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LSE Channel Estimation and Performance Analysis of OFDM Systems

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Abstract

Orthogonal frequency division multiplex (OFDM) is one of the best approaches to overcome frequency selectivity of channels. In multiple-input multiple-output (MIMO) orthogonal frequency division multiplexing (OFDM) systems, we purposed channel estimation with least squares (LS) estimation method in this paper. To improve channel estimation achievement a LS algorithm is developed, so we obtain Bit Error Rate (BER) performance of channel. Mean Square Error (MSE) of LS estimation calculated and depicted with figures. Signal to noise ratio (SNR) indicated notable efficacy in this paper that obtained by using the LS algorithm, in particular channels with variation in time.

Keywords : Channel Estimation, LSE, MIMO System, OFDM.

OFDM Sistemlerinde LSE Kanal Tahmini ve Performans Analizi

Özet

Dikgen frekans bölmeli çoğullama (Orthogonal frequency division multiplex-OFDM) kanalların frekas seçiciliğiyle baş etmek için kullanılan en iyi yöntemlerden biridir. Bu çalışmada çok girişli çok çıkışlı (Multiple-İnput Multiple-Output-MIMO) OFDM sistemlerinde kanal tahmini için en küçük kareler (Least Squares-LS) yöntemi önerilmiştir. Kanal tahmininin başarısını ilerletmek için bir en küçük kareler algoritması geliştirilmiştir bunun sonucunda kanalın bit hata oranı (Bit Error Rate-BER) performansı elde edilmiştir. LS tahmin edicinin ortalama karesel hatası hesaplanmış ve şekillerle gösterilmiştir. LS algoritması kullanılan bu çalışmada sinyal gürültü oranı özellikle zamanla değişen kanallarda önemli bir etki göstermiştir.

Anahtar Kelimeler: Kanal Tahmini, LSE, MIMO Sistemler, OFDM.

1. Introduction

In recent years in communication systems data rate is getting high and researchers have notable interest on rapid modulation techniques. As a multicarrier modulation technique OFDM is fairly interested by researchers. Because of its basic application and stability, frequency-fading channels are transformed the channel into flat-fading sub channels. OFDM has been performed for a lot of applications, such as high speed telephone line communication, digital audio broadcasting, wireless local area network digital television broadcasting and lines of digital subscriber. In recent communication systems we can realize a remarkable increased capacity OFDM and multiple antennas together and this enhancement obtained due to diversity of transmit and receive sides. [1]. Adding training pilot symbols at the transmitter in practice implementations, CSI is effective estimated at the receiver. Channel estimation with pilot symbol is especially attractive for wireless communication systems in the channel with varying time [2].

Meanwhile a lot channel estimators use for OFDM, error probability examination availability of channel estimation errors has taken notionally less care. In recent days phase shift keying and quadrature amplitude modulation approximations were progressive about BER performance for channel estimation errors of OFDM [3, 4].

OFDM systems consist completely of pilot symbols because of identifying the multiple training channels. This approach for single input and single output (SISO) systems is showed in [5-7], whereas MIMO systems is detailed described in [8]. Like this application firstly any transmission of data we compute estimation of the CSI. When remarkably changes exist for CSI, reobtaining pilot symbols is transmitted. To estimate the CSI in fast time varying surroundings, we must continuously retrain for such systems. About retraining, these systems are experienced an incremented BER because of their antiquated channel estimates. Wiener filter method as based on a known channel correlation function can be used to advance the estimation of channel parameters [9, 10].

MSE of the channel estimation with LS technique is recommended the pilot symbols have an optimum location for SISO OFDM systems. If this channel estimation technique wanted to length to MIMO OFDM systems, seeing that either the location of the pilot symbol or the pilot sequence must be optimized to enhance the MSE value minimum with channel estimation method with LS [11].

In this paper, based on pilot tones MIMO OFDM system is described with a LS channel estimation scheme. MSE of the channel estimation with LS technique is computed, optimum pilot tones of the pilot subcarriers are supplied. LS channel estimation design for multiple OFDM symbols is debated. LS channel estimation algorithm is proposed to advance estimation application.

The organization of this paper is regulared as trace. In chapter II OFDM technique is explained, LSE channel estimation steps are given in chapter III. Analysis of channel estimation is introduced in chapter IV and conclusions are offered in chapter V.

2. OFDM Technique

Transmission system of the OFDM about account is depicted in Figure 1. High data rate streams of the random input signal are transformed into low data rate streams. The low data rate streams are modulated in parallel subcarriers in the OFDM. This parallel stream is dedicated input to the IFFT block structure. The data is transformed from frequency to time before the data accessed the channel by the IFFT block structure. The data is encoded with adding the cyclic prefix as the guard interval and transmission is succesfulled at receiver [12]. Binary source generator produced the digital input data like as BPSK, QPSK and QAM modulation approach are used to modulate the binary data with several different constellations. The data is transformed frequency domain to time domain by the IFFT block in Figure 2. To insert guard interval known as CP succeed the problems like ICI/ISI with acquiring the delay connected problems at the channel. Before the symbols transmitting to the channel, firstly the symbols of OFDM are in the time domain available length. After that all the operations enforced in the inverse direction and obtained OFDM signal as the output of receiver block. CP insertion in the OFDM modulation is the most extensive technique among all the multicarrier modulations because of its facility and its stability across to multipath fading using the cyclic prefix. Even so this technique caused a decrement of spectral efficiency owing to the CP. Also the OFDM spectrum is not dense because of the large side lobe levels resulting from the rectangular pulse [13].

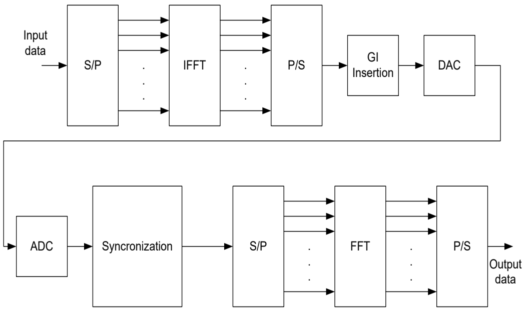

Figure 1. OFDM transmitter and receiver block diagram

OFDM is a typicial multiple channel modulation technique that used to separate to the channel numerous of parallel sub channels and the parallel channels transmit multiple symbols. OFDM has an attractive feature that is considered efficient spectral and also applications of OFDM cope with equalization of dispersive slowly fading channels which is a perfect way. OFDM is used by multiuser systems that exhibited perfect schemes for multiple accesses such as transmission systems with single carrier. When we compared to carrier systems with each other, as a variable modulation technique for multiple access systems OFDM is in that case intrinsically make easy multiple access both time domain and frequency domain.

OFDM also has some imperfections properties. OFDM is sensitive errors of carrier frequency, because a given spectral assignment divides into many narrow subcarriers by OFDM structure with small spacing for subcarriers inherently. Furthermore, to obtain the orthogonality about subcarriers, it needs linear amplifiers. Because of OFDM systems own a high peak to average power ratio the systems require a large amplifier power back off and a many of bits in the analog to digital (A/D) and digital to analog (D/A) designs. So high requirement is available transmitter and receiver sides in OFDM [14].

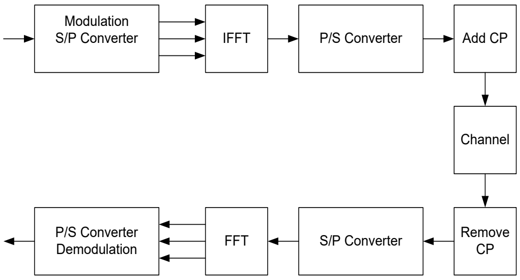

Figure 2. OFDM block diagram

OFDM modulation and demodulation block diagram is given in Figure 2. Guard interval is transformed CP in this figure.

3. Channel Estimation With Least Square Method

In this part, channel estimation with LS design is clarified. Data vector is formulated as $X_r(n)$ in Equation 1.

$$X_r(n) = S_r(n) + B_r(n) \qquad (1)$$

In Equation 1, $S_r(n)$ is some optional Kx1 data vector, $B_r(n)$ is some optional *Kx1* pilot sequence vector and demodulated signal is described in Equation (2).

$$Y_q(n) = \sum_{r=1}^{Nt} diag\{X_r(n)\}Fh_{q,r} + \Xi_q(n) \qquad (2)$$

$$= \sum_{r=1}^{Nt} (diag\{S_r(n)\} + diag\{B_r(n)\}) * Fh_{q,r} + \Xi_q(n) \qquad (3)$$

Taking to FFT of $Y_q(n)$ in Equation (3) we obtained finally as Equation (4).

$$Y_q(n) = \sum_{r=1}^{Nt} S_{r,diag}(n)Fh_{q,r} + \sum_{r=1}^{Nt} B_{r,diag}(n)Fh_{q,r} + \Xi_q(n) \qquad (4)$$

We consider the data model as Equation (5).

$$Y_q = Th_q + Ah_q + \Xi_q \qquad (5)$$

LS estimate of *hq* can obtained as $\hat{h}_q$ and formulated in Equation (6).

$$\hat{h}_q = A^{t}Y_q \qquad (6)$$

Note that equation (6) shows that $\hat{h}_q$ is a composition of the true channel vector h_q and noise vector in the system. We can see whether or not the pilot tones are the same for each ofdm symbol. Namely, same set of pilot tones in ofdm structure is not compulsory.

4. Channel Estimation Performance And Simulations

This section presents enhancement of the MSE of the channel estimation with LS. Results of applications are provided to have optimal pilot sequences and optimal placement of the pilot tones in point of the MSE. In Equation 7, *L* describes the maximum channel length. MSE calculation of the channel estimation with LS is formulated in Equation 7.

$$MSE = \frac{1}{LNt}\varepsilon\left\{\left\|\hat{h}_q - h_q\right\|^2\right\} \qquad (7)$$

Because of obtaining the minimum MSE of the channel estimation with LS linked to a fixed power ρ given for training and zero mean white noise is σ_n^2 in Equation 8.

$$MSE_{\min} = \frac{\sigma_n^2}{\rho} \qquad (8)$$

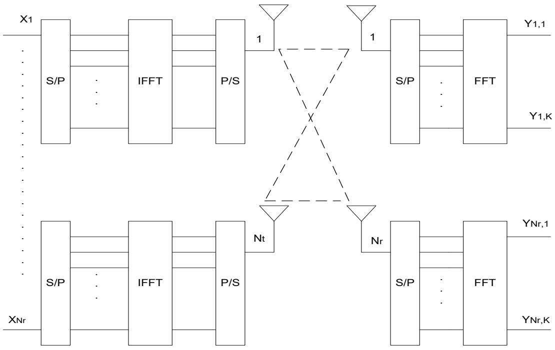

Figure 3. MIMO-OFDM block diagram

Figure 3 is depicted block diagram of MIMO-OFDM. In Figure 3 number of transmit antennas is N_t, number of receive antennas is N_r and number of subcarriers is K. Each transmit or receive antenna which is common practice in wireless communications. Since we extracted the cyclic prefix from the q th receive antenna, $Y_q(n)$ is obtained as $Kx1$ vector length.

To channel estimation in OFDM is used is utilized in conventional OFDM modulator or demodulator. Take for the OFDM symbol that is transmitted from the r th antenna at time index n is denoted by $Kx1$ the vector $X_r(n)$. Before transmission, IFFT is processed to this vector, and v lengthed a cyclic prefix is added. If all channels maximum length is L we obtain that $v \geq L-1$,
pilot symbols. OFDM is directly practicable to techniques from single carrier flat fading systems when each subcarrier is flat fading. The sparse insertion of known pilot symbols is found in pilot symbol assisted modulation (PSAM) on channels with flat fading that is in a stream of data symbols in such systems. When the pilot symbols attenuation is callculated the data symbols attenuations among the pilot symbols are characteristically predicted with the fading channel on time correlation features.

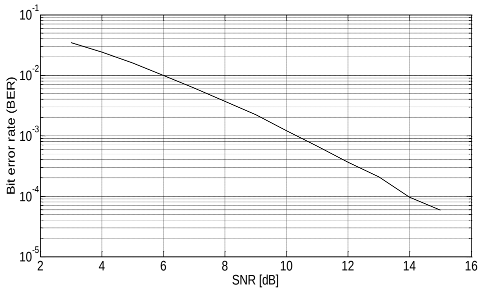

Figure 4. BER versus SNR in LS channel estimation for MIMO OFDM

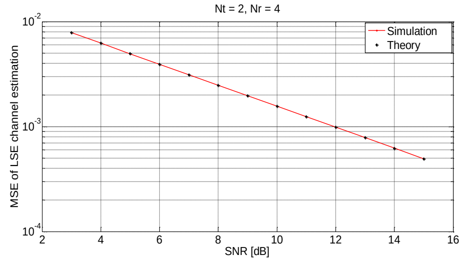

Figure 5. MSE of LSE channel estimation for MIMO OFDM

BER versus SNR in LS channel estimation for MIMO OFDM system application is shown in Figure 4. MSE of LS channel estimation in simulation and theory for MIMO OFDM system is depicted in Figure 5. In application we selected that N_t=2, N_r=4, number of subcarriers is 128 and percentage of guard interval is 0.25. Number of pilot symbols is 64 plus number of the data symbols is 64 we get all of subcarriers.

In literature most of document explains that channel estimation impressions consist of two steps using the channel correlation property. First, correlation of channel technique is attenuations of the data symbols is estimated used to measure and smooth the attenuations at the pilot positions. Then complex valued by these measurements in the second step. Channel correlation properties are used in this second step by filters interpolation technique or a decision directed technique. [15].

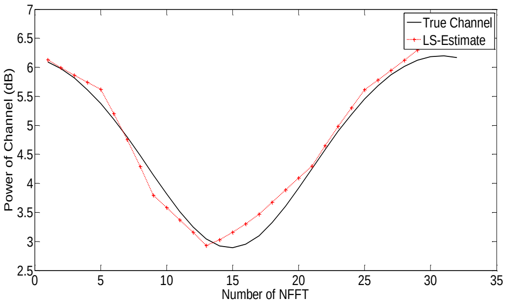

Figure 6. Power of channel with LSE channel estimation and true channel.

In Figure 6 power of estimated channel and true channel with LSE is depicted. Estimated channel power is fairly close to true channel. So this result shows that LS estimation is appropriate for MIMO OFDM channel estimate.

5. Conclusion

This study focused channel estimation with LS method based on pilot tones approach has been evaluated for application of MIMO OFDM systems. The pilot sequences must be equal powered, equal spaced, and obtained orthogonal phase shift to enhance the channel estimation with the minimum MSE. Our results indicates that purposed method about pilot tones the number of transmit antennas are increased so pilot tones for training require more and decreases the efficiency of application. When the channel is slowly time-varying, estimating the channel parameters can reduce this effect over multiple OFDM symbols. Also in next organizations, BER performance will be improve with different from LS estimation method about of MMSE estimation method.

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