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

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Abstract—This research focused about mobile communication systems at line communication of road with tree obstacle. Frequency communication was used 10 GHz. Every node at line communication through tree. That tree was caused diffraction. Single diffraction was used for modeled this communication. The communication transmission that used was Orthogonal Frequency Division Multiplexing. The modulation variation that used was consisted of 16 QAM and 64 QAM. Analysis that used was consisted of modulation variation, transmitter power variation, and coverage area variation. The result showed that SNR was decreased when transmitter power was increased, the value BER 64 QAM lower than BER 16 QAM, and percentage of coverage area that obtained was around 96%.

Keywords-OFDM; QAM; trees; 10 GHz; mobile station

I. PENDAHULUAN

OFDM (Orthogonal Frequency Division Multiplexing) was one of the transmission technique. Some research was related with OFDM technique such as DFT (Discrete Fourier Transform) with spectral based OFDM [1], Edge Windowing for systems based OFDM [2], and transmitter power with constraint of intervention threshold for cognitive at OFDM systems [3]. The communication propagation between Base Transceiver Station with mobile station could be influenced by obstacle. Some research was related with an obstacle at communication propagation, such as the communication system through trees used Giovanelli Knife Edge method at 2.3 GHz frequency [4], determination mobile station location through building was used AoA (Angle of Arrival) method at 47 GHz frequency [5], propagation for RBS femtocell at pole lamp was used 10 GHz frequency [6], diffraction effect was caused by building environment at millimeter wave [7], diffraction measurement at building environment was used 10 GHz frequency [8], measurement for multipath characteristic was used 28 GHz frequency [9], and adaptive modulation and coding around building [10].

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

This research described about the propagation of mobile communication around the tree. The mobile station was moving at line communication of road. Every node at line communication through tree. Characteristic propagation of communication systems through tree. That tree was caused diffraction. Single Knife Edge method was used for that diffraction The transmission system was used OFDM with modulation of QAM (Quadrature Amplitude Modulation). The communication was obstructed by tree. The contribution for this research was used for development mobile communication around trees with frequency communication of 10 GHz. That frequency was used for this research because that was used for development research of mobile communication. The analysis that was used consisted of transmitter power variation, and communication modulation variation. The comparison for analysis was used power transmitter at communication systems. The transmitter power that was used consisted of 0.1 watt and 1 watt. The communication modulation that was used consisted of 16 QAM and

64 QAM. As the result showed that signal to noise ratio value, bit error rate, amount of bit error, and percentage of communication coverage.

II. METODE PENELITIAN

A. *Environment Model*

In this research showed the communication propagation with trees obstacle. The model of communication environment was consisted of 300 meter for long road, 2 meter for wide walk street, and 8 meter for wide road. The trees were modeled 10 meter of distance between trees and 2 meter of high trees. The communication model as shown in Figure 1.

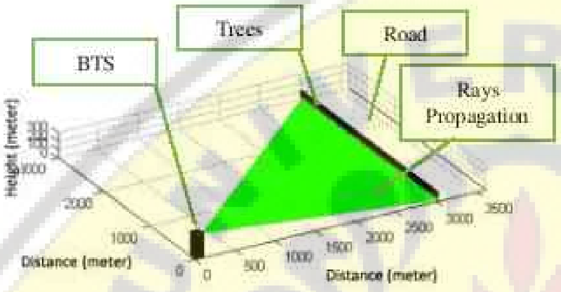

Fig. 1. The propagation of model with tree obstacle

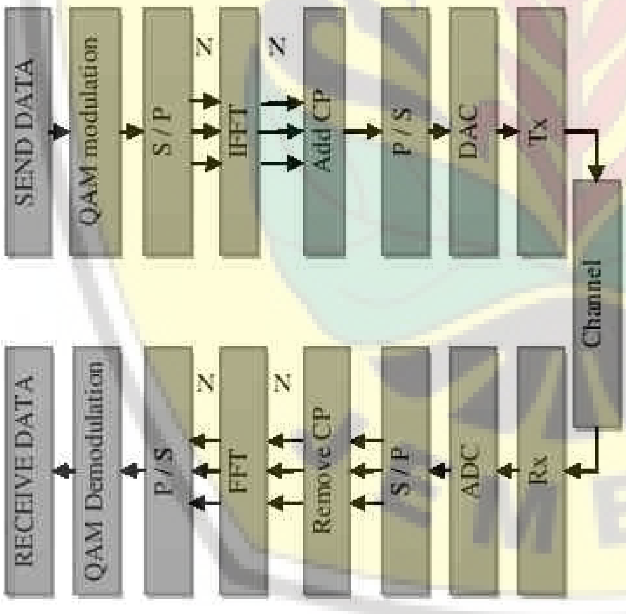

Fig. 2. OFDM block diagram

B. *Propagation*

Noise value for communication systems could be seen at equation (1). At Equation (1) showed noise figure (F) value was used 7 dB, and T_0 parameter was used 290° K, 3 x 10^{-23} Boltzman constant [18], 200 MHz bandwidth with channel amount of 8. Path loss value could be seen at equation (2).

$$N = kT_0 B\ F \quad (1)$$

$$L = G_T G_R \left(\frac{\lambda}{4\pi d}\right)^2 \quad (2)$$

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

$$SNR = \frac{S}{N} \quad (3)$$

The SNR value was obtained from S value as signal (dB), and N parameter of noise. The transmission communication of this research was used orthogonal frequency division multiplexing (OFDM), that transmit multiple data symbols continuously used subcarriers orthogonal. The transmission system diagram that used OFDM, could be seen in Figure 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 receiver, Analog Digital Converter (ADC), remove cyclic prefix, serial to parallel, FFT, parallel to serial, QAM demodulation, and receive data.

Receive data block was bit sequence that will send. QAM principle was information data sequence that was send and converted to parallel form, originally bit rate of R, M parameter was parallel line amount that was same with sub carrier amount. The S/P block that used for change of serial data bit become parallel data bit. Generate subcarrier at OFDM system used technique of invest fast furrier transform (IFFT) subcarriers and orthogonal for every duration at OFDM symbol. Guard interval was used cyclic prefix (CP). The distance between sub carrier (Δf) and time duration from OFDM symbol was 1/Δf + cyclic prefix, that function for orthogonal guard between subcarrier.

That cyclic prefix that used for extended of OFDM symbol, such as with multiply method of last sample part at OFDM symbol become add at first sample part. The observed at equation (4), that showed symbol period of T_{symbol} . T_{sample} parameter was period for data part, and T_{cp} parameter was addition part that taken from that data.

$$T_{symbol} = T_{sample} + T_{cp} \quad (4)$$

Data $(d_{n,k})$ was placed at scale group of N and n block modulated become wave form of exponential complex $\phi_k(t)$, can be seen at equation (5) until equation (7).

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

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

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

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

P/S block at receiver side was block that used for change of parallel data bit become serial bit data. CP addition block at transmitter side constitute cyclic prefix block, where at that block carried was add bit of CP. P/S block at 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 Figure 2 IFFT block that used for accomplish 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 frequency domain become time domain.

S/P block at receiver side constitute block that used for change of serial data bit become parallel data bit. Block for CP remove at receiver side was process 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 taken from QAM modulation. Demodulation process based orthogonal at subcarrier $\phi_k(\tau)$, could be seen at equation (8) [19].

$$\int_N \phi_k(t)^*{}_l(t) dt = T_d \delta(k-l) = \begin{cases} T_0 & k = 1 \\ 0 & another \end{cases} \quad (8)$$

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. RESEARCH RESULT

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

The modulation variation that used consist of 16 QAM and 64 QAM. The communication relation of SNR value with BER for modulation 16 QAM, was shown in Figure 3. Figure 4 showed bit error value for modulation 16 QAM. Some data when used 16 QAM modulation, MS movement of 14 meters and transmitter power was used 0.1 watt, so that SNR value was obtained 33 dBW with value bit error of 0 bit from 5.76 x 10^6 bit. When MS movement of 290 meters was obtained SNR value of 17 dBW with value bit error of 0 bit from 5,76x10^6bit.

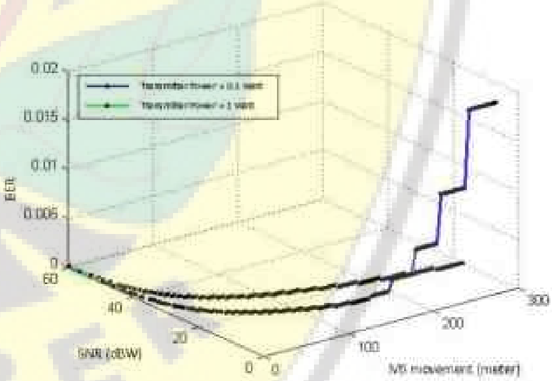

Fig. 3. SNR and BER with modulation 16 QAM

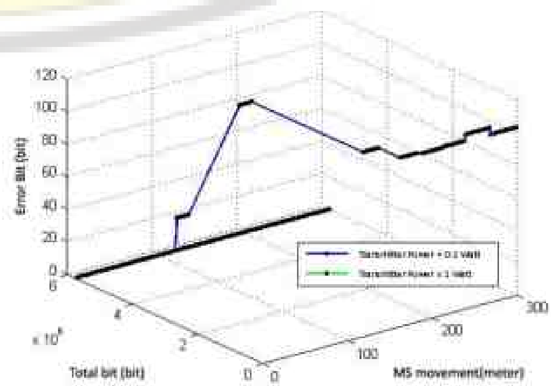

Fig. 4. BER for modulation 16 QAM

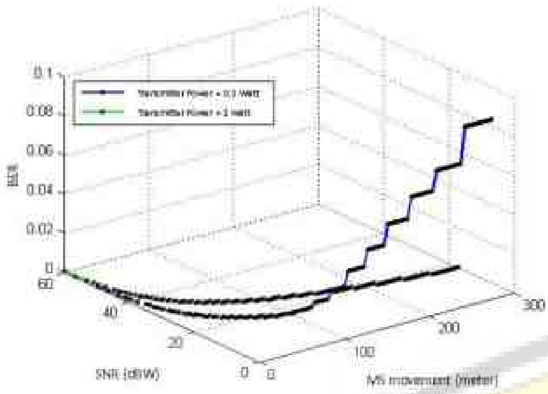

Fig. 5. SNR and BER with modulation 64 QAM

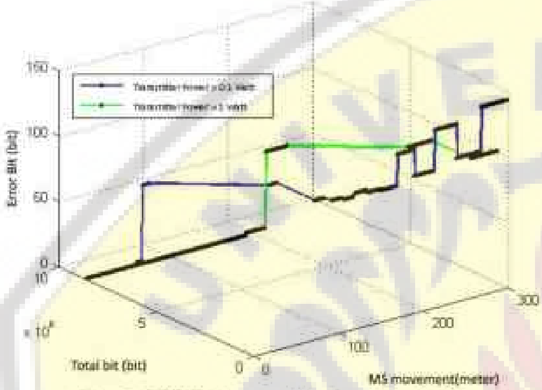

Fig. 6. BER for modulation 64 QAM

At Figure 5 showed relation from communication SNR with BER for modulation 64 QAM. At Figure 6 showed bit error value for modulation 64 QAM. Some data when usage modulation 64 QAM. MS movement of 14 meters and transmitter power 0.1 watt that was obtained SNR value of 33 dBW with value bit error of 0 bit from 8,64x10^6 bit. When MS movement of 290 meters was obtained SNR value 7 dBW with value bit error of 144 bit from 1728 bit, so BER value 0,0833 dB. When used modulation 64 QAM with MS movement of 14 meters and transmitter power 1 watt so was obtained SNR value 43 dBW with value bit error of 0 bit from 8,64x10^6 bit, so BER value 0 dB. When MS movement of 290 meters was obtained SNR value 17 dBW with value bit error of 101 bit from bit amount 538.272 bit, so BER value 0,000188 dB.

At Figure 7 showed relation between BER value with mobile station movement. That figure showed result from transmitter power variation 0.1 watt and 1 watt, and communication modulation variation was consisted of 16 QAM and 64 QAM. Transmitter power usage 1 watt with communication modulation of 64 QAM showed with green color line. Line for that green color didn't seen at figure, because BER value from communication did not have bit error result.

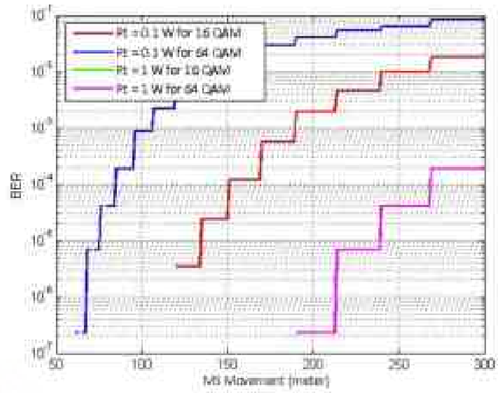

Fig. 7. Comparison BER value

Mobile station movement along track with trees obstacle was obtained percentage of coverage area 96%. That coverage area was note or location where communication between base transceiver station with mobile station could be happened.

IV. DISCUSSION

This section was described about propagation for mobile station around tree at the road. Some of the tree could be effect at mobile communication. That propagation was used single line signal direction to node. Percentage coverage for that communication was obtained 96%. Some attenuation influenced at communication systems and modelled by trees and atmospheric. The atmospheric attenuation was consisted of oxygen and water vapor.

Some data for transmitter power of 1 watt, when used modulation 16 QAM such as MS movement at 14 meters obtained SNR 33 dBW, and MS movement at 290 meters obtained SNR 7 dBW. When used modulation 64 QAM such as MS movement at 14 meters was obtained SNR43 dBW, and MS movement at 290 meters was obtained SNR 17 dBW.

Some data for BER value when used transmitter power 0.1 watt at 16 QAM such as MS movement at 14 meters was obtained BER of 0, and MS movement at 290 meters was obtained BER of 0.017882. When used modulation 16 QAM and transmitter power 1 watt was obtained BER value such as MS movement at 14 meters was obtained BER of 0, and MS movement at 290 meters was obtained BER of 0.

Some data for BER when used transmitter power 0.1 watt at 64 QAM such as MS movement at 14 meters obtained BER of 0, and MS movement at 290 meters obtained BER of 0.0833. When used modulation 64 QAM with transmitter power 1 watt was obtained BER value such as MS movement at 14 meters obtained BER of 0, and MS movement at 290 meters obtained BER of 0.000188.

V. CONCLUSION

The section described conclusion from this research. Some result was obtained such as SNR value of communication, BER value, and percentage coverage area of mobile station track. SNR value was increasing when transmitter power was increased. BER value was increasing when mobile station was moved far away from base transceiver station, such as BER value of 16 QAM with transmitter power 1 watt lower than 16 QAM with transmitter power 0.1 watt. BER value of 64 QAM with transmitter power 1 watt lower than 64 QAM with transmitter power 0.1 watt. The percentage of coverage area for communication around the tree was obtained 96%.

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