A Novel Central Symmetric MIMO Antenna Performance

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1. Introduction

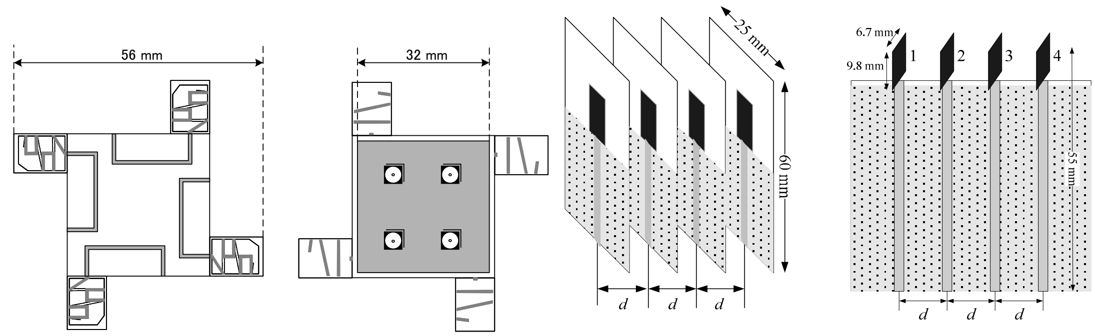
It is well known that multiple-input multiple-output (MIMO) antennas can substantially increase the spectral efficiency of communication system. Fortunately, the correlation is low even if close separation. However, in practice the channel capacity could not be increased linearly as the number of antennas does at the mobile terminals due to the pronounced mutual coupling among them [1][4].

With the growing capabilities of the terminals, the antenna design is a great challenge for antenna engineers. Nowadays, the handset has typically the length between 80 and 100 mm, the width around 50 mm and the depth around 10 mm in 2.4 GHz band. It was found in previous research, which is battled with the dilemma, that the performance with antennas on separated ground plane is far better than those on co-ground plane, but the former is too massive to apply to portable phones. [2] Moreover, if 4 antennas are parallel mounted on the ground plane, the antenna spacing 6 ~ 12 mm is applicable for portable phones. It was also proved that the relatively high capacity could be provided even if the antenna spacing is small. The most important issue is that how to make the antenna structure small enough without loss of much capacity.

2. Antenna Experimental System

2.1 Antenna Configuration

The novel central symmetric antennas with both sides are shown in Figure 1(a). Four antenna elements are mounted symmetrically on each side of square ground plane with the antenna spacing *d* of 30 mm ~ 36 mm which are made cross polarized. The design balances the problems compared to previous antennas shown in Fig. 1 (b), (c) with spacing *d* of 5 mm ~25 mm, regarding small antenna spacing, massive dimension and single polarization.



(a) (b) (c)

Figure 1: Proposed MIMO antennas.
(a) Novel central symmetric structure (NCS) (b) Separated ground (SG) (c) Co-ground (CG)

2.2 Experimental Structure

MIMO performance is measured under the flat fading environment. The experimental system for evaluating the capacity of MIMO antennas is shown in Figure 2. The operation is more automatic with the support by relay switches and PIC. The moving stage bar is also escalated to 2-axis. Each experiment can be achieved only by one command from PC. [2]

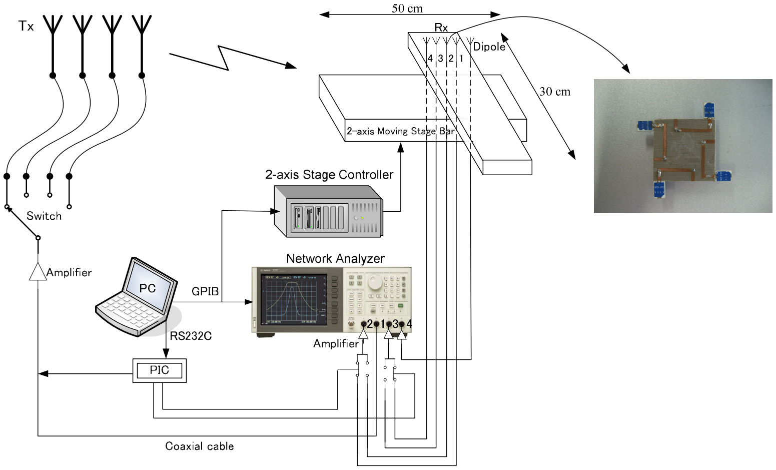


Figure 2: Configuration of experimental system.

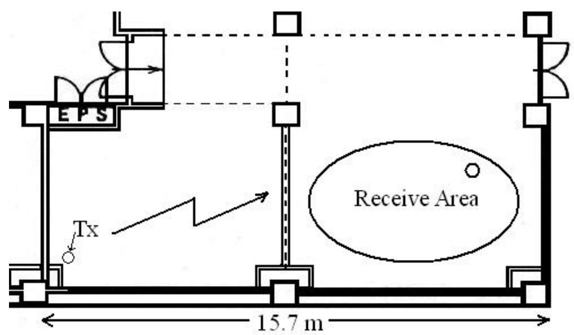


Figure 3: The indoor experimental environment.

In the measurements, the receive antennas were successively moved at different locations on the 2-axis moving stage bar. The experiments were conducted in the office room shown in Figure 3 which is approximated to the Rayleigh multipath environment. The Rayleigh fading test is depicted as following figures:

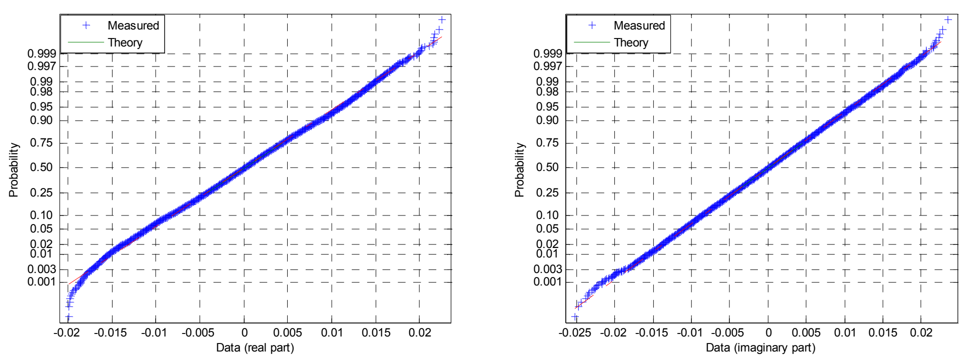


Figure 4: Normality test of real and imaginary parts

The real and imaginary parts obey approximately Gaussian distribution, equivalently the data submit to Rayleigh distribution. Therefore these data can be enough considered for Rayleigh fading environment.

3. Performance Measurement

3.1 Return Loss and Mutual Coupling

Return loss and mutual coupling reflect the performance of MIMO antennas. The proposed novel central symmetric antennas have larger bandwidth, lower mutual coupling than the others. In Figure 5, the average return loss and mutual coupling are depicted respectively, and the mutual coupling of co-ground is strong. In the case of separated ground and co-ground, the antenna spacing is 12 mm.

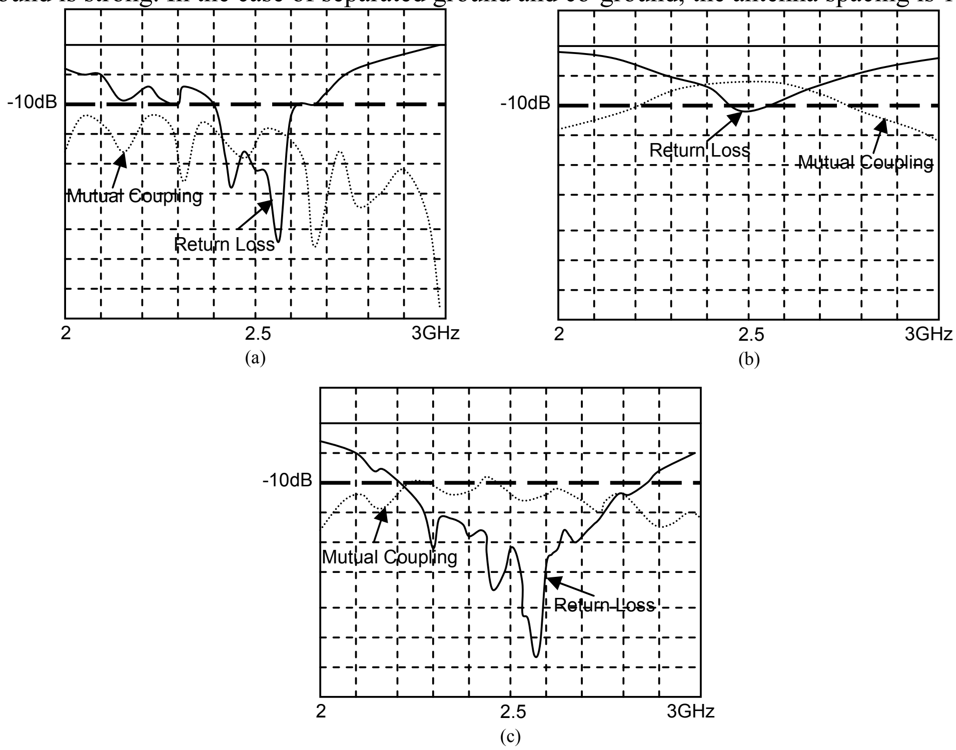


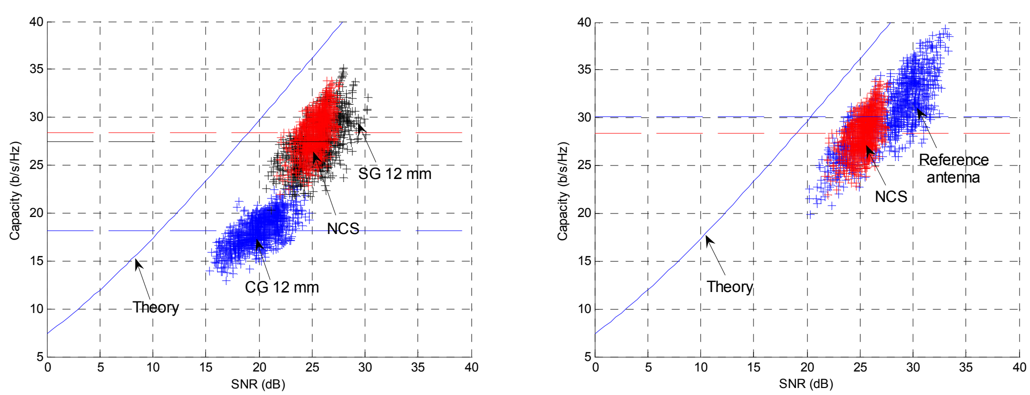
Figure 5: S-parameters of proposed antennas.
(a) Separated ground (SG) (b) Co-ground (CG) (c) Novel central symmetric structure (NCS).
The operation frequency bands are 200 MHz, 100 MHz, 650 MHz for SG, CG, NCS respectively.

3.2 Channel capacity

Here, we assume that the transmitter has no knowledge of the channel, but the receiver knows it perfectly. Channel capacity on N x N MIMO antennas under the rich Rayleigh multipath fading environment could be computed by

$$C = \log_2 \det(I_N + \frac{P}{\sigma^2 N} HH^{\mathrm{T}}),$$

where P is the total transmit power at each transmit branch, σ^2 is the noise power, $(\cdot)^{\mathrm{T}}$ is for conjugate transpose, and I_N is identity matrix with size of n x n. [1][3]



(a) (b)

Figure 6: Measured capacity and comparison with SG, CG and dipole arrays.

Figure 6 presents the measured MIMO channel capacity for NCS (f = 2.45 GHz), CG (f = 2.55 GHz, spacing = 12 mm), SG (f = 2.55 GHz, spacing = 12 mm) and reference dipole arrays (f = 2.45 GHz, spacing = 120 mm).

3.3 Correlation

For each transmit antenna, we calculated the average correlation between receive antennas using antenna patterns. The average correlation with co-ground/separated ground plane is depicted in Figure 7.

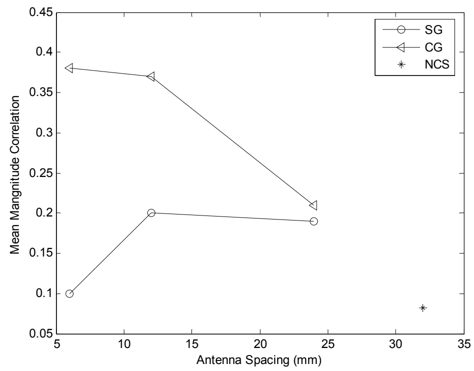


Figure 7: Calculated average magnitude correlation of MIMO antennas

Compared with SG and CG cases, the correlation of the novel central symmetric antennas is around 0.082.

4. Conclusion

Experimental results show that the capacity of the proposed novel MIMO antenna is high with small dimension compared to the previous antennas, similar with SG case. Such antenna has the following advantages:

(1) A low profile is applicable to mobile terminals;

(2) Cross polarization can cause antennas to perform well under Rayleigh fading environment;

(3) The operational bandwidth is wide, approximately 650 MHz (return loss > 10dB);

(4) The mutual coupling is not significant and the correlation between antenna elements is quite low.

The experiment just verified that such central symmetric structure can improve the performance. However, it is not investigated yet that which antenna spacing is the optimum (tolerance) for the maximum capacity.

References

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