



Propagation of Mobile Communication with Tree Obstacle using OFDM-QAM at 10 GHz

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Abstract - This research focused on mobile communication system on the road. The communication frequency used was 10 GHz. The tree was modeled as communication's obstacle for every node. The communication itself was modeled with single diffraction using the single knife-edge model. The communication transmission used Orthogonal Frequency Division Multiplexing. This paper used modulations that consisted of 16 QAM and 64 QAM. This paper utilized the variation of modulation and transmitter power. As a result, the SNR was decreased when transmitter power was increased, the value of BER 64 QAM was lower than BER 16 QAM, and the percentage of the coverage area for communication around the tree was around 96%.

Keywords – OFDM, QAM, tree, 10 GHz, mobile station

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I. INTRODUCTION

OFDM (Orthogonal Frequency Division Multiplexing) was one of the transmission techniques for digital modulation. Some researches related to OFDM techniques were DFT (Discrete Fourier Transform) with spectral based OFDM [1], Edge Windowing for systems based OFDM [2], and transmitter power with the constraint of intervention threshold for cognitive at OFDM systems [3]. An obstacle could influence the communication propagation between Base Transceiver Station with a mobile station. Researches related to the obstacle at communication propagation were the communication system through trees using the Giovanelli Knife Edge method at 2.3 GHz frequency [4], determining mobile station location through the building using AoA (Angle of Arrival) method at 47 GHz frequency [5], the propagation for RBS femtocell at pole lamp using 10 GHz frequency [6], the diffraction effect caused by the building environment at millimeter-wave [7], the diffraction measurement at building environment using 10 GHz frequency [8], the measurement for multipath characteristics using 28 GHz frequency [9], and the adaptive modulation and coding around building [10].

The communication systems could be influenced by atmospheric attenuation due to water vapor and oxygen [11]. Some researches related to millimeter-wave were cellular communication propagation using 38 GHz and 60 GHz frequency [12], handoff process for wireless using 60 GHz frequency [13], code rate influence at communication systems of RBS femtocell using 47 GHz frequency [14], the multipath effect at building environment for mobile communication at 47 GHz frequency [15], the performance of self-backhauling with flexible reuse of the resources for access and backhaul in the street scenario with 5G network [16], the performance of the millimeter-wave network for self-backhauling relay nodes and centralized transmission coordination [17].

This research discussed the propagation of mobile communication around the tree. The mobile station was moving on the road or its track communication. However, each node faced communication obstacles such as the tree, causing the diffraction effect. The diffraction is modeled using the Single Knife Edge method. The transmission system used OFDM with modulation of QAM (Quadrature Amplitude Modulation). The contribution of this research was developing mobile communication around the trees with frequency communication at 10 GHz. That

frequency was used for developing mobile communication. The analysis part consisted of transmitter power variation and communication modulation variation analysis. As an addition, the comparison analysis based on power transmitter at communication systems was also discussed. The transmitter power part consisted of 0.1 watts and 1 watt. The communication modulation consisted of 16 QAM and 64 QAM. The result part discussed the signal to noise ratio value, bit error rate, amount of bit error, and percentage of communication coverage.

II. RESEARCH METHOD

A. Environment Model

This research showed the communication propagation with trees obstacle. The model of the communication environment has consisted of 300 meters for the long road, 2 meters for full walk street, and 8 meters for a wide road. The trees were modeled 10 meters of distance between trees and 2 meters of high trees. The communication model, as shown in Fig.1.

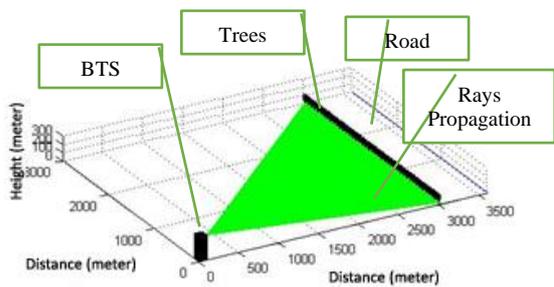


Fig. 1. The Propagation Of Model with Tree Obstacle

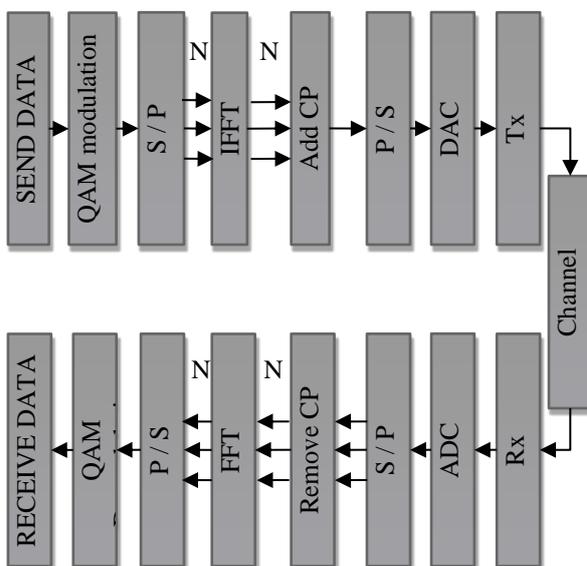


Fig. 2. OFDM Block Diagram

B. Propagation

Noise value for communication systems could be seen in equation (1). At Equation (1), the noise figure (F) value was 7 dB, the T_0 parameter was 290° K, the

Boltzman constant was 3×10^{-23} [18], and the amount of 200 MHz bandwidth's channel was 8. Path loss value could be seen in equation (2).

$$N = kT_0BF \tag{1}$$

$$L = G_T G_R (\lambda/4\pi d)^2 \tag{2}$$

Transmitter power that was used consisted of 0.1 watts and 1 watt. L parameter was a loss, G_T parameter was transmitter gain (dB), G_R parameter was receiver gain (dB), d parameter was communication distance, and λ parameter was wavelength (m). The SNR value could be seen in equation (3).

$$SNR = S/N \tag{3}$$

The SNR value was obtained from S value as a signal (dB), and N parameter of noise. The transmission communication of this research was used orthogonal frequency division multiplexing (OFDM), which transmits multiple data symbols continuously used subcarriers orthogonal. The transmission system diagram that used OFDM could be seen in Fig.2. That figure showed OFDM systems such as transmitter and receiver. The transmitter block was used consisted of send data, QAM modulation, serial to parallel, IFFT, cyclic prefix, parallel to serial, Digital Analog Converter (DAC), and transmitter [19]. The receiver block was used consisted of the receiver, Analog Digital Converter (ADC), remove a cyclic prefix, serial to parallel, FFT, parallel to serial, QAM demodulation, and receive data.

Send data block was a bit sequence that will be sent. QAM principle was an information data sequence that was sent and converted to parallel form, formerly bit rate of R, M parameter was a parallel line amount that was the same with subcarrier amount. The S/P block that used for changing serial data bit became a parallel data bit. Generate subcarrier at OFDM system used technique of inverse fast furrier transform (IFFT) subcarriers and orthogonal for every duration at OFDM symbol. The Guard interval was used by cyclic prefix (CP). The distance between subcarrier (Δf) and time duration from the OFDM symbol was $1/\Delta f +$ cyclic prefix, functioning as the orthogonal guard between subcarrier.

The cyclic prefix used for extending the OFDM symbol, such as multiplication at the last sample part of OFDM symbol, becomes addition at the first sample part. At equation (4), T_{symbol} parameter was symbol period of T_{sample} . T_{sample} parameter was period for part of data, and T_{cp} parameter was the addition part of data that is taken from the data.

$$T_{symbol} = T_{sample} + T_{cp} \tag{4}$$

The data ($d_{n,k}$) that was placed at scale group of N and n block modulation that became waveform of exponential complex $\phi_k(t)$, can be seen at equation (5) until equation (7),

$$x(t) = \sum_{n=-\infty}^{\infty} \sum_{k=0}^{N-1} d_{n,k} \phi_k(t - nT_d) \quad (5)$$

$$\phi_k(t) = \begin{cases} e^{j2\pi f_k t} & ; t \in [0, T_d] \\ 0 & \text{another} \end{cases} \quad (6)$$

$$f_k = f_0 + \frac{k}{T_d}, k = 0, \dots, N - 1 \quad (7)$$

The $d_{n,k}$ parameter was a symbol that transmitted along interval time n using k subcarrier. T_d parameter was symbol duration. N parameter was the amount OFDM subcarrier. f_k parameter was frequency subcarrier k , and f_0 parameter became the lower value [19].

P/S block at the receiver side was blocked that used for change of parallel data bit become serial bit data. CP addition block at transmitter side constitutes cyclic prefix block, where at that block carried was add bit of CP. P/S block at the transmitter side constitute block that used to change parallel data bit become serial data bit. Generated subcarrier at OFDM systems used fast furrier transform (FFT) technique. At Fig.2 IFFT block that used for accomplishing modulation block at data constellation of single carrier orthogonal. Inverse Fast Fourier Transform (IFFT) can decrease of necessities RF divider so that block more efficient for divider at subcarriers. IFFT accomplished transformation at parallel data symbol from the frequency domain become the time domain.

S/P block at the receiver side constitutes block that used for change of serial data bit become parallel data bit. Block for CP remove at the receiver side was processed where data bit was removed process at cyclic prefix bit. That FFT block was used for demodulation at data constellation from single carrier orthogonal. IFFT input from constellation N showed number at FFT node. That constellation has taken from QAM modulation. Demodulation process based on orthogonal at subcarrier $\phi_k(\tau)$, could be seen in equation (8) [19].

$$\int_N \phi_k(t)^* \phi_l(t) dt = T_d \delta(k - l) = \begin{cases} T_0 & k = l \\ 0 & \text{another} \end{cases} \quad (8)$$

Demodulator was implemented to digital with orthogonal relation at subcarrier. IFFT was used for modulation at OFDM signal, and FFT was used for demodulation at OFDM signal. Equation (9) was implemented for FFT block [20].

$$d_{n,k} = \frac{1}{T_d} \int_{nT_d}^{(n+1)T_d} x(t)^* \phi_k(t) dt \quad (9)$$

C. Atmosphere

Atmospheric attenuation was influenced by oxygen and water vapor. Equation (10) consisted of γ_a parameter that was attenuation atmospheric specification (dB/km), d parameter was LOS (line of sight) distance (km). Equation (11) showed γ_a value, that consist of γ_w and γ_o [11]. Where γ_w parameter was water vapor attenuation, although γ_o parameter was oxygen attenuation.

$$A = \gamma_a d \quad (10)$$

$$\gamma_a = \gamma_o + \gamma_w \quad (11)$$

III. RESULT

This section described the result of this research. The communication systems from mobile station movement with trees obstacle used OFDM-QAM transmission. The mobile station moved to 300 meters. The communication frequency was used 10 GHz; that frequency was influenced by atmospheric attenuation. Transmitter power variation consists of 0.1 watts and 1 watt.

The modulation variation consists of 16 QAM and 64 QAM. The communication relation of SNR value with BER for modulation 16 QAM, was shown in Fig.3. Figure 4 showed bit error value for modulation 16 QAM. Based on the data shown in the figure below, with the parameter such as 16 QAM, MS movement at 14 meters, and the transmit power at 0.1 watts, the SNR value of 33 dBW was obtained with a 0-bit error of 5.76×10^6 bits. When MS movement at 290 meters was obtained SNR value of 17 dBW with bit error of 0 bit from $5,76 \times 10^6$ bit.

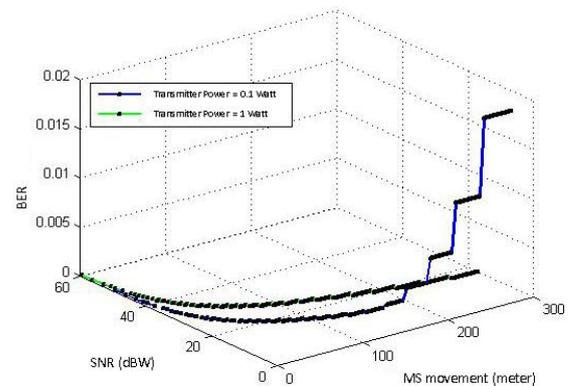


Fig. 3. SNR and BER for 16 QAM

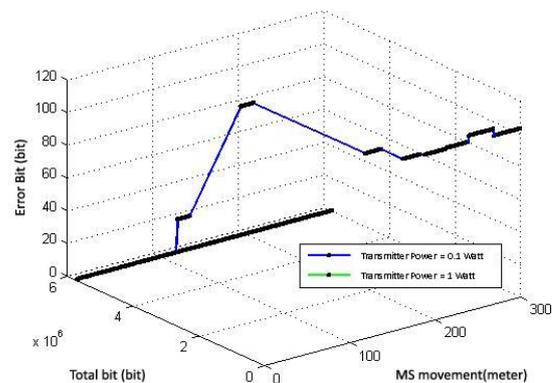


Fig. 4. BER for 16 QAM

Figure 5 showed relation from SNR and BER with 64 QAM. Figure 6 showed bit error value for 64 QAM. Based on the data shown in the figure, with the parameter such as 64 QAM, MS movement at 14 meters, and the transmit power at 0.1 watts, the SNR value of 33 dBW was obtained with a 0-bit error from

8,64 x 10⁶ bit. During MS movement at 290 meters with the same condition, the SNR value of 7 dBW with 144-bit error from 1728 bit and the BER value of 0,0833 dB are obtained. When used 64 QAM with MS movement at 14 meters, and transmitter power of 1 watt, that condition was obtained SNR value 43 dBW with bit error of 0 bit from 8,64 x 10⁶ bit, and BER value 0 dB. During MS movement at 290 meters with the same condition, the SNR value of 17 dBW with 101-bit error from 538.272 bit and the BER value of 0,000188 dB are obtained.

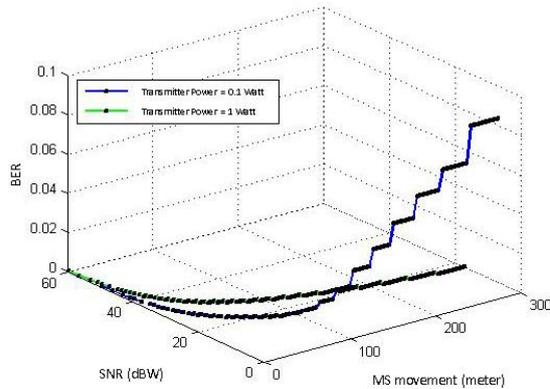


Fig. 5. SNR and BER for 64 QAM

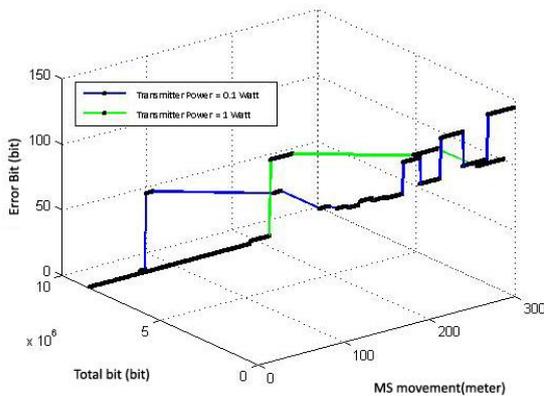


Fig. 6. BER for 64 QAM

Figure 7 showed the relation between BER value with the mobile station movement. That figure showed results from transmitter power variation 0.1 watts and 1 watt, and communication modulation variation consisted of 16 QAM and 64 QAM. Transmitter power usage 1 watt with communication modulation of 64 QAM showed with green color line. The line for that green color did not appear at the figure, because BER value from communication did not have bit error result.

The percentage of coverage area communication from MS movement at track communication was 96%. That communication condition was modelled with tree obstacle.

IV. DISCUSSION

This section described propagation for mobile station around the tree on the road or track. The

propagation communication was influenced by the tree. The propagation used a single line signal directly to the node. The percentage result for coverage area communication was 96%. Some attenuation influenced communication systems by trees and atmosphere. The atmospheric attenuation consisted of oxygen and water vapor.

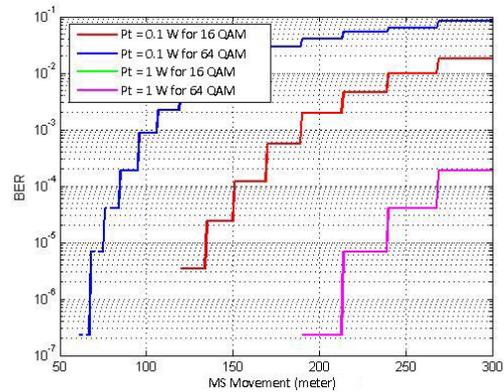


Fig. 7. Comparison BER Value

For some data that used parameter consisted of the transmitter power of 1 watt and 16 QAM, the SNR value of 33 dBW was obtained for MS location at 14 meters. With the same condition, the SNR value of 7 dBW was obtained for MS location at 290 meters. However, if 64 QAM was used with the same condition, the SNR value of 43 dBW was obtained for MS location at 14 meters, and the SNR value of 17 dBW was obtained for MS location at 290 meters.

For some data that used parameter consisted of the transmitter power of 0.1 watts and 16 QAM, the BER value of 0 was obtained for MS location at 14 meters. With the same condition, the BER value of 0,017882 dBW was obtained for MS location at 290 meters. However, if 16 QAM and the transmitter power of 1 watt were used with the same condition, the BER value of 0 was obtained for MS location at 14 meters, and the BER value of 0 was also obtained for MS location at 290 meters.

For some data that used parameter consisted of the transmitter power of 0.1 watts and 64 QAM, the BER value of 0 was obtained for MS location at 14 meters. With the same condition, the BER value of 0,0833 was obtained for MS location at 290 meters. However, if 64 QAM and the transmitter power of 1 watt were used with the same condition, the BER value of 0 was obtained for MS location at 14 meters, and the BER value of 0,000188 was obtained for MS location at 290 meters.

V. CONCLUSION

The result showed some data that consist of SNR, BER, and percentage of coverage area. The SNR value was increasing when the transmitter power was increased. The BER value was increasing when the mobile station was moved far away from the base

transceiver station, for example, the BER value from 16 QAM with the transmitter power of 1 watt was lower than the BER value from 16 QAM with the transmitter power of 0.1 watts. The BER value from 64 QAM with the transmitter power of 1 watt was lower than the BER value from 64 QAM with the transmitter power of 0.1 watts. The percentage of the coverage area for communication around the tree was 96%.

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