Wireless Beamforming With Polarization Diversity

M.F. Abd Kadir [1], M.K. Suaidi [1], M.Z.A. Abd Aziz [1], M.R. Che Rose [1], M.S.R. Mohd Shah [1], D. Misman [1], Z. Daud[1], M.R. Abu Bakar[1], A. Jaâafar[1], M.K.A Rahim [2]
[1] Department of Telecommunication, Faculty of Electronic and Computer Engineering, Universiti Teknikal Malaysia MelakaHang Tuah Jaya, Ayer Keroh, 75450 Melaka
muhammadfaiz.abdulkadir@gmail.com, mohamadzoinol@utem.edu.my
muhammadrafie@gmail.com
[2] Wireless Communication Center, Faculty of Electrical Engineering, Universiti Teknologi Malaysia, 81300 Johor, Malaysia

1. Introduction

MIMO have become interesting common technology that can transmit parallel signal in one time synchronously. So the capacity will increase without changing power transmit or having a large bandwidth [3, 4, 6]. The MIMO system can be divided into two categories which are RF section and coding section [6]. This work is focusing to the RF section that related the beamforming and antenna diversity. A polarization diversity was been introduced in this project. The impact of polarization diversity will be study and the result related due to the correlation between signal source and output signal will be presented.

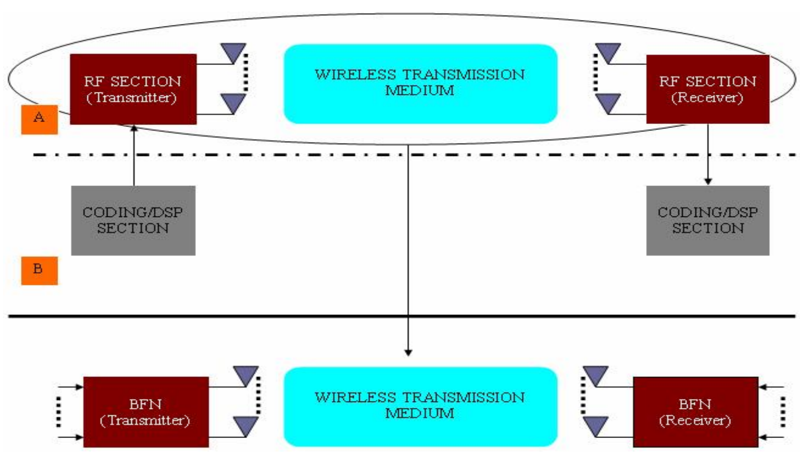
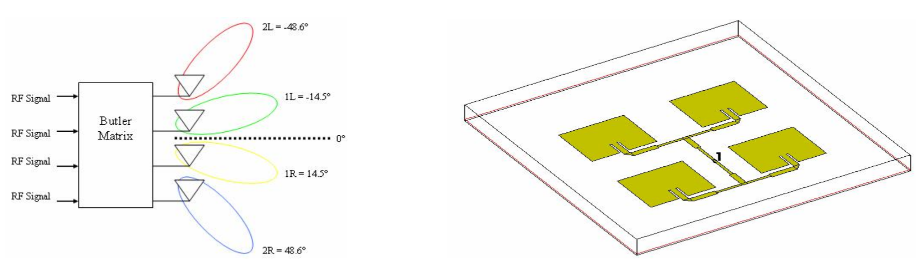


Figure 1: Block Diagram of MIMO



(a) (b)

Figure 2(a): Signal Coming Out From Beamformer (b) 2x2 Rectangular Microstrip Arrays Antenna

2. Measurement Setup

Figure 1: Measurement 4x4 MIMO Block Diagram

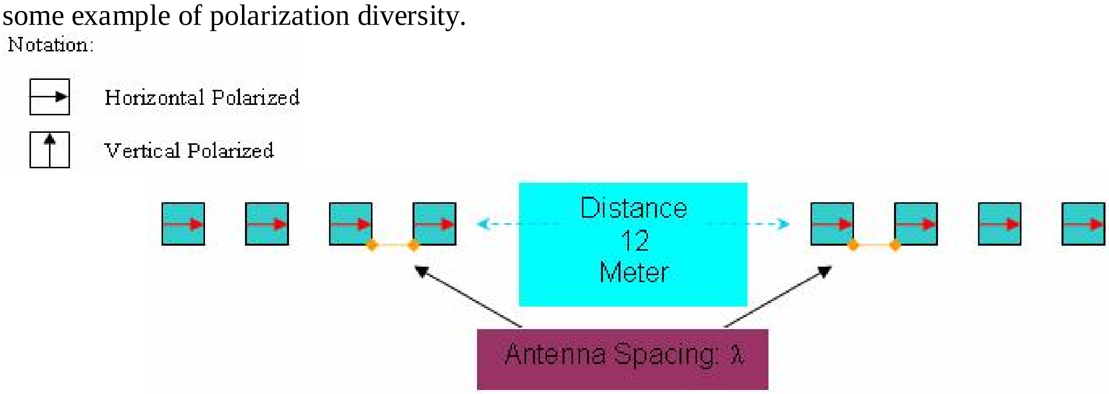
The measurement took place at microwave laboratory faculty of electronic and computer engineering UTeM which is in Line of Sight (LOS) indoor environment. Distance between receiver and transmitter antenna is 12 meters. The 4x4 MIMO measurement setup as follows. Operating frequency 2.4GHz, 2x2 array antenna was been used at transmitter and receiver and a fix antenna spacing is λ. Butler matrix was used also at both transmitter and receiver. The function of Butler matrix is to steer a beam with magnitude and fixed phased [2]. The correlation is introduced between a signal input sources and receive power at receiver. Correlation between function can be expressed as below:

$$\rho_{ij} = \frac{\mathrm{cov}_{ij}}{\sqrt{\sigma_{ii}}\sqrt{\sigma_{jj}}} \tag{1}$$

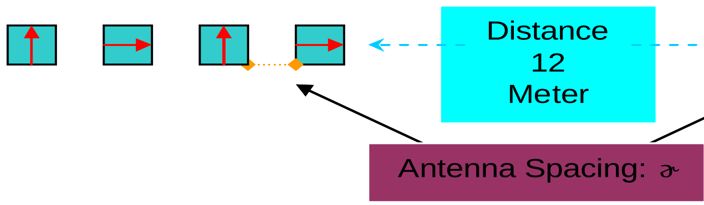
Where ρ_{ij} is represented as the correlation between input and output signal where i^{th} is the input port and j^{th} is the output port signal. The channel H matrix can be represented as below:

$$H = \begin{bmatrix} \rho_{11} & \rho_{12} & \rho_{13} & \rho_{14} \\ \rho_{21} & \rho_{22} & \rho_{23} & \rho_{24} \\ \rho_{31} & \rho_{32} & \rho_{33} & \rho_{34} \\ \rho_{41} & \rho_{42} & \rho_{43} & \rho_{44} \end{bmatrix} \tag{2}$$

Polarization diversity can be achieved by utilizing the antenna polarization such as placed the antenna horizontal and vertical polarized with neighbouring orthogonal each others. The figure below illustrated some example of polarization diversity.



(a)



(b)

Figure 2: Some Example of Antenna Configuration during Measurement

3. Results

The power correlation coefficient between transmitter and receiver obtained from (1):

(1) HHHH case

$$\rho = \begin{bmatrix} 0.4158 & 0.2748 & -0.0431 & 0.0946 \\ 0.3376 & -0.1597 & 0.5685 & -0.1826 \\ -0.1353 & 0.6551 & -0.2169 & 0.3967 \\ -0.5809 & -0.0690 & -0.7818 & 0.3765 \end{bmatrix}$$

(2) VVVV case

$$\rho = \begin{bmatrix} -0.1004 & 0.2912 & -0.4996 & 0.7245 \\ 0.0443 & -0.4593 & 0.1574 & -0.1596 \\ 0.1731 & 0.4039 & -0.6060 & 0.4045 \\ 0.3720 & -0.2912 & 0.4613 & -0.1257 \end{bmatrix}$$

(3) HVHV case

$$\rho = \begin{bmatrix} 0.4140 & -0.0387 & 0.6541 & 0.0628 \\ -0.3782 & -0.0303 & -0.5345 & 0.4835 \\ 0.1423 & -0.0501 & 0.6827 & 0.0208 \\ 0.2991 & -0.4524 & -0.6251 & -0.5721 \end{bmatrix}$$

(4) VHVH case

$$\rho = \begin{bmatrix} 0.3770 & -0.3743 & 0.7449 & 0.0814 \\ -0.0881 & 0.0006 & -0.0692 & 0.1269 \\ 0.4791 & -0.0122 & 0.1036 & 0.1556 \\ 0.2699 & -0.4015 & -0.5548 & 0.0276 \end{bmatrix}$$

From the normal system which is no polarization diversity been applied, shows that case (2) have greater correlated value. There were only seven that are minus value compared to case (1). The high correlation number appeared at $\rho_{14} = 0.7245$ in case (2). While in case (1) the high correlation value is at ρ_{23} with 0.5685. Case (3) and (4) is when polarization diversity is applied. In case (3) there where two number that have close value which at ρ_{13} (0.6541) and ρ_{33} (0.6827). In case (4), the high correlation value only at ρ_{13} (0.7449). The polarization diversity case has good correlation compared normal systems, this may happen because of multipath fading. So polarization diversity is one method to solve the problem.

4. Conclusion

In this paper, a correlation coefficient property has been highlighted for Line of Sight (LOS) condition. Normal system and polarization diversity system have been compared, where the comparison based on correlation coefficient. The polarization diversity system shows a good result compared the normal system.

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