International Research Journal of Advanced Engineering and Science
ISSN (Online): 2455-9024

Analysis of Unsynchronization Carrier Frequency Offset for OFDM System Using Moose Estimation Method

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***Abstract*— *One of the greatest technology in telecommunications technology is a modulation technology. Variety of modulation technology offers a lot of advantages but there are also disadvantages, and it will always be corrected so we can get better technology. One of such technology is Orthogonal Frequency Division Multiplexing (OFDM), in this research using CFO moose techniques to overcome the frequency offset in OFDM. The simulation results showed that the level of accuracy and range estimation CFO is directly proportional to the value of SNR, the number of sample preamble CFO estimation and correction residue.Range Moose method between -0.4 and 0.4, with the MSE reached 1.48 x 10-5 when SNR 20dB. In the range -0.4 to -0.5 or 0.4 to 0.5 MSE and BER will increase drastically. Moose estimation method is not recommended for estimation of CFO more than 0.5 because it produces very large BER namely 0,5. increase correction residue in the system can reduce BER and increase the range estimation especially at lower SNR of 20dB.*

***Keywords*— *OFDM; Carrier Frequency offset; SNR; Moose Estimation; Bit Error Rate*.

I. INTRODUCTION

One of component in wireless communication is a modulation processing. Some modulation technology offers a lot of advantages but there are also disadvantages, and it will always be corrected so we can get better technology. One such technology is the Orthogonal Frequency Division Multiplexing (OFDM) [1]. OFDM is a transmission technique that uses multiple frequency (multicarrier) which are mutually perpendicular (orthogonal). Each of these sub-carriers are modulated with a conventional modulation techniques at low symbol rate. One key principle of OFDM is a modulation scheme using a low ratio of symbols that have small effect intersymbol interference of multipath fading and interference due to noise [2]. OFDM is a system that has high capacity and resistant to fading, but vulnerable to the Carrier Frequency Offset (CFO) caused by the Doppler effect. CFO can cause a shift in the frequency and causes the modulus on the system becomes constant. Therefore, the CFO should be minimized in order to get better system performance, it would require an estimator to minimize the CFO that occur [3].

Muhroni Kadaryanto has done research on "Blind Carrier Frequency Offset Estimation in Ofdm Systems With Constant Modulus", estimator that used was estimator Blind. Blind estimator is very good for getting high bandwidth efficiency as well as effective in estimating CFO [5]. Whereas in our study to analyze the influence of the carrier frequency offset using the estimated moose to see the effect of Bit Error Rate (BER) to frequency offset and Bit Error Rate (BER) to Signal Noise Ratio (SNR).

II. THEORY

A. Orthogonal Frequency Division Multiplexing (OFDM)

Orthogonal frequency division multiplexing (OFDM) is a technique that uses a multicarrier transmission, which divides the frequency spectrum into multiple subcarrier. While the orthogonal signal is a signal that is perpendicular and overlapping (overtaking each other) between one another. So the system that applied OFDM technique can strengthen the signal when transmitted over frequency selective fading channels.

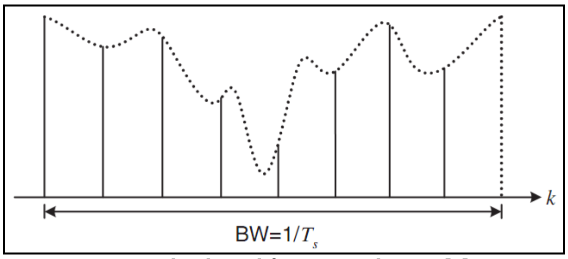

Fig. 1. The channel frequency selective. [2]

The main process in the OFDM modulation is occurring on a block inverse fast Fourier transform (IFFT) and fast Fourier transform (FFT) where the transmitter IFFT transform the frequency domain signal into the time domain, and at the receiver, the signal is returned into time domain signals in the frequency domain through the FFT process. OFDM transmission scheme show in Figure 2 [3].

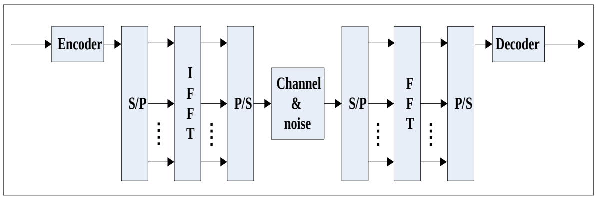

Fig. 2. Schematic transmission system IFFT and FFT. [2]

In OFDM, subcarriers used at a frequency f0, f1, f2, ..., fn-1 must be mutually orthogonal to each other.

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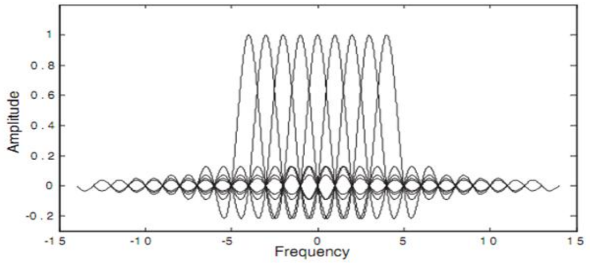

Fig. 3. The spectrum of the OFDM signal 9 subcarrier. [2]

B. IFFT and FFT

IFFT and FFT process is key in OFDM. IFFT serves as a symbol of manufacture (modulator) OFDM and FFT as decomposers of OFDM symbols (demodulator) [6]. FFT and IFFT equation can be written as follows.

FFT:

$$x(k)=\sum_{n=0}^{N-1}x(n)sin\left(\frac{2\pi kn}{N}\right)+j\sum_{n=0}^{N-1}x(n)cos\left(\frac{2\pi kn}{N}\right) \quad (1)$$

IFFT:

$$x(n)=\sum_{n=0}^{N-1}x(n)sin\left(\frac{2\pi kn}{N}\right)-j\sum_{n=0}^{N-1}x(n)cos\left(\frac{2\pi kn}{N}\right) \quad (2)$$

Input of the IFFT OFDM signal is a time domain, it is does'nt matter because IFFT is a mathematical concept, so no matter what the output and input of the system, as long as the input have amplitudes of several sinusoidal, IFFT will produce a value in the form of time domain [4].

C. Cyclyc Prefix

Before the signal is sent, a guard interval inserted between symbols to prevent Inter Symbol Interference (ISI) caused by multipath. Cyclic Prefix which serves as a Guard Interval is longer than the delay in multipath propagation channels. Guard interval insertion can be seen in Figure 4. In the cyclic prefix insertion should be longer than the delay spread channel. So that the total of the symbol period becomes:

$$T_{total}=T_{Guard}+T_{Simbol}$$

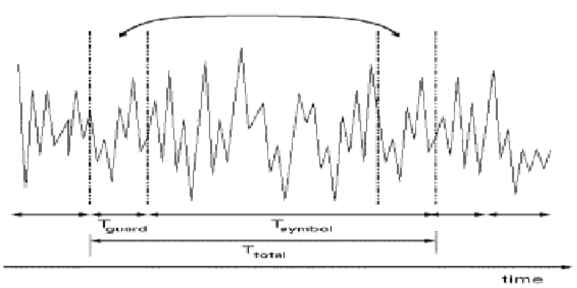

Fig. 4. The addition of the symbol cyclic prefix.

Cyclic prefix that has been transmitted during the guard interval, is consist of the end OFDM symbol which is copied to the guard interval, and the guard interval is transmitted followed by an OFDM symbol. The reason of guard interval consists of copies the end OFDM symbol is that the receiver will integrate each multipath through an integer number of cycles of sinusoid when the FFT OFDM demodulation process. After the OFDM symbol is added to the Cyclic Prefix, the symbols transmitted.

D. Carrier Frequency Offset (CFO)

CFO is differences frequency signal between transceiver and receiver oscillator. This occur because shifting of both, so it's make different frequency that can cause the inter carrier interference (ICI).

In Figure 5 shows that the frequency offset can shift the received signal, thus causing an offset between the matched filter and the received signal.

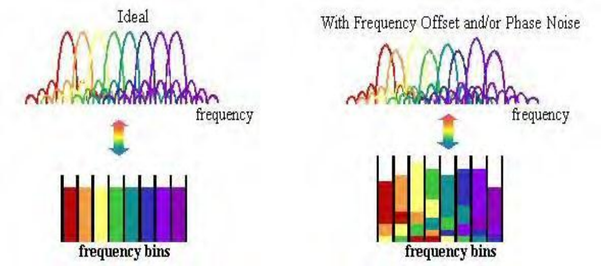

Fig. 5. Frequency offset on the signal.

E. Additive White Gaussian Noise (AWGN)

AWGN is a channel model for analyzing modulation schemes and add Gaussian noise to the signal passing through it. AWGN is a simple model with a density of white noise spectrum that remains and has distributed amplitude Gauss. The concept of the AWGN is generating random samples that have an amplitude distribution Gauss, and then randomly distributed. AWGN is one type of noise,on communication system is thermal noise. Thermal noise caused by movements of electrons in telecommunications systems, for example on the receiving device. On frequency, thermal noise has a same spectrum density value for a wide frequency range, like thermal noise. The movement of electrons causes thermal noise is random, so that the magnitude of thermal noise is also changed randomly with time. Random changes can be predicted statistically ie Distribution.

With the following equation:

$$f(n)=\frac{e^{\left(\frac{\pi^2}{2\sigma^2}\right)}}{\sqrt{2\pi\sigma^2}} \quad (3)$$

With :

Mean = 0 dan variance = σ^2

Variance have value:

$$\sigma^2=\frac{N_0}{2T_b} \quad (4)$$

With:

$\frac{N_0}{2}=\frac{KT_sB}{2}$ Is the noise power spectral density and T_b is bit rate, thus:

$$\sigma^2=\frac{KT_sB}{2T_b} \quad (5)$$

Where:

K: Boltzman Constanta (1,38.10^{-23}J/K)

T_s: Noise Temperature (K)

B: Bandwidth Noise (Hz)

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III. Results and Discussion

In this section we show output simulation and some discussion our research. Figure 6 is preamble additions. Required additional symbol training/ preamble which will be used for synchronizing the frequency in the receiver. Training symbol consists of 2 identical symbols/ recurring. Then the signal is applied to the IFFT (Inverse Fast fourrier Transform), for an OFDM symbol. The use of IFFT cause frequency orthogonally and change the time domain into the frequency domain.

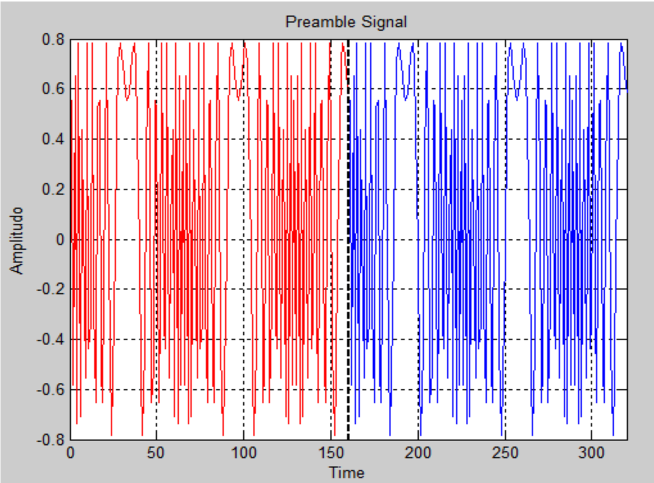

Fig. 6. Preamble Signal.

To reduce ISI, using cyclic prefix. In the simulation, the lenght of cyclic prefix is 25% from the length of the OFDM symbol. Figure 7 shows one simbol OFDM signal, the beginning of the red signal describe cyclic prefix which is a 25% copy of the last part of the OFDM symbol and a blue signal is OFDM symbol.

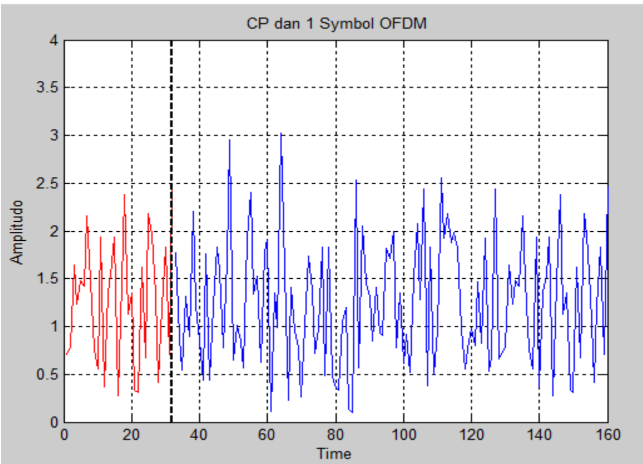

Fig. 7. The OFDM symbol plus CP in Tx.

Figure 8 shows constellation signal after CFO added. The smaller SNR signal means the signal is getting distorted. While figure 9 shows signal constellation after the correction using the value of the previous CFO estimation results. Better signal constellation (approaching the OFDM signal constellation) when compared with the constellation before synchronization frequency. The higher the SNR, the signal closer to the signal ideall

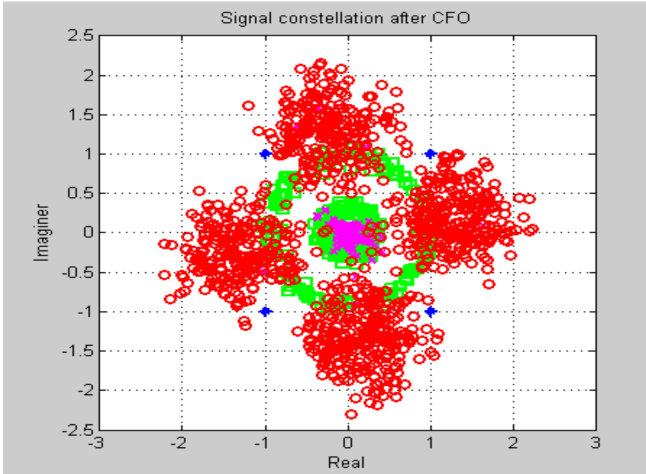

Fig. 8. Constellation graph of OFDM signal after add CFO.

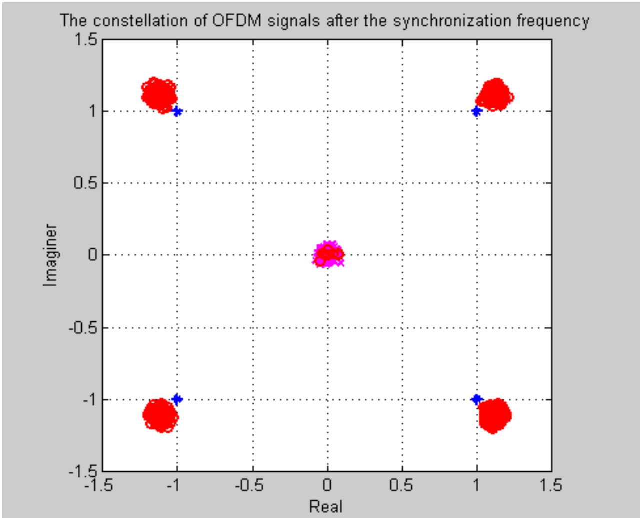

Fig. 9. Constellation graph of OFDM signal after synchronization.

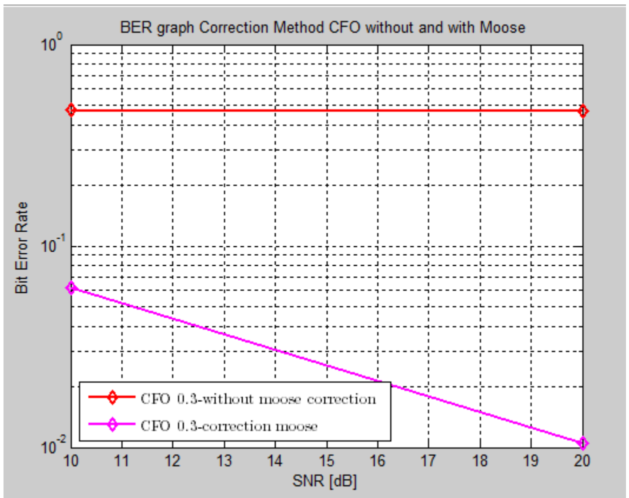

Fig. 10. Graph of BER vs SNR without and with correction moose methods.

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On without correction, the value of BER will be inversely proportional to SNR, while estimation accuracy Moose is directly proportional to the value of SNR.

CFO correction can improve system performance (BER). From the chart above can be analyze that more accurate an estimate (MSE is small), BER is getting smaller.

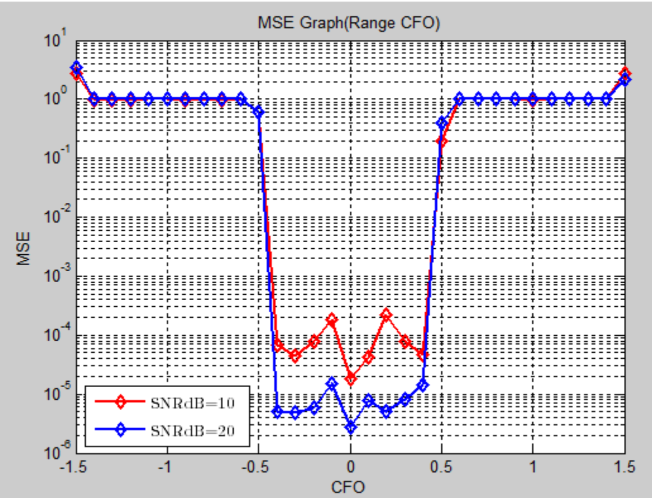

Fig. 11. Graph MSE Range CFO.

It is known that the range of Moose estimation methods affected by the received signal SNR. When the SNR is 20 dB Moose accurate estimate for CFO range between -0.4 to 0.4 which produces 7.9 x 10-5dan BER MSE is smaller than 0.04 The effect of residual correction is not significant when signal SNR is high.When SNR in 10dB then the estimated Moose experiencing sizable error as shown in Figure above, Moose Range becomes narrower estimate that the CFO -0.3 to 0.3.

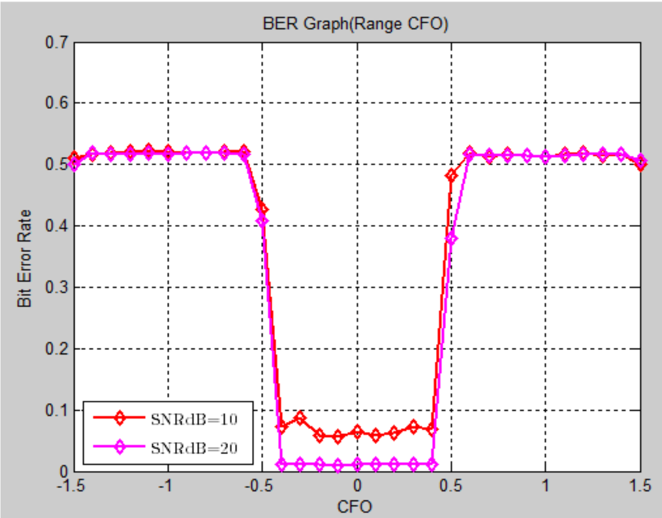

Fig. 12. Graph BER (Range CFO).

Moose technique when SNR 10dB can better correct the CFO 0.3 while at 20dB moose can correct better the CFO 0.2

IV. Conclusion

OFDM techniques is sensitive to time shift and Carrier Frequency Offset (CFO). CFO causes the OFDM system performance decreases. So it is necessary to estimate the CFO and correcting the received signal. In this study the frequency synchronization process simulation designed in OFDM-based modulation 4QAM. CFO estimation performed in the frequency domain using a preamble which was introduced by moose technique. The simulation results showed that the level of accuracy and range estimation CFO is directly proportional to the value of SNR, the number of sample preamble CFO estimation and correction residu. Moose method can estimate and correction of CFO between -0.4 and 0.4, with the MSE reached 1.48 x 10-5 when SNR 20dB. In the range -0.4 to -0.5 or 0.4 to 0.5 MSE and BER will increase drastically. Moose estimation method is not recommended for estimation of CFO more than 0.5 because it produces very large BER which is 0.5. Adding correction residue in the system can reduce BER and increase the range estimation especially at lower SNR of 20dB. MSE and BER estimation SNR is inversely proportional to the signal. Increasing the number of samples preamble 4, 8 and 16 will increase the accuracy of the estimates, the estimated range and lower BER.

For further research simulations Carrier Frequency Offset with moose method will be applied to the hardware in the form of Universal Software Radio pheriperal (USRP).

V. Acknowledgment

we would like to thank the Politeknik Negeri Madiun support research funding.

References

[1] Yofie Harfana Sarif, "Analysis of effect of noise on bit error rate (BER) System orthogonal frequency division multiplexing (OFDM)," Teknik Elektro, Universitas Diponegoro, Semarang, 2009.

[2] T. Nguyen, D., "Implementation of OFDM systems using GNU radio," *IEEE International Multitopic Conference (ITMIC'04)*, Lahore, Pakistan, pp. 201-207, 2004.

[3] Muhroni Kadaryanto and Gamantyo Hendrantoro, "Estimasi blind carrier frequency offset pada sistem OFDM dengan modulus konstan," Jurusan Teknik Elektro-FTI, Institut Teknologi Sepuluh Nopember, Surabaya, 2008.

[4] Kusuma Abdillah, Ir Yoedy Moegiharto, MT, "Analisa kinerja orthogonal frequency division multiplexing (OFDM) berbasis perangkat lunak," Politeknik Elektronika Negeri Surabaya, 2010.

[5] Muhroni Kadaryanto, Gamantyo Hendrantoro, and Titiek Suryani, "Estimasi blind carrier frequency offset pada sistem ofdm dengan modulus konstan," Jurusan Teknik Elektro-FTI, Institut Teknologi Sepuluh Nopember Kampus ITS, Keputih-Sukolilo, Surabaya-60111.

[6] Hamid Saeedi-Sourck, Yan Wu, Jan W. M. Bergmans, Saeed Sadri, and Behrouz Farhang-Boroujeny, "Sensitivity analysis of offset QAM multicarrier systems to residual carrier frequency and timing offsets," *Signal Processing*, vol. 91, issue 7, pp 1604-1612, July 2011.

[7] Jun Wang, Bao Guan, Shou-yin Liu, and Wen-wu Xie, "Frequency offset estimation based on peak power ratio in LTE system," *The Journal of China Universities of Posts and Telecommunications*, vol. 20, issue 6, pp 49-54, December 2013.

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