1][2]. In the case of orthogonal polarization for 2x2 MIMO, the isolation between the horizontal and horizontal polarizations and that between the vertical and horizontal polarizations must be taken into account for the evaluation. However, up to date, there has been no report that closely evaluates the isolation of orthogonal polarization at repeater systems based on time-domain simulation. Accordingly, in this paper, the authors report the isolation characteristics of orthogonal polarization for a MIMO repeater by performing a computer simulation.

2. Simulation Model of Antenna and Isolation Evaluation

Figure 2 shows the simulation model for evaluating the isolation between antennas of the MIMO repeater. The computer simulation is conducted using the CST Microwave Studio software [3]. The simulation mesh size is approximately from 1 million to 3 million. Figure 2(a) shows the antenna model inside the radome. This planar antenna is composed of 2x2 cross dipole array with vertical and horizontal dipole elements. The distance between cross dipoles is 300mm. The square radome has a side length of 520 mm. The donor antenna and the service antenna have the same structure. The symbol θ indicates the angle difference in the beam direction between donor and service antennas in the horizontal plane. The symbol H represents the height difference between the donor and service antennas in the vertical plane. The service antenna has a vertical tilt of 10 degrees for the service area coverage. In contrast, the donor antenna has no tilt. The horizontal distance between antennas and the center of the metallic pole is 220 mm and the diameter of the metallic pole is 160 mm. The antenna gain is approximately 13 dBi for both vertical and horizontal polarizations.

Figure 3 shows the antenna pattern with the pole. Figure 3(a) indicates the antenna beam in horizontal pattern and Figure 3(b) is the vertical pattern and angle=0 in Figure 3(b) means the direction of the horizontal plane. In these figures, solid lines represent the co-polarization and dotted lines represent the cross-polarization. f0 is set at 840 MHz, which is identical to the center frequency of the Japanese cellular 800MHz band. Here, the VSWR and the mutual coupling between the V-pol. and H-pol. of these antennas are less than 2.0 and -20 dB, respectively, between -0.97*f0 and 1.03*f0 in the frequency band. From these figures, the 3 dB beam width is approximately 35 degrees for both the V-pol. and H-pol. The XPR(=Co-pol. - X-pol.) is high at the main beam and back lobe region for both the V-pol. and H-pol. On the other hand, the XPR in the side beam direction from -120 to -60 and from 60 to 120 deg. for H-pol. in Figure3(a) is low. These high XPR are expected to improve some of the isolation characteristics between the donor and the service antennas using orthogonal polarizaion.

3. Simulation Results

Figure 4 shows the antenna isolations of V-pol. to V-pol.(VV), V-pol. to H-pol.(VH) and H-pol. to H-pol.(HH) at H=2000 and 4000mm. For example, the notation VH indicates a pair comprising the V-pol. of the donor antenna and the H-pol. of the service antenna.

For VV, the isolation varies from 59dB to 73dB at H=2000mm and from 63dB to 74dB at H=3000mm. And, the isolation performance of HH is almost flat at any angle. Namely, the isolation value fluctuates from 67 to 75 dB in the case of H=2000mm and from 72 to 84dB in the case of H=4000mm. On the other hand, the isolation in the case of VH is over 90 dB in the back-to-back region and same direction. For VH, the minimum isolation is 64 dB when θ is 120degrees at H=2000mm and it increases up to 80dB at H=4000mm.

The isolation of VH is high probably because the XPR of both the donor and service antennae is high, so a high quality orthogonal signal is maintained at an almost horizontal angle. The reason for the high isolation in the HH case is less probably because the sidelobe level of the H-pol. in the direction of 0 degree and 170 degrees(=180-10(=tilt angle)) in Figure3(b) is less than that of the V-pol.

These results show that the isolation of the MIMO repeater using orthogonal polarization is better than that of the MIMO repeater using single vertical polarization. For achieving VV isolation up to 70dB, for example, an echo canceller is useful. On the other hand, an echo canceller may not be required for VH and HH. Therefore, it is possible that a MIMO repeater using orthogonal polarization can be built at a very low cost.

4. Conclusion

In this paper, the isolation for orthogonal polarization of the MIMO repeater system was evaluated by computer simulation. The simulation results suggest that a MIMO repeater using an orthogonal polarization technique would be both cost effective and have excellent performance. In future work, other positions of the donor and service antennae and other frequencies should be evaluated.

References

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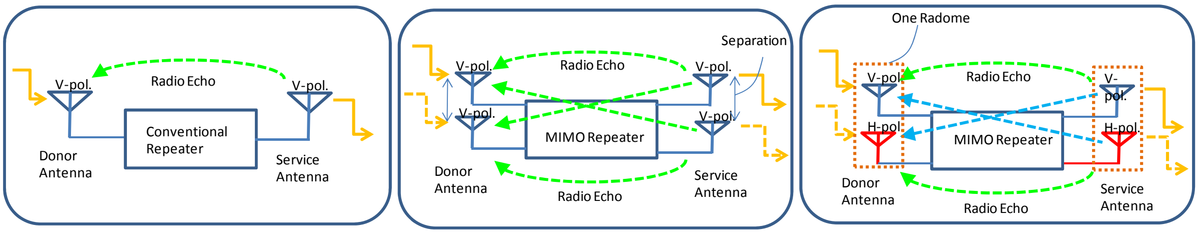
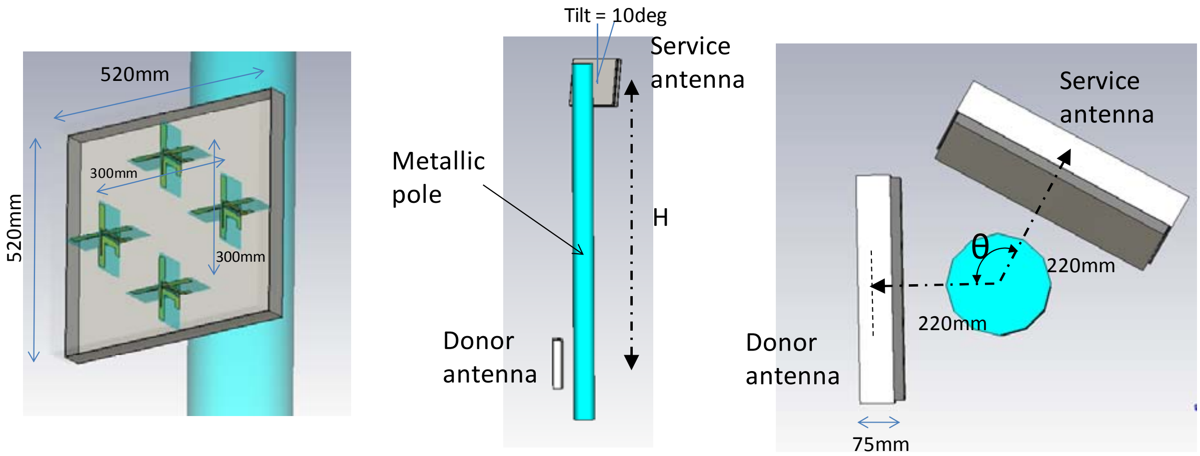


(a) Conventional Repeater (b) MIMO Repeater (c) MIMO Repeater using Orthogonal Polarization

Figure 1 Repeater system in downlink



(a) Inside view of the radome (b) Side view (c) Top view

Figure 2 Simulation model

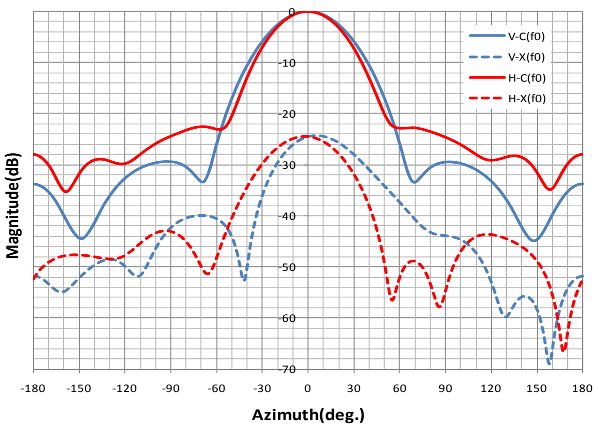


Figure 3(a) Horizontal pattern

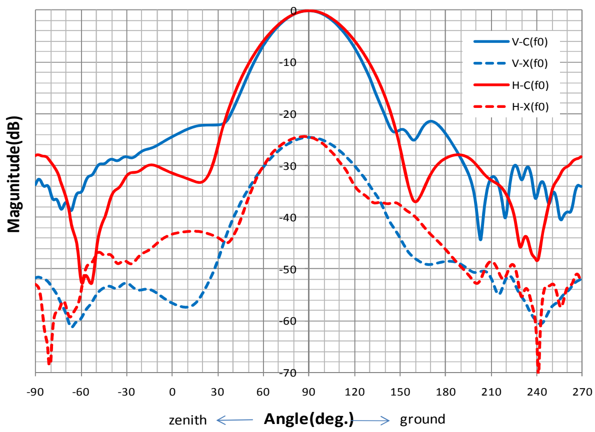


Figure 3(b) Vertical pattern

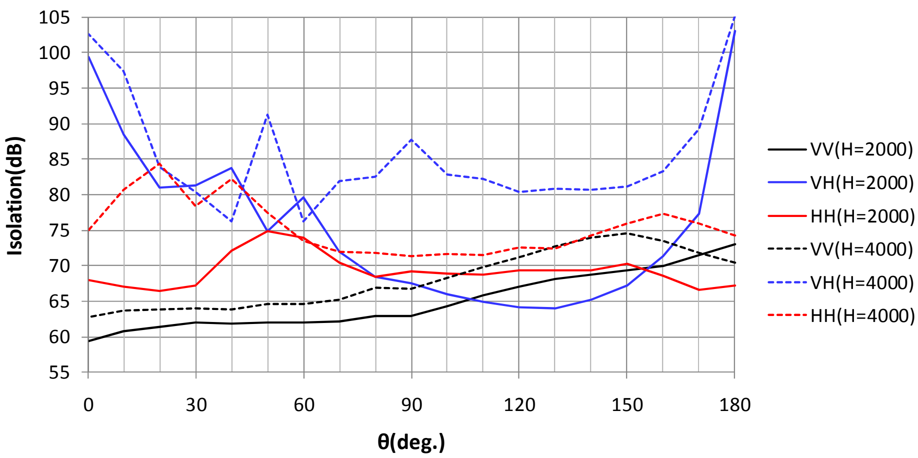


Figure 4 Antenna Isolations