Performance of Mimo-Ofdm Systems in Canal Rayleigh

Nia Watoniah [1], Subuh Pramono [2], Eni Dwi Wardihani [3]
[1,2,3]Telecommunications Engineering, Politeknik Negeri Semarang

Abstract— Along with the development of wireless communication makes the increasing demand for obtaining quality services and better range, bandwidth-efficient and reliable system. OFDM is a multicarrier transmission technique to overcome multipath fading, which may result in intersymbol interference (ISI). On the other hand there is the antenna system with the use of multiple antennas at the transmitter and receiver that can also be overcome multipath fading,ie Multiple Input Multiple Output (MIMO) to increase channel capacity and diversity gain. MIMO techniques used in this Final adaldah Space Time Block Code. Simulation aims to simulate and analyze the MIMO OFDM technique using space-time block code against the influence of the number of subcarriers and influence user speed in AWGN channel and Rayleigh. The simulation results based on the number of subcarriers in AWGN channel, the best performance is obtained by subcarrier number 256. With BPSK and QPSK modulation obtained BER = 6 10-4 when SNR 4 dB. Simulation based on Rayleigh channel obtained when BER = 9.7 10-5 with BPSK modulation. Based on the comparison of the greater frequency doppler given doppler frequency, resulting in BER generated even greater, because the state of the canal will be getting worse.

Index Terms— *MIMO, OFDM, subcarriers, doppler frequency.*

1. Preliminary

Along with the development of wireless communication makes the increasing demand for obtaining quality services and better range, bandwidth-efficient and reliable system. Ganngguan common in wireless communication is multipath fading. Multipath fading is a phenomenon that makes the wireless transmission is not reliable.[1]

One technique to overcome multipath fading is Orthogonal Frequency Division Multiplexing (OFDM). OFDM is a transmission technique using multiple frequency carriers (multicarrier) are transmitted perpendicular (orthogonal). Because the symbol duration is longer so that OFDM can face Intersymbol Interference (ISI) caused by multipath interference. OFDM is more efficient to prevent interference because it does not need a guard band, in addition to the more efficient use of bandwidth.[2]

Another technique that can overcome multipath fading is the MIMO system. This system uses a number of antennas on the receiver and sender. One scheme is MIMO Space Time Block Code (STBC), which aims to improve the reliability of transmission by using a technique deiversitas on the sender and receiver.[3]. The combination of MIMO - OFDM, has the ability to offer access to communications is fast, reliable and flexible, and efficient use of bandwidth.[4]

The purpose of this final project to simulate and analyze the MIMO OFDM technique using space-time block code modulation BPSK, QPSK and 16 - QAM subcarrier to influence the number and influence of user-speed in AWGN channel and Rayleigh.

2. Multiple Input Multiple Output (Mimo)

MIMO is the use of a number of antenna on the side of the sender and receiver. When the transmission of information is performed independently of the transmission channel, which is expected to overcome fading and increase channel capacity.[5]

There are two kinds of techniques such as MIMO spatial diversity and spatial multiplexing. Spatial diversity is to get the highest possible signal quality by sending the same data in parallel in multipath fading channel conditions. So that the received data can be overcome fading and can improve the SNR. This large increase is called diversity gain, diversity gain increases with the number of antennas MtxMr.

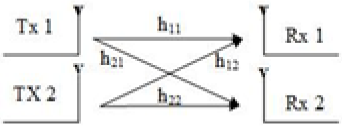
MIMO with elements nt on the sender side and nr elements on the receiver side. The impulse response of the channel is denoted hi, j (τ, t), j is an element of the sender and receiver i is an element. In general, nr x nt MIMO system can be described on the channel matrix H (τ, t) as follows

$$H(\tau,t)=\begin{bmatrix} h_{1,1}(\tau,t) & h_{1,2}(\tau,t) & \cdots & h_{1,n_t}(\tau,t) \\ h_{2,1}(\tau,t) & h_{2,2}(\tau,t) & \cdots & h_{2,n_t}(\tau,t) \\ \vdots & \vdots & \ddots & \vdots \\ h_{n,1}(\tau,t) & n(\tau,t) & \cdots & h_{M_R,n_t}(\tau,t) \end{bmatrix} \quad (1)$$

Matrix element is a complex number that is associated with attenuation and phase shift in the wireless channel that has a delay τ to arrive at the receiver side. Input - Output MIMO system can be expressed by the equation

$$y(t) = H(\tau, t) \times s(t) + u(t) \quad (2)$$

That y (c) is the vector r on the receiving signal, s (t) is the vector nt on the signal transmitter and u (t) is the noise AWGN [6] Space Time Block Code (STBC) is the simplest technique STC. Introduced by Alamouti in 1998 using two antenna transmitter. But before it is ready for broadcast, data flow that goes to every antenna undergo different treatments. Alamouti STBC system can be seen in Figure 1.[6]



Picture 1 STBC Alamouti 2x2

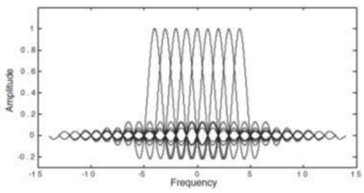
On STBC technique utilizing diversity to reduce the effects of multipath fading. Diversity scheme is used to improve the reliability of the signal with different channel characteristics so as to reduce fading in wireless channels.

Alamouti STBC can be expressed in a matrix as follows:

$$X = \begin{bmatrix} x_1 & -x_2^* \\ x_2 & x_1^* \end{bmatrix} \quad (3)$$

3. Orthogonal Frequency Division Multiplexing (OFDM)

OFDM is a multicarrier transmission technique with the delivery of mutually orthogonal subcarriers. The distance between subcarrier 1/T, the symbol T states symbol period. Delivery allows subcarrier orthogonal overlapping each other, because the intersubcarrier has a value of zero when the center frequency with each other so that there will be no interference between subcarrier. This is as shown in Figure 2.



Picture 2 Frequency Spectrum OFDM

The concept of OFDM is to divide the high-speed serial data into low-speed parallel data is transmitted through mutually orthogonal subcarriers. The advantages of OFDM which makes frequency selective fading channels will be perceived as flat fading on each - each subcarrier.

4. Binary Phase Shift Keying (BPSK)

BPSK mapped bits of information into two signals with different phases. Each phase express a logic 1 and logic 0, premises 180^0. The phase difference signal is modulated by BPSK is defined has the form:

$s1(t) = A\cos 2\pi f\ ct, \quad 0 \le t \le T, \quad logika\ 1$

$s2(t) = A\cos 2\pi f\ ct, \quad 0 \le t \le T, \quad logika\ 0$

5. Quadrature Phase Shift Keying (QPSK)

QPSK mapping the bits of information into a symbol, by having two bits of information for each symbol. QPSK can be obtained by merging two BPSK modulation. QPSK signal is defined as

$$si(t) = A\cos(2\pi f\ ct + \theta i), \quad t \le T,\ i = 1,2,3,4.$$

The word refers to the four likelihood Quadrature phase carrier state (4-PSK) at one time. The four-phase refers to the angle of the modulated bit, ie 00,900,1800,2700.

6. 16 - QAM (Quadrature *Amplitude Modulation*)

QAM is the modulation with a combination of phase and amplitude. This technique sends a signal to the four different phases. In this simulation, the type of QAM modulation used is 16QAM. For each symbol modulation 16 - QAM contains 4 bits of information, which has 2^4 state phase. QAM modulation signal transmitted split into two parts or bit stream, the In-phase and Quadrature-phase. The second part of phase 90 degrees, because the in-phase bit stream multiplied by the cosine signal, while the quadrature-phase signal is multiplied by sinus. In both parts of the data transmission are combined according to Equation 4.

$$S(t) = I(t)\cos(2\pi f0t) + Q(t)\sin(2\pi f0t) \quad (4)$$

QAM modulation has the advantage in terms of speed in data transmission and efficient use of bandwidth.

7. Additive White Gaussian Noise (AWGN)

In the communication system cannot be separated from the noise. Thermal noise is noise caused by electrons at all dissipative components including resistors and wires. [8]. AWGN is a distributed thermal Gaussian noise with value - average of zero. Statistically pdf on Gaussian namely:

$$p(n) = \frac{1}{\sigma\sqrt{2\pi}} \exp\left[\frac{1}{2}\left(\frac{n}{\sigma}\right)^2\right] \quad (5)$$

With σ is the variance of n. Standard assumed Gaussian pdf with σ = 1. The signal has been given a Gaussian noise can be written by the equation:

$$z = a + n \qquad (6)$$

Multipath Rayleigh Fading On the wireless radio channel signal from the transmitter can be received by the various channels on the receiver. It is caused by reflection, and scattering diffraction. Because the signal is transmitted through various channels so called multipath signals. As a result of multipath signals occur delay and a different amplitude. Fading occurs as a result of multipath signals that have variations in amplitude and phase.[2] Rayleigh distribution often used to describe the character of statistical probabilitias because the response that lasted random channels. Rayleigh distribution is often used to describe the statistical time-varying signal veil on flat fading channel or on each multipath component. If there is no dominant multipath components, then the average - average Gaussian distribution becomes 0 and phase evenly distributed. Sheath signal is the sum of the two quadrature Gaussian noise signals resulting Rayleigh distribution. Rayleigh distribution has a pdf as follows:[7]

$$p(r) = \begin{cases} \frac{r}{\sigma^2} \exp\left[\frac{r^2}{2\sigma^2}\right] & (0 \le r \le \infty) \\ 0 & (r < 0) \end{cases} \qquad (7)$$

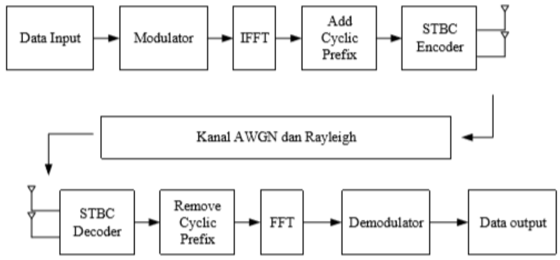
Doppler Effect may occur due to fading. At the time of the mobile station from the base station, each multipath wave frequency changes. Changes in the frequency of the signal receiver that moves is called the Doppler Effect. The maximum shift occurs when the angle of arrival of a signal equal to 00 is equal

$$\text{to:} f_d = \frac{v}{\lambda} = \frac{f_c \cdot v}{c} \qquad (8)$$

Based on the above formula Doppler effect influenced the movement of the car from the base station, when approaching a positive doppler effect and when away from the base station, the Doppler effect negative.

8. Simulation Program

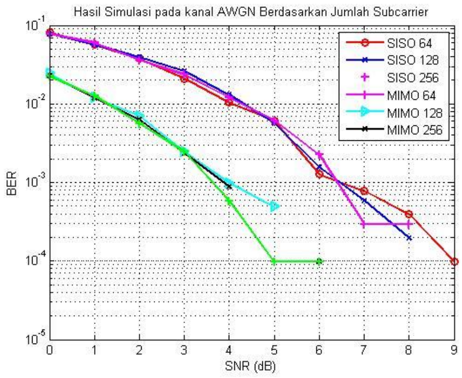
The purpose of this final project to simulate and analyze the MIMO OFDM technique using space-time block code modulation BPSK, QPSK and 16 - QAM based on subcarrier and user-speed in AWGN and Rayleigh channel. Parameters measured were SNR and BER. Block design of MIMO OFDM system simulation in AWGN channel and Rayleigh can be seen in Figure 3



Picture 3 Block Diagram Simulation of MIMO OFDM

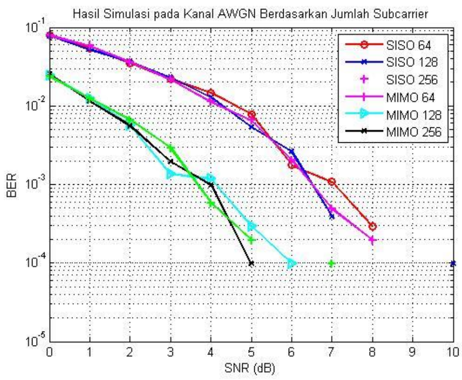
9. Result and Analysis

Performance of MIMO OFDM based Subcarrier This simulation is carried how number of subcarrier on the performance MIMO OFDM with AWGN and Rayleigh fading channels. Variations in the number of simulated subcarrier is 64, 128 and 256.



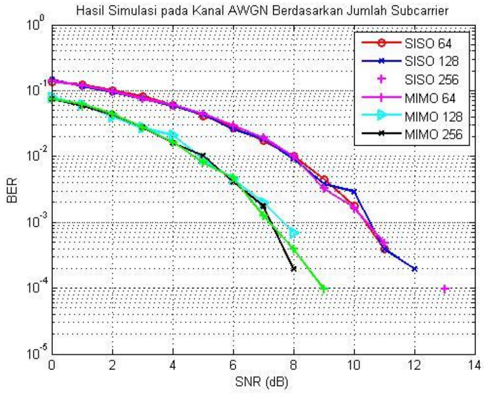
Picture 4 Simulation results on AWGN channel based on the number of subcarriers with BPSK modulation.

Based on simulation results Picture 4 by providing diversity techniques can improve system performance. This can be seen when the value of 4 dB SNR BER generated looks different. By giving the diversity shown by the diversity technique has a smaller BER to achieve BER of 10-3 compared to no diversity given only reach BER 10-2 at the same SNR.



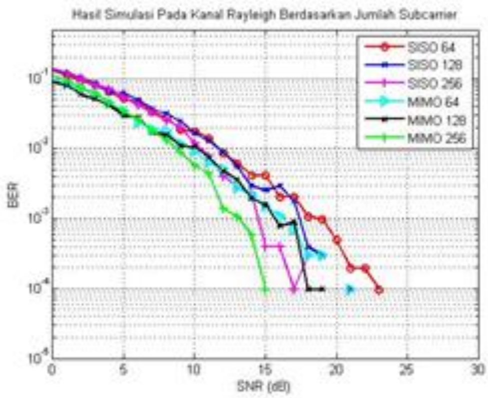
Picture 5 Simulation results on AWGN channel based on the number of subcarriers with QPSK modulation.

In performance SISO OFDM and MIMO OFDM with QPSK modulation show by giving each subcarrier that can improve performance, as shown by the BER gets smaller. When the value of 4 dB SNR for the provision of diversity shown in Picture 5 shows better performance than the performance is not given the diversity. With the diversity technique has a smaller BER to achieve BER of 10^{-3} compared to no diversity given only reach BER 10^{-2} at the same SNR.



Picture 6 The simulation results in AWGN Channel based on the number of subcarrier modulation 16-QAM

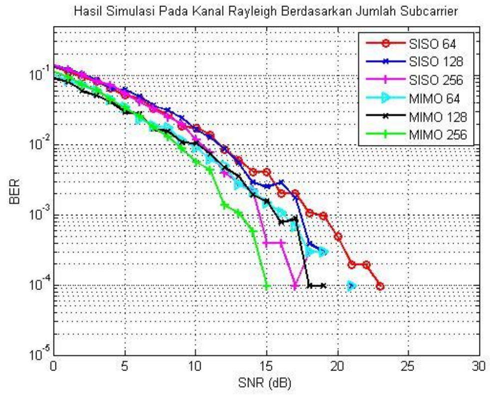
To 4 dB SNR value on diversity systems or systems that are not given the diversity showed optimal subcarrier at 16-QAM modulation is 128 subcarrier. At the same SNR value, performance by providing diversity to minimize the BER value. BER value with 128 subcarriers when not given the diversity that is 5,79 10^{-2} and BER values with diversity system is 1,6 10^{-2}.



Picture 7 Simulation results on Rayleigh Channel based on the number of subcarrier modulation BPSK

Based Picture 6 shows the diversity system administration with the same SNR value can reduce the value of BER. So that a data error on the receiver side is smaller.

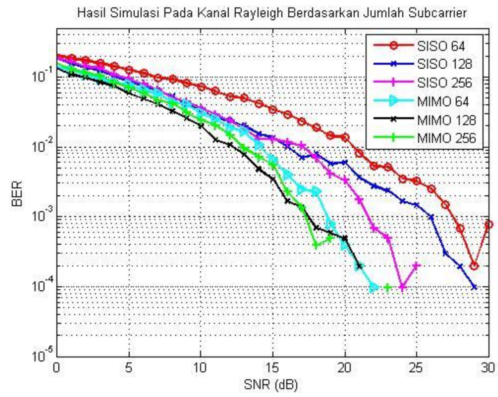
Simulation used BPSK modulation type, deliveries every single bit per symbol makes it more resistant to interference. So when given a greater number of subcarriers in the error detection, the better. It is characterized when the subcarrier delivery gained 64 BER of 10^{-3} and is currently shipping 1.5 256 subcarrier BER obtained was 9.77 10^{-5}.



Picture 8 Simulation results on Rayleigh Channel based on the number of subcarrier modulation QPSK

At the same SNR value is 15dB, the subcarrier 64 and 128 has a value of 0.8 BER of 10^{-3} and 3.5 10^{-3}. While the value of BER obtained when the subcarrier 256 is 0.6 10^{-3}.

Picture 7 shows a simulation based on the provision of diversity with the same SNR value can reduce the value of BER. Performance MIMO OFDM subcarrier number 256 showed the best performance. It is marked on the value of 15 dB SNR, BER on MIMO OFDM is 0.6 10^{-3}, and the SISO OFDM BER was 3.5 10^{-3}.

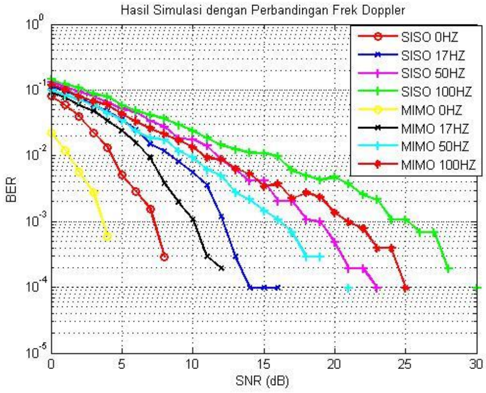


Picture 9 Simulation results on Rayleigh Channel based on the number of subcarrier modulation 16-QAM.

Performance results based Picture 8 shows improvement when given system diversity. Although the number of different optimal subcarrier, the subcarrier diversity system without optimal is 256 and the number of subcarrier diversity system is 128. However optimal BER values generated at the same SNR is 15 dB, BER with a smaller diversity system.

10. OFDM MIMO Performance Based on Doppler Frequency

This simulation aims to look at the effects of Doppler frequency on the performance of MIMO OFDM. Simulations performed with doppler frequency variation of 0, 17, 50 and 100 Hz, while the number of subcarriers used fixed (the number of subcarriers = 64).

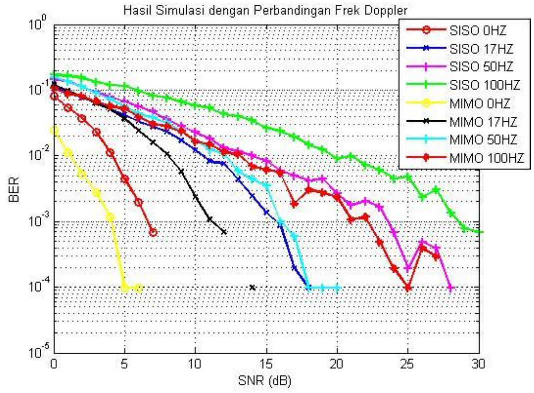


Picture 10 Simulation results based on the frequency doppler with BPSK modulation

Based Picture 9, when the user is at rest, the speed of 0 km/h when the value of 4 dB SNR, BER is obtained is 1.34 10^{-2}. At the time of the Doppler frequency 17 Hz, 50 Hz and 100 Hz with a value of 12 dB SNR, BER is generated each performance is 4,72 10^{-2}, 6,45 10^{-2} and 7,8 10^{-2}.

In MIMO OFDM system decreased performance when channel conditions deteriorate. However the performance of the given system diversity is better than not. This can be seen when the user quiescent conditions, the current value of 4 dB SNR, BER obtained was 0.6 10-3. At the doppler frequency of 17 Hz, 50 Hz and 100 Hz when the value of SNR of 12 dB, the resulting BER is 0.2 10^{-3}, 5.0 10^{-3} and 8.8 10^{-3}.

It shows the diversity diberikann can improve system performance. In the Doppler frequency is greater, the worse the BER is obtained, because the state of the canal is also getting worse. When compared with the Doppler frequency is small, the BER obtained is also getting smaller.

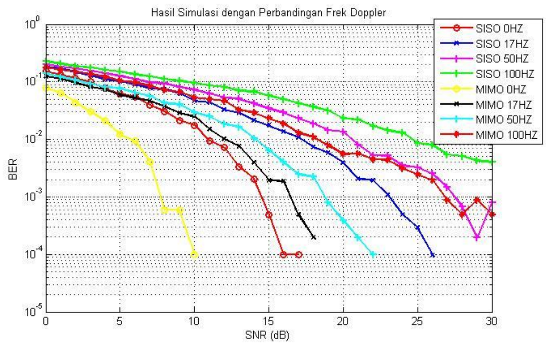


Picture 11 Simulation results based on the frequency Doppler with QPSK modulation

Picture 10 show performance without the effect of frequency diversity by doppler with QPSK modulation. Simulations show the magnitude of decline in performance over a given doppler frequency. When the user silent for grades 4 dB SNR, BER obtained was 1.12 10^{-2}. At the doppler frequency of 17 Hz, 50 Hz and 100 Hz respectively - each performance at SNR of 12 dB, the BER is obtained is 7.6 10^{-3}, 1.31 10^{-3} and 4.32 10^{-2}.

The simulation results showed improvement by providing diversity. Although the state of the channel is getting worse by the given system can improve kinerja.Hal diversity can be seen when the user condition still, with MIMO OFDM as the value of 4 dB SNR, BER obtained was 1.2 10^{-3}. At the time of the rise doppler frequency 17 Hz and 50 Hz, with a SNR of 12 dB BER value obtained was 0.7 10^{-3} and 1.07 10^{-2}. When doppler frequency of 100 Hz, BER is obtained is 1.15 10^{-2}.

The simulation results show the diversity in the provision of the same Doppler frequency can provide a smaller BER. It shows the diversity of techniques suitable for poor channel conditions.



Picture 12 Hasil Simulasi berdasarkan frekuensi doppler dengan modulasi 16-QAM

Picture 11 shows the performance of MIMO OFDM based frequency doppler effect with 16-QAM modulation. An improvement of performance than systems without diversity. Despite a decrease in performance with increasing frequency doppler given. 17 Hz Doppler frequency performance when SNR is 12 dB, the resulting BER is 1.02 10^{-2}. When doppler frequency of 50 Hz and 100 Hz, the resulting BER is 1.86 10^{-2} and 4.68 10^{-2}.

Based on simulation results show the greater the Doppler frequency can result in deep fade that caused the loss of signal at a particular frequency, it demonstrates the diversity provision can fix a bad channel conditions. In addition to 100 Hz Doppler frequency is approaching fast fading so that when the SNR of 12 dB, the BER obtained Doppler frequency greater than smaller ones.

11. Conclusion

From the results of the simulation and analysis of the performance of MIMO OFDM system, then obtained some conclusions as follows:

1. SISO OFDM simulation results based on the number of subcarriers in AWGN channel, the BPSK modulation lowest BER value obtained when subcarrier 64, the lowest BER QPSK modulation is obtained when subcarrier 256, and 16-QAM modulation lowest BER obtained when subcarrier 128.
2. The simulation results based on the number of MIMO OFDM subcarrier in AWGN channel, the BPSK and QPSK modulation lowest BER value obtained when subcarrier 256 and the 16-QAM modulation lowest BER value obtained when subcarrier 128.
3. The simulation results SISO OFDM and MIMO OFDM subcarrier based on channel Rayleigh number, the BPSK and QPSK modulation lowest BER value obtained when subcarrier 256. In the 16-QAM modulation for SISO OFDM system when the lowest BER MIMO OFDM subcarrier 256 and subcarrier 128 current low BER.
4. The simulation results based on the Doppler frequency Rayleigh channel shows that the BER value increases with increasing magnitude of the Doppler frequency, for performance without diversity as well as the performance of the system diversity.

12. Suggestion

Here are some things that can be done for the further development of this final project:

1. Using other channels to present channel conditions with various disturbances.
2. Using other modulation techniques with larger M-arry ie 8-PSK, 64-QAM
3. Other MIMO techniques such as STTC or Spatial Multiplexing

13. Refference

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