International Journal of Engineering Research and Technology.
ISSN 0974-3154 Volume 11, Number 10 (2018), pp. 1633-1640

http://www.irphouse.com

Improving jacks model using a Kalman filter in the OFDM system

ADIL HAMEED SHAKIR[1]

[1] *Najaf Technical Institute, Al-Furat Al-Awsat Technical University, 31001 Al-Najaf, Iraq. inj.adl@atu.edu.iq*

Mohemmed Abdulmahdi Mohammed Ali[2]

[2] *College of Health and Medical Techniques\ Kufa Al-Furat Al-Awsat Technical University, 31001 Al-Najaf, Iraq.*
kuh.muh1@atu.edu.iq

FAHAMA Hassoon Salman[3]

[3] *Najaf Technical Institute, Al-Furat Al-Awsat Technical University, 31001 Al-Najaf, Iraq.*
inj.haso@atu.edu.iq

AL-GBURI Maki Jebur Kadhim[4]

[4] *Najaf Technical Institute, Al-Furat Al-Awsat Technical University, 31001 Al-Najaf, Iraq.*
inj.mke@atu.edu.iq

Abstract:

Due to rapid development in a wireless communication system, the researches focus on the improving the quality of the service provided by this system by reducing the bit error rate for giving an exact replica for the source signal in the destination taking into consideration the complexity of the system and optimal channel exploitation. A radio frequency OFDM system simulation model using MATLAB Simulink environment has been presented in this paper. The model contains the essential component of the communication system (transmitter, receiver & channel). The channel model & signal generated via transmitter output has been used as IEEE 802.11a standards. To reduce the Doppler effect the receiver was modified by adding Kalman filter section. The system is more complex than the standard but batter result appeared. both real system and simulation have been handled in radio frequency, so the result can be compared.

Keywords: Jake’s model, IEEE 802.11a. , Kalman filter, equalizer.

I. INTRODUCTION

Mobile communication is developing in the world widely and continually evolve by expanding the quantity(bit rate) and quality of the services provided for satisfying the user's request. This development is realized either by improving the existing network or creating a new global network infrastructure. However, the large congestion of the allocated frequency ranges has hampered the further development of the first direction. The use of the latest technologies and scientific discoveries in the field of communication and signal processing made it possible. Furthermore, the complexity of communication systems has sharply increased. Development and planning of such systems are not possible without the use of methods of mathematical modeling. Modeling is the process of constructing an object model and investigating its properties by examining a model. Thus, modeling involves two main steps: development of a model & Model research and derivation.

At the same time, different tasks are solved at each stage and different methods are used. At present, wireless information transmission systems using radio signals with orthogonal frequency division multiplexing (OFDM) are becoming increasingly broadly which allow increasing the transmission rate, the spectrum of signals and mobility of users required[1]. By development of microprocessor technology allows the creation of inexpensive transceivers. One of OFDM disadvantage is sensitivity to the Doppler Effect, which limits the use of OFDM in mobile systems. The second source of interference is multipath propagation and the third disadvantage is the high requirements for synchronization of frequency and time[2]. When the subscriber moves, the communication system parameters change, so a device is needed that monitors the signal parameters. To decrease the Doppler effect in OFDM technology, it is necessary to use an equalizer. In this paper, mitigation the Doppler by modifying Jack’s model.

II. JAKE’S MODEL

Jake’s model is widely used for the representation of the dynamic channel due to its simplicity for producing a channel complex gain samples which be statistically reliable. The frequency of signal has been computed by the simulation model characterized by the actual physical channel model that equally distributed scattered around a circle Simulations[3].

III. OFDM

Digital modulation use multiple subcarriers within the same single channel is called Orthogonal Frequency Division Multiplexing (OFDM) used before the signal processing [4]. OFDM technology is also used in advanced wireless data transmission systems of the 4th generation. An increase in the transmission rate, a spectrum of signals and an increase in the mobility of users requires the development of new signal-code structures, methods for estimating the data transmission channel, various ways to reduce the cost of constructing transceivers and specialized channel-level microcircuits[1]. As we mentioned earlier one of the OFDM disadvantages. One of them is sensitivity to the Doppler effect, which limits the use of OFDM in mobile systems. The IEEE 802.11a standard, based on OFDM, speeds of data up to 54 Mbps[4]. This standard work within 3.7 0r 5 GHz band and the ranges indoor/outdoor ranges from 35m to 125m. This type of standard used antennas type (SISO) , and is widely used and is used worldwide [5].

IV. EQUALIZER

To receive OFDM signals correctly, reduce errors in the signal is used at the stage of receiving a device that compensates or reduces the distortion in the spectrum of signals received and to struggle the Doppler effect in OFDM technology, it is necessary to use an equalizer[6]. There are many kinds of the equalizer, will mention some of them:

1- Fractionally-Spaced Equalizer (FSE)

   the sampling of incoming signal identifies the operation of this equalizer which is at least equal to Nyquist rate[7]. FSE have enough number of taps because the taps in FSE is nearby than another equalizer which is fairly independent of the channel delay distortion. This indicates the channel distortion can be Eliminated by using this type without noise enhancing[8]. The equalizer able to minimize the slop amplitude distortion for a wide range of linear distortion caused by the rectifying synthesizing the adaptation delay by the equalizer. The output signal to noise ratio gain between 2 to 3 dB at 9.6 kbit/s[9].

2- Decision Feedback Equalizer(DEF)

   One of the popular nonlinear equalizers is DEF which is appreciated and reduce ISI (Inter Symbol Interference) [10]. The DFE is complex in design but has good performance .It’s constructed by two parts: feedforward and feedback part the first one composed with the transversal filters and the other one consisted of a feedback transversal filter and a symbol detector to overcome the ISI. The decision output device signal is as same as to the infinite impulse response (IIR). Since the feedback has IIR in his structure, this equalizer can compensate both amplitudes and delay distortion[11].

3- Adaptive Equalization Approach

Adaptive Decision Feedback Equalizer (DFE) it's automatically adaptive according to the varying of the communication channel over time [12]. It reduces the propagation effects and the Doppler Effect. Because of that features will use this type in our work It is used with many modulation systems as PSK this type of filter is given by figure 1

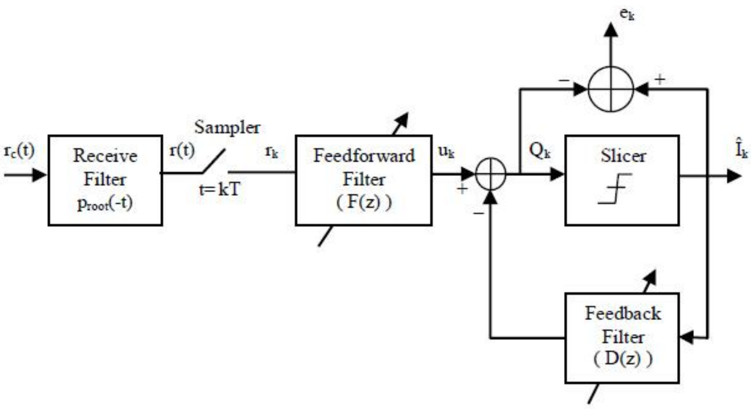

Figure (1) Adaptive (DFE) Diagram

V. KALMAN

The Kalman filter is one of digitals filters types Considered as a MIMO's Filter that can optimally appreciation in real time, system's states depend on its noisy outputs[13]. From measurements that includes random errors. Can estimate the state of the system, that is considered as the purpose of this filter.
Starting by following equation which almost obtained by drop out the state matrix[14]:

$$\hat{X}_k = K_k Z_k + (1 - Z_k).\hat{X}_{k-1} \qquad (1)$$

where:

$\hat{X}_k$: Current estimation, K_k : Kalman Gain, Z_k : Measured value and $\hat{X}_{k-1}$: previous estimation.

The process model can usually be represented as a linear stochastic difference equation as:

$$X_k = AX_k + Bu_k + W_{k-1} \qquad (2)$$

The relation between the measurements and the process state . can be represented with a linear expression as a (3) equation [13] :

$$Z_k = HX_k + V_k \quad (3)$$

$$X_k = AX_{k-1} + Bu_k + W_{k-1} \quad (4)$$

Process and noise measurement respectively can give as a random variables W_k and V_k

Discrete Kalman filter time update (prediction) equations.

$$\hat{X}_k = A\hat{X}_{k-1} + Bu_k \quad (5)$$

$$P^-{}_k = AP_{k-1}A^T + Q \quad (6)$$

Discrete Kalman filter measurement update (Correction) equations.

$$K_k = P.K.H^T HP_k^- (H^T + R)^{-1} \quad (7)$$

$$\hat{X}_k = \hat{X}^-{}_k K_k (Z_k - H\hat{X}_k{}^-) \quad (8)$$

$$P_k = (I - K_k H)P_k^- \quad (9)$$

Where:

$\hat{X}^-{}_k$: prior estimate $P^-{}_k$ prior error covariance and K_k Kalman Gain

Which used for measure update equation are also called posterior values.

VI. MODEL DESCRIPTION

The classical model of the IEEE 802.11a WLAN PHY standard has been used originally that represents the structure of OFDM signals, similar to the modern standards of wireless local area networks such as IEEE 802.11g and IEEE 802.11n a standard 802.11a model that includes such units as:

1) A modulator and a demodulator
2) multiplexer and de-multiplexer
3) blocks of the Fourier transform (direct transformation and inverse discrete transformation).
4) the error rate estimation unit.
5) equalizer.

VII. CONTRIBUTION

The contribution made as shown in the figure 2 at the output of communication channel a pilot and Kalman filter are added rather than demodulator and disassemble OFDM which shifted after Kalman filter. This addition give a batter results comparing with the stander simulation results.

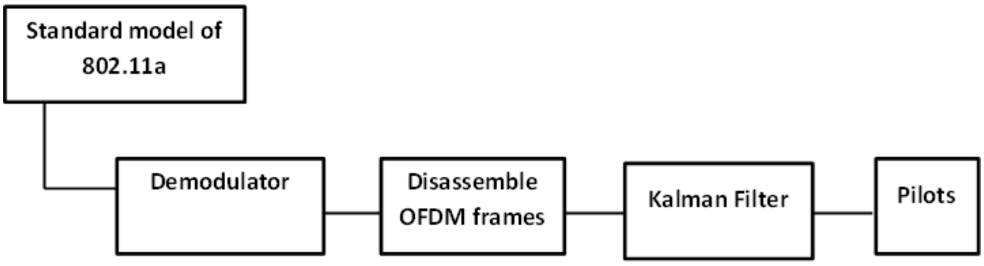

Figure (2) proposed model of 802.11a

VIII. RESULTS

Use in modified model 52 sub-carrier signal, 3 experimental tones, intermittent Fourier transform 64, OFDM codes in each block was 50, Doppler frequency range tested between 30 to 320, contrast 1, carrier frequency 2.4 GHz.

Simulations were performed at a rate of SNR = 30 dB, data transfer rate (54 and 24) megabits per second. Dispersion value used (0.01 & 0.001).

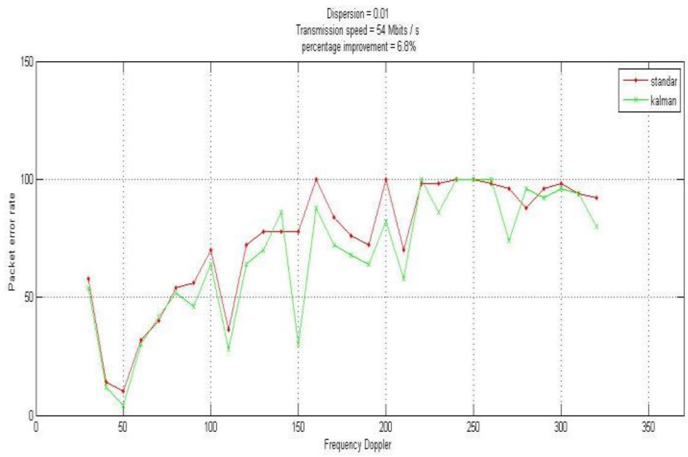

Figure (3): The graph of the error factor versus the Doppler frequency for dispersion (0.01) and transmission rate (54) Mbit/s.

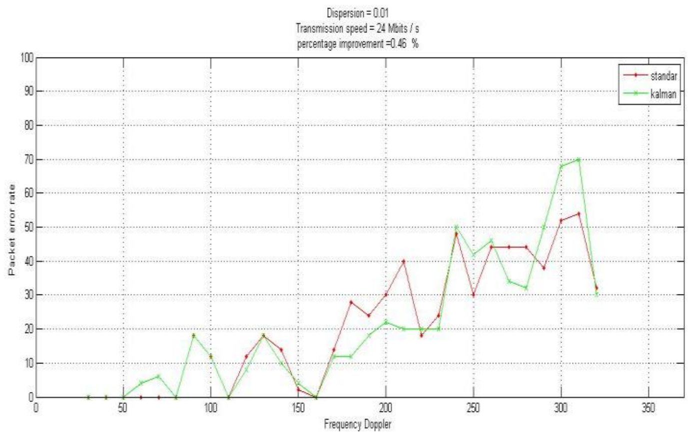

Figure (4): The graph of the error rate versus the Doppler frequency for dispersion (0.01) and the transmission rate (24) Mbit/s

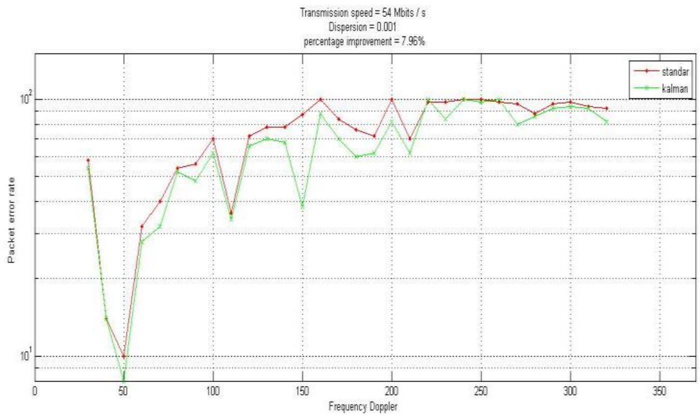

Figure (5): The graph of the error rate versus the Doppler frequency for dispersion (0.001) and the transmission rate (54) Mbits/s

CONCLUSION

The result which observed in this by modification of Jack's model can be summarizing as: First of all, it is possible to increase the accuracy of the complex multiplier estimation of the communication channel compared to the traditional method of filtering. Second, the gain depends on Doppler frequency and the filter parameters. Third, the greatest gain is achieved with the model dispersion equal to 0.001. Finally, The results obtained with the IEEE 802.11a system model can be used to analyze the effectiveness of the Jakes model in networks using OFDM.

REFERENCES

[1] C. Engineering, “Features and Principles of OFDM : A Brief,” *IJIRCCE*, pp. 15209–15213, 2016.

[2] M. Lee, “A Jakes’ channel simulation based on 2-dimensional channel model,” *Int. Conf. Commun. Circuits Syst.*, pp. 261–264, 2004.

[3] R. Safaya and C. Science, “A Multipath Channel Estimation Algorithm using a Kalman filter,”, *Journal of the ICRU,* 1997.

[4] P. A. S. Bhosle, “Modern Tools and Techniques for OFDM Development and PAPR Reduction,” *ICEEOT*, pp. 290–292, 2016.

[5] R. Babiker, M. Abdelrahman, and A. B. A. Mustafa, “A Comparison between IEEE 802 . 11a , b , g , n and ac Standards,” *IOSR-JCE*, vol. 17, no. 5, pp. 26–29, 2015.

[6] M. Abdulmahdi, M. Ali, and A. Bharathi, “COOPERATIVE POWER ALLOCATION AND POWER CONSUMPTION ON SUBCARRIER ANALYSIS USING MIMO-OFDM CHANNEL,” *IJESR*, no. 5, p. 2685, 2015.

[7] T. Hasan-al-mahmud, M. M. Rahman, and S. K. Debnath, “Performance Analysis of Best suited Adaptive Equalization Algorithm for Optical Communication,” *JOURNAL Telecommun.*, vol. 1, no. 2, pp. 35–41, 2010.

[8] B. Razavi, “The Decision-Feedback Equalizer,” *IEEE SOLID-STATE CIRCUITS Mag.*, no. c, pp. 13–17, 2017.

[9] T. Company, “Fractionally-Spaced Equalization : An Improved Digital Transversal Equalizer,” *BELL Syst. Tech. J.*, vol. 60, no. 2, 1981.

[10] T. Zhu, “Optimized Decision Feedback Equalizer Algorithm based on Sparse Underwater Acoustic Channel,” *Rev. Téc. Ing. Univ. Zulia.*, vol. 39, pp. 47–56, 2016.

[11] M. Kumar and K. Rohilla, “Adaptive Equalization of Fractionally Spaced Equalizer Based on Activity Detection and Tap Decoupling,” *IJEIT*, vol. 3, no. 12, pp. 209–212, 2014.

[12] V. Negi, S. K. Shah, S. Singh, A. Shekhar, and T. Sundriyal, “Equalization of Doppler Effect Using Constellation Diagram of 8- PSK Modulation,” *IJCER*, vol. 3, no. 3, pp. 203–208, 2013.

[13] A. Valade, P. Acco, P. Grabolosa, and J. Fourniols, “A Study about Kalman Filters Applied to Embedded Sensors,” *Sensors*, vol. 17, no. 2810, pp. 1–18, 2017.

[14] G. Bishop and N. Carolina, *An Introduction to the Kalman Filter*. 2001.