A Decision Feedback Channel Estimation Approach of The Satellite Mobile Communication System

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ABSTRACT

In this paper we present a decision feedback channel estimation way for the mobile satellite communication system in order to improve the bit error performance. The transmission is disturbed not only by shadowing and multipath effects and additive white Gaussian noise, but also by the weather attenuation. The conventional Least Square(LS) is not well suited to detect the transmitter sequence, whereas the LS-based decision feedback is able to take into account the fading channel and therefore is able to detect the signal much better. The LS-based decision feedback channel algorithm first estimate channel response, then the estimation channel response use decision feedback estimation to get the next frame channel response. Our simulation results show that LS-based decision feedback channel estimation algorithm performs much better than the origin LS channel estimation method in terms of bit error rate(BER) with a gain of probably 1 dB.

Keywords: *mobile satellite communication system, decision feedback, LS channel estimation*

1. INTRODUCTION

Besides weather attenuation such as rain and snow, satellite mobile communication systems, based on Ka band are seriously influenced by shadowing and multipath effects. These factor make the random process of satellite mobile communication complex and create errors in the satellite mobile communication transmission. In order to improve the bit error performance, satellite communication system use channel estimation to get the channel response. Channel estimation has many ways, such as LS(Least Square), MMSE(minimum mean-square error), LMMSE(linear minimum mean-squared-error) and so on. Wherein the LS channel estimation has the advantages of a simple way, mature technology, low complexity[1] and etc. Therefore the LS channel estimation way is seen as the most promising estimation way. But the LS channel estimation can't accurately get the channel response, which has a greater impact on system bit error performance.

For satellite mobile communication, LS channel estimation has been recognized that LS channel estimation provides highly efficient bit error performance. Recently, C. Tang[2] proposed a received signal in the time domain zero-padded channel algorithm for the high-speed communications created Doppler frequency shift. Zidane[3] used the auto-correlation-based approach and expectation maximization algorithm improved channel estimation performance. M. K. Arti[4] used a channel estimation way and ES transmission signal detection scheme from the satellite to the destination. W. C. Zhong[5] advance the LS channel estimation algorithm based on the power judgment and PLS zero padding algorithm. Y. Wang[6] study the channel fading fast changes made the interpolation way based on minimum mean square error. L. Zhao[7] proposed an estimation way utilizing m-sequence and combination of Orthogonal Frequency Division Multiplexing decision feedback channel. These studies raise improvements only individually from LS channel estimation way, didn't optimized the entire system.

In order to improve the bit error performance in mobile satellite communication system, the paper proposes a decision feedback channel estimation way based on LS channel estimation. Firstly, the received signal uses LS channel estimation to obtain an initial channel estimation response, then in the next frame the received signal divided by the initial channel estimation response is to obtain the signal estimation response. Thirdly the channel response obtained after soft demodulation and soft LDPC decoding the signal estimation response.

The rest of the paper is organized as follow. Section 2 introduces the mobile satellite communication system decision feedback channel estimation scheme. We design the decision feedback channel estimation algorithm which is based on LS channel estimation way in Section 3. In section 4, we simulate the channel estimation way for decision feedback algorithm. Finally, conclusion is drawn in Section 5.

2. MOBILE SATELLITE COMMUNICATION DECISION FEEDBACK CHANNEL ESTIMATION SCHEME

Mobile satellite communication system based on decision feedback channel estimation scheme of the block diagram is shown in Fig.1, which mainly consists of the transmitter, satellite channel, and the receiver.

In the transmit side source signal is processed by LDPC encoding and M-PSK and M-QAM modulation, then the pilot add the signal and the signal sent to the satellite channel.

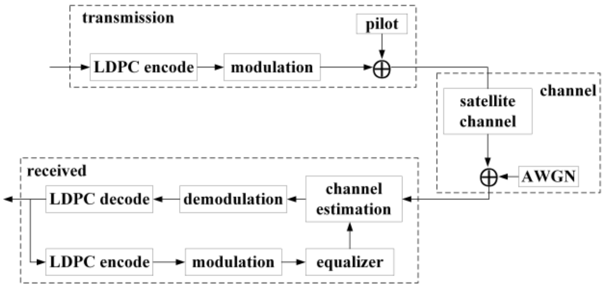

Fig.1 satellite mobile communication system based on decision feedback channel estimation block diagram

In the satellite channel, due to the presence of signal attenuation, the channel model uses the Markov channel model of urban areas. The Markov chain part of the model defines three states for each type of environment plus elevation angle combination representing the follow link conditions. Three states are line-of-signal(LOS) conditions, moderate fading conditions, and deep fading conditions. The markov transition probability matrix[8] in urban areas is shown in Equation (1):

$$P=\begin{bmatrix} 0.8828 & 0.0662 & 0.0510 \\ 0.1447 & 0.8139 & 0.0414 \\ 0.0848 & 0.0471 & 0.8681 \end{bmatrix} \quad (1)$$

And in the Ka-band, the channel has also Rain attenuation characteristics. The transmission signal will ba affected by sun, rain, snow and other weather conditions through the satellite channel. In this paper the satellite channel use the ITU-R rain attenuation model[9]. In the model the different weather conditions, such as rain, snow, are analyzed, respectively.

In the receiving side the received signal $b(n)$ is represented as:

$$b(n)=H(n)\bullet a(n)+\omega(n), n=1,\ldots N \quad (2)$$

Where $b(n)$ represents the received signal, $a(n)$ denotes the transmitted signal, and H_n and $\omega(n)$ are the channel response and the additive Gaussian noise, respectively.

The received signal $b(n)$ execute LS channel estimation to get the channel estimation response H_{n-1}, then the channel estimation response H_{n-1} is processed by decision feedback estimation to obtain the channel estimation response H_n. Decision feedback channel estimation algorithm is as follow:

a) The received pilot signal $P(k)$ is divided by the transmission pilot signal $p(k)$ to get the pilot channel estimation signal $h(k)$.

b) The pilot channel estimation signal $h(k)$ through the linear interpolation way obtain the channel estimation response H_{n-1}.

c) In the next frame, the received signal Y_n is calculated to obtain a signal X_n.

$$X_n=\frac{Y_n}{H_{n-1}} \quad (3)$$

d) The signal X_n is soft demodulation, soft LDPC decoding, after re-encoding, re-modulation getting the signal $\overline{X_n}$.

e) The received signal Y_n divided by $\overline{X_n}$ obtain the channel estimation response $\overline{H_n}$.

$$\overline{H}_n=\frac{Y_n}{\overline{X_n}} \quad (4)$$

f) H_n is averaged by $\overline{H_n}$ and H_{n-1}.

$$H_n=\text{average}(\overline{H}_n, H_{n-1}) \quad (5)$$

3. SIMULATION ANALYSIS

In order to verify the bit error performance of the decision feedback channel estimation way, in Markov channel model, we assume LDPC code rate is 3/4, the modulation way is QPSK modulation. The Markov transition probability matrix is shown as Equation (1).

In urban area, compare bit error rate of LS channel estimation and decision feedback, the simulation results are shown in Fig.2.

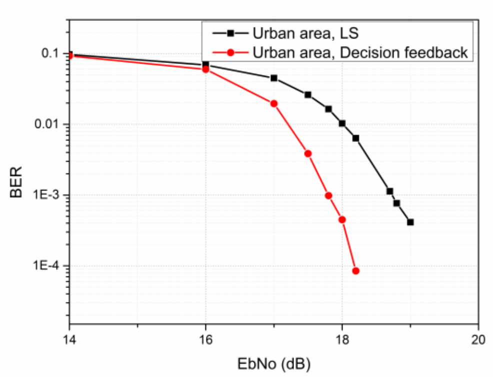

Fig.2 Bit error performance of urban area satellite mobile communication with LS channel estimation and decision feedback estimation.

As can be seen from the Fig.2, bit error performance of decision feedback channel estimation way technology is enhanced by the 1dB than that of LS channel estimation way. This is because when the signal in processed by decision feedback channel estimation, the channel estimation response combine the last channel estimation response and this channel estimation response. The decision feedback algorithm can better estimate the time-varying channel response.

But in Ka-band, satellite channel also has rain fading characteristics. In the satellite channel which has Markov chain model and rain fading characteristics, we compare the bit error rate of decision feedback channel estimation way and that of LS channel estimation way, the simulation results is shown in Fig.3.

It can be seen that in the same weather condition bit error performance of decision feedback channel estimation is better than that of LS channel estimation in terms of uncoded bit error rate(BER) with a gain of probably 1 dB.

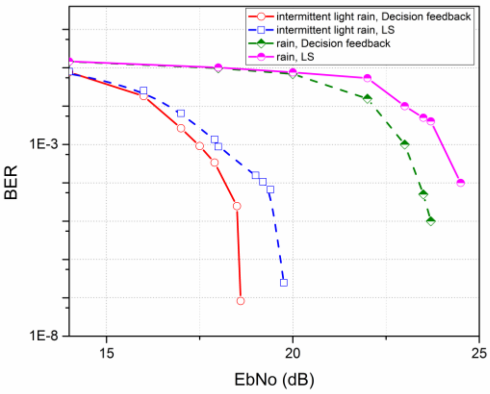

Fig.3 In rain attenuation and Markov channel, the satellite communication system bit error rate.

4. CONCLUSION

This paper has introduced a decision feedback channel estimation algorithm, which is based on LS channel estimation method. This algorithm firstly obtains a channel estimation response value, and then the received signal divided by the last channel response of LS channel estimation to get the channel estimation value which soft demodulation and LDPC soft decoding, thirdly the received divided by the signal that re-code and re-modulation to get the channel estimation response. Using decision feedback channel estimation approach can reduce the number of pilot inserted in the signal and improve the system spectral efficiency. And we also compare the simulation results of the decision feedback channel estimation and the LS channel estimation in the urban satellite channel. Results show that error bit rate of decision feedback channel estimation is lower by about 1dB than that of LS channel estimation. The decision feedback channel estimation approach based on LS channel estimation can effectively improve the system BER performance of mobile satellite communications.

5. ACKNOWLEDGMENTS

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