Design of a Unified Indoor Repeater Antenna with High Isolation Characteristic

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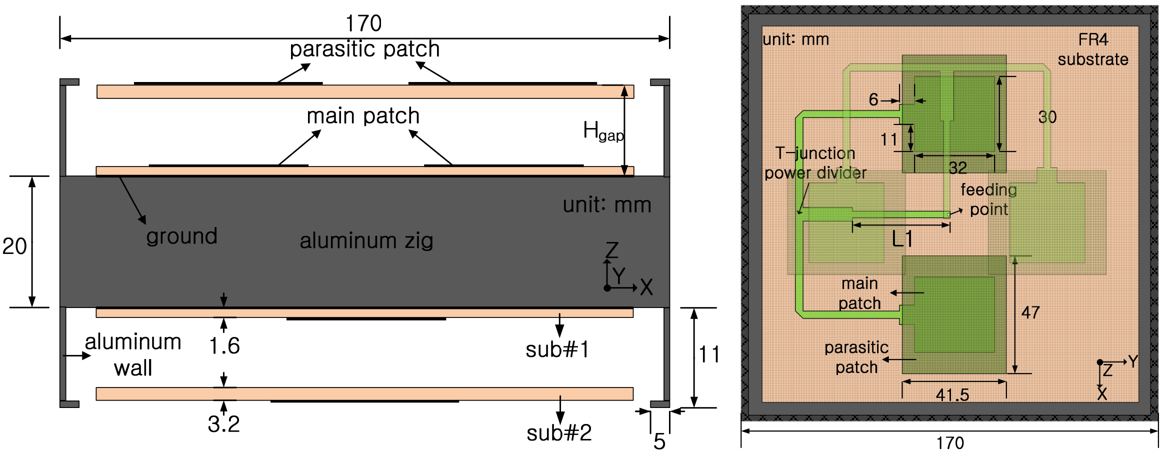
1. Introduction

Repeater antennas are often used to increase the signal strength in weak signal area or to expand the coverage in shadow region instead of installing an additional base station. However, positive feedback between donor and server antennas of a repeater could make a signal distortion. Therefore, the isolation between donor and server antennas is a critical factor in designing a repeater. Typically, the isolation should be higher than 65dB. In order to improve the isolation, increasing the physical separation between two antennas, using antennas with higher attenuation at the required direction and introducing additional shielding factor in the feedback path are commonly used[1]-[3].

In this paper, a unified indoor repeater antenna with high isolation performance is proposed. The proposed repeater antenna uses orthogonal allocation and adopts inverted-L shaped aluminium walls to obtain high isolation between donor and server antennas over the WCDMA (1.92GHz ~ 2.17GHz) band.

2. Antenna design



(a) side view (b) top view

Figure 1: The proposed repeater antenna structure

Figure 1(a) shows the side view of the proposed repeater antenna structure. The proposed repeater antenna consists of a donor antenna, a server antenna, aluminium walls, and an aluminium zig. The aluminium zig occupies the volume of 170mm x 170mm x 20mm. The donor and server antennas are installed orthogonally on opposite sides of the aluminium zig to achieve the high isolation. The inverted-L shaped aluminium walls enclose donor and server antennas in order to reduce the back radiation and improve the isolation.

Figure 1(b) shows the top view of the proposed antennas. The donor and server antennas consist of main patches, parasitic patches, a T-junction power divider, a ground plane, and two FR-4 substrates(ε_r=4.4) with different thickness. The main patches and T-junction power divider are printed on the top side of substrate#1(thickness=1.6mm). The main patches are fed by the T-junction power divider with notches. The parasitic patches are printed on the top side of substrate#2(thickness=3.2mm) which is 10mm above the ground plane.

Figure 2 shows the simulated VSWR characteristics for various gap distance (H_{gap}) between the ground plane and parasitic patches. As the gap distance is increased, the VSWR characteristic in the center frequency region is improved due to the reduced coupling between the ground and parasitic patches.

Figure 3 shows the simulated isolation characteristics between the donor and server antennas. When the two antennas are positioned orthogonally to each other, the isolation improves more than 25dB than that of parallel allocation.

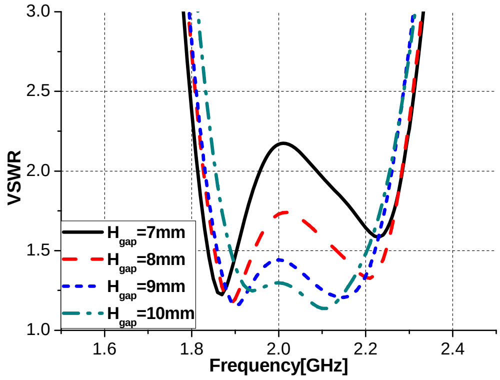


Figure 2: VSWR for various value of H_{gap}

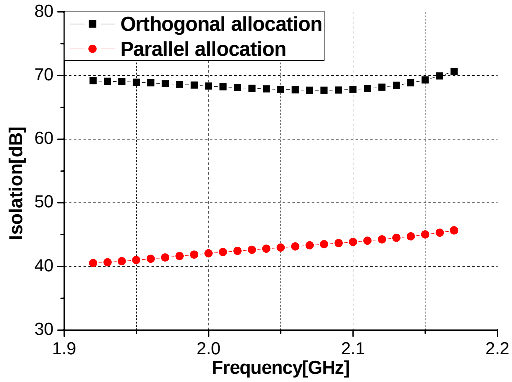


Figure 3. Isolation for different antenna allocation

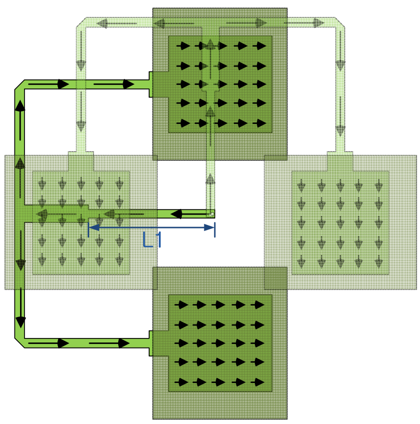


Figure 4: The direction of current flow

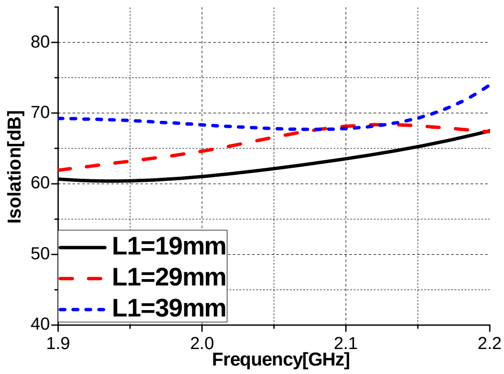
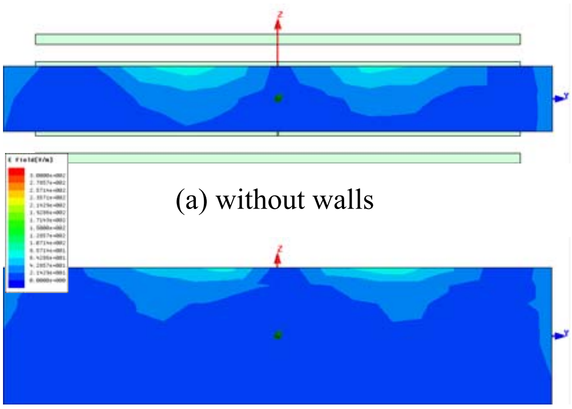


Figure 5: Isolation for variation of feed line length (L1)



(a) without walls

(b) with walls

Figure 6: Magnitude of induced E-field on the surface of zig

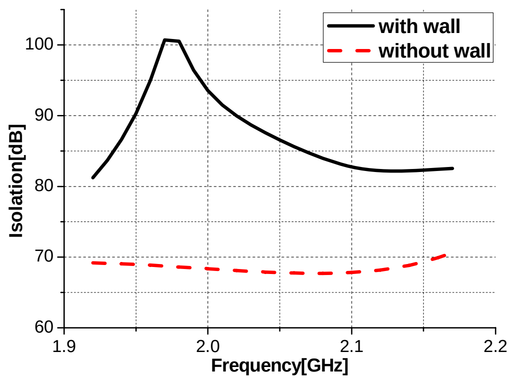
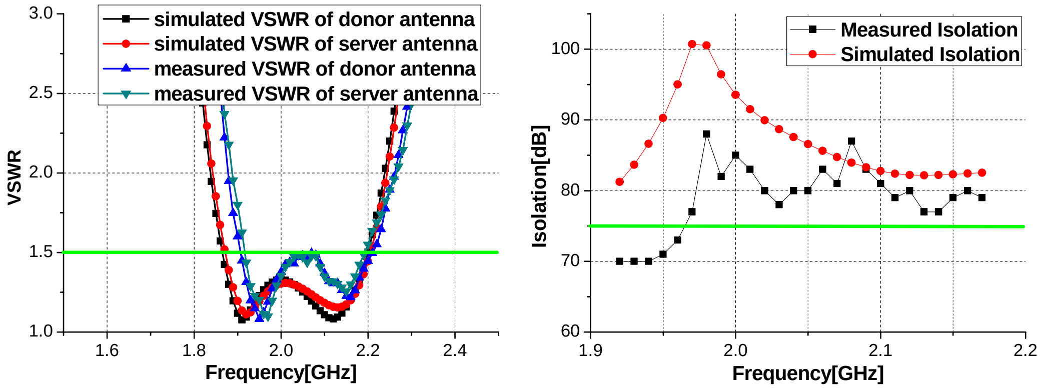


Figure 7: Isolation characteristics for with and without wall

Figure 4 shows the direction of current flow on donor and server antennas. When the length of feed line (L1) is short, the direction of current flow on the main patch is parallel to that in the feed line of other antenna and the isolation is degraded. On the other hand, when the length of feed line is long enough, the direction of current flow on the main patch is orthogonal to that in feed line of other antenna and the isolation is improved as shown in Figure 5.

Figure 6(a) shows the induced E-field on the surface of zig without walls. This back radiated field through the zig could degrade the isolation characteristic. However, when inverted-L shaped aluminium walls are added, the E-fields are concentrated on the wall and the back radiation is considerably reduced as illustrated in Figure 6(b). The isolation is improved more than 10dB by adding the inverted-L shaped aluminium walls as shown in Figure 7.

3. Results



(a) VSWR (b) Isolation

Figure 8: Simulated and measured VSWR and isolation characteristics

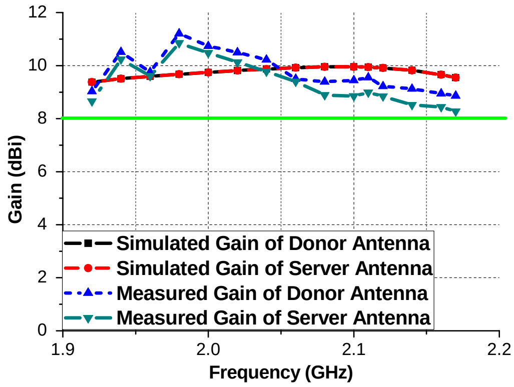


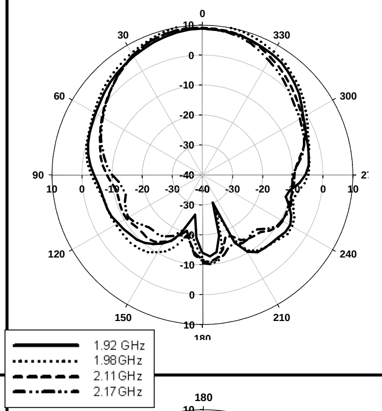
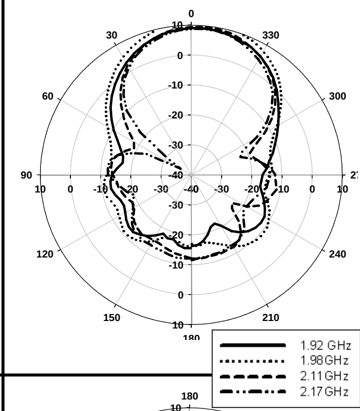
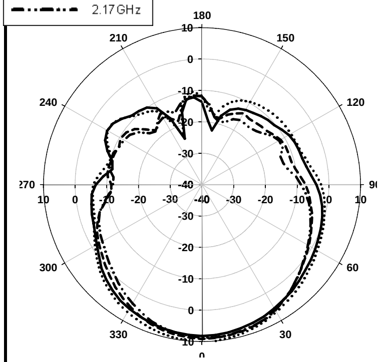
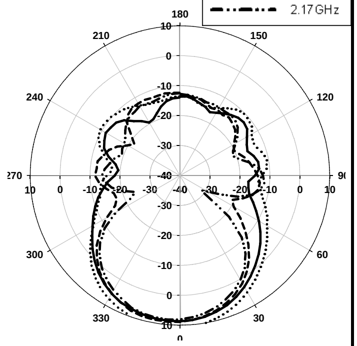
Figure 9: Simulated and measured gains

The measured and simulated VSWR characteristics of donor and server antennas are shown in Figure 8(a). The measured and simulated VSWR of two antennas are below 1.5 over the WCDMA band. The isolation between donor and server antennas is shown in Figure 8(b). Although the simulated isolation characteristic is higher than 80dB over the WCDMA band, the measured isolation characteristic is higher than 75dB over the frequency range from 1.97GHz to 2.17GHz. The difference between the simulation and measurement is caused by the manufacturing error.

Figure 9 shows the simulated and measured gains of donor and server antennas. The simulated gains are higher than 9dBi, whereas the measured gains are in the range from 8dBi to 11dBi.

The measured radiation pattern of donor and server antennas in E-plane and H-plane are listed and compared in Table 1. The average measured HPBW values of donor antenna are 57.3˚ in E-plane and 45.5˚in H-plane while those of server antenna are 57.5˚ and 46.5˚ in E- and H-plane, respectively.

Table 1: Measured radiation patterns and HPBW's

	E-plane		H-plane	
	Pattern	HPBW	Pattern	HPBW
DONOR		63˚@1.92GHz 57˚@1.98GHz 56˚@2.11GHz 53˚@2.17GHz		65˚@1.92GHz 58˚@1.98GHz 55˚@2.11GHz 54˚@2.17GHz
SERVER		49˚@1.92GHz 48˚@1.98GHz 44˚@2.11GHz 42˚@2.17GHz		50˚@1.92GHz 49˚@1.98GHz 45˚@2.11GHz 43˚@2.17GHz

4. Conclusion

In this paper, a unified indoor repeater antenna was proposed. The proposed antenna utilizes the coupling effect between the main and parasitic patches in order to obtain the broader bandwidth. The proposed antenna has the HPBW's over 50˚ in E-plane and over 40˚ in H-plane. The gain of the proposed antennas is higher than 8dBi. In order to obtain high isolation between donor and server antennas, two antennas are installed orthogonally and the inverted-L shaped aluminium wall is added. The measured isolation is higher than 75dB in the frequency range from 1.97GHz to 2.17GHz.

Acknowledgments

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