ISSN (Print) : 2319-5940
ISSN (Online) : 2278-1021

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 2, Issue 3, March 2013

Comparing Slow Fading Channels for Adaptive Equalization and Channel Estimation

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Abstract: Fading channels are multiplicative noise channels and results in spurts of inaccuracies in symbol detection. In this paper we ascertain BER and constellation plots using QPSK modulation for Rayleigh fading channels. Effects of different fading channels on an image are to be examined. Pilot based channel estimation technique proves to be the most operative amongst several available and equalizers are intended to reimburse channel distortions. To study the effect a wireless communication simulator is formed that includes flat fading and frequency selective channel models, adaptive equalization, channel estimation and demodulation. Improvement in the performance of slow Rayleigh fading channel is shown in result.

Keywords: Flat fading, Frequency selective fading, Slow fading, Channel estimation, LMS, RLS.

I. INTRODUCTION

The mobile radio communication industries has developed by orders of magnitude, fuelled by digital and RF circuit fabrication improvements [1]. The mobile radio channel places fundamental impairments on the performance of wireless systems as they are unpredictable and difficult communication medium consisting various path with different time delays [3]. These multiple reflective paths can cause fluctuation in amplitude and phase of received signal that can be experienced as a result of small changes in spatial positioning between transmitter and receiver. This phenomenon is known as small scale fading or simply fading. Small scale fading is called Rayleigh fading if there are multiple reflective paths that are large in number without any line of sight signal component; the envelope of such a received signal is statistically defined by Rayleigh probability density function [5].

Due to the multipath channel there is some intersymbol interference (ISI) in the received signal. Therefore the detection algorithm needs to know channel impulse response (CIR) characteristics to ensure successful equalization (removal of ISI), which is usually estimated by using the known training sequence in the middle of transmission burst [4]. The training sequence at the beginning of each block is used to estimate channel or train an adaptive equalizer. In this paper we are using two types of trained equalization algorithms i.e.Least mean square (LMS) and Recursive least square (RLS) [2,12].

A small scale fading is identified as slow fading if the channel impulse response varies at a rate much slower than the transmitted baseband signal [1]. Our paper aims to build up a slow fading channel scenario for both flat fading and frequency selective fading channel. The concise description of flat fading and frequency selective fading channel is stated in figure 1.

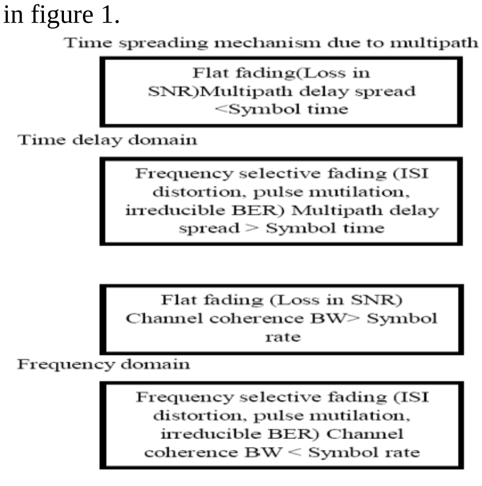

Fig.1 Small-scale fading: Mechanisms, degradation categories, and effects

The rest of the paper is arranged as follows. In the section II, the proposed modal for the slow fading channels is shown. Section III discusses the simulation parameters. Section IV describes the simulation results obtained for flat fading channel and frequency selective fading channel. Finally, section V concludes the paper.

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II. PROPOSED MODEL FOR SLOW FADING CHANNEL

The proposed model is build up by baseband simulation in which the input data source is either a randomly produced data or an image file. Our model uses image file as an input data as it gives an instinctive impression and comparison of BER performance and channel effect due to signal constellation for different channels. PSK modulation technique is used to modulate the data source. In our simulation we test the QPSK modulation [6]. The pilot data length is 8% of the total data length and is inserted into head of source of data in each coherence time. It is used to estimate the random phase shift of fading channel and train the decision to adjust the received signal with phase recover. The received signal constellations of both with and without phase recover are dynamically showed in the simulation.Figure2 shows the flow chart of our Matlab simulation which is used in this paper.

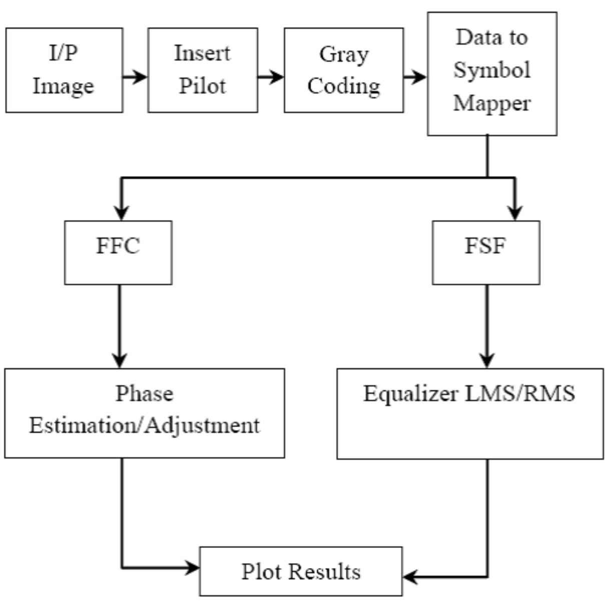

Fig.2 Block Diagram of Proposed Modal for Slow Fading Channel

III. SIMULATION PARAMETERS

For preparing the two scenarios of flat fading channel and frequency selective fading channel following parameters are taken into consideration.

TABLE I
DESCRIPTION of PARAMETERS for FADING CHANNELS

	Flat fading(FFC)	Frequency selective fading(FSF)
Parameters	**Format/values**	**Format/values**
Image name	Baby.png	Baby.png
Mod type	PSK	PSK
M-ary	4	4
Training %	8	8
Varchen	Flat	FSF
Symbol period(T_s)	0.00540e-06	0.00540e-06
Coherence time(T_c)	0.0054	0.0215
Eq. algorithm	LMS	RMS
Velocity(km/hr)	20	5

IV.SIMULATION RESULTS

We have discussed our simulated results by analysing the performance comparison setting different parameter in each channel and then analysing performance by comparing two different channels under the same parameters setting. All the simulations are based on QPSK modulation with gray code.

A. For Flat Fading Channel

1) *BER of Simulation vs. Theoretical:* Error probability decreases asymptotically as the inverse of SNR. The BER performance after channel estimation provides worst result than theoretical one as shown in figure 3 [7]. Simulation result also describes the BER performance for varying SNR. For low SNR, BER performance is improved dramatically while high SNR provides lower value.

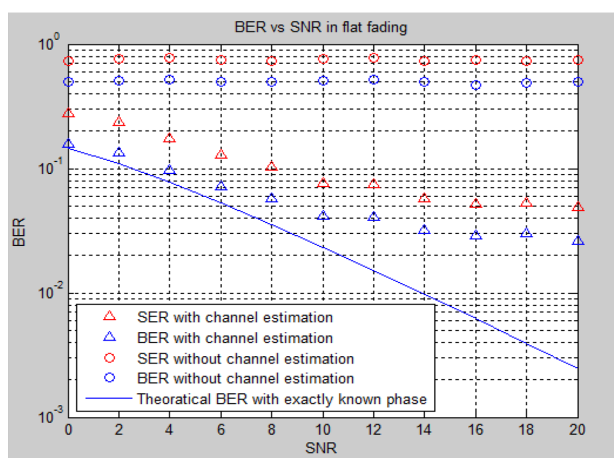

Fig.3BER of simulation vs. theoretical

2) BER and Constellation of Training vs. Non-training: The constellation is plotted at SNR=10dB shown in figure 4. Results obtained after channel estimation shows great improvement in BER performance and constellation.

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3) Image Quality of Received vs. Original: The received image is obtained at SNR=10dB. The presence of block noise including random noise can be easily made out from the figure 6(a) due to the phase estimation error in coherence time.

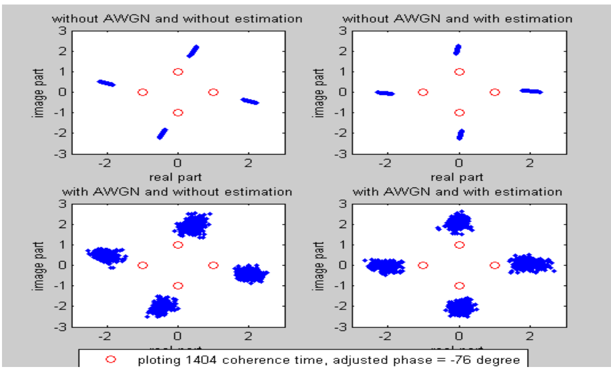
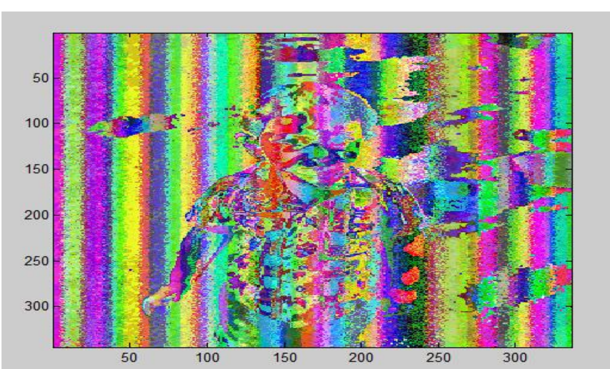
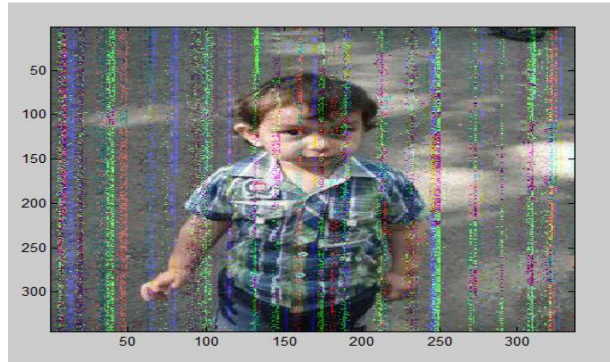


Fig.4 BER & constellation of training vs. non-training

Fig. 5 Original image



(a)



(b)

Fig.6 (a) Without adjustment (b) With adjustment

B. For Frequency Selective Fading Channel

1) BER of Simulation vs. Theoretical: Error probability decreases asymptotically as the inverse of SNR. The BER performance after channel estimation provides worst result than theoretical one as shown in figure7 [7]. Simulation result also describes the BER performance for varying SNR. For low SNR, BER performance is improved dramatically while high SNR provides lower value.

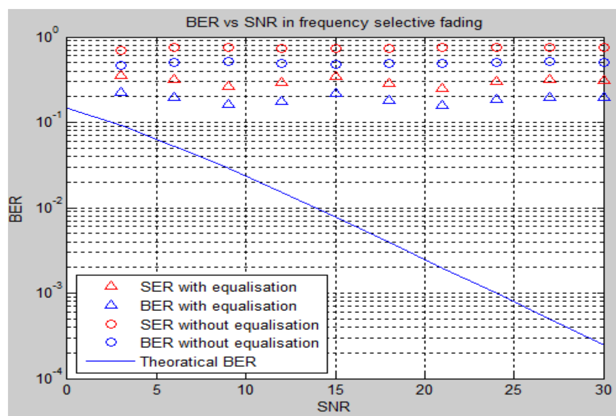


Fig.7BER of simulation vs. Theoretical

2) BER and Constellation of Equalized vs. Non-equalized: The constellation is plotted at SNR=15dB shown in figure 8. Results obtained after channel estimation shows great improvement in BER performance and constellation.

3) LMS vs. RLS: The BER performance for both the algorithm are same but they are different in sense that LMS require more training sequence than RLS to converge equalizer [4].We propose LMS adaptation rule here to avoid heavy computations as RLS is more complex and time consuming.

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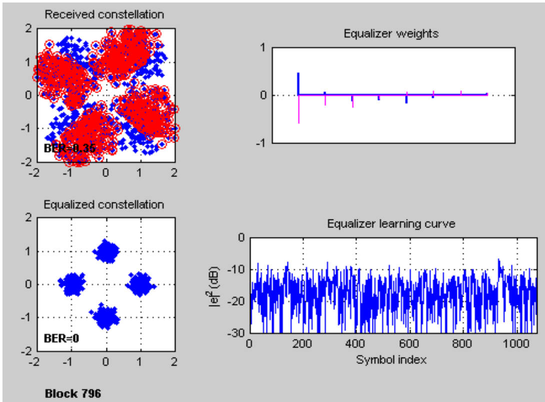
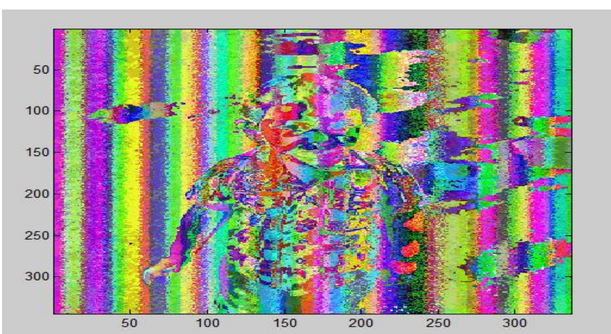
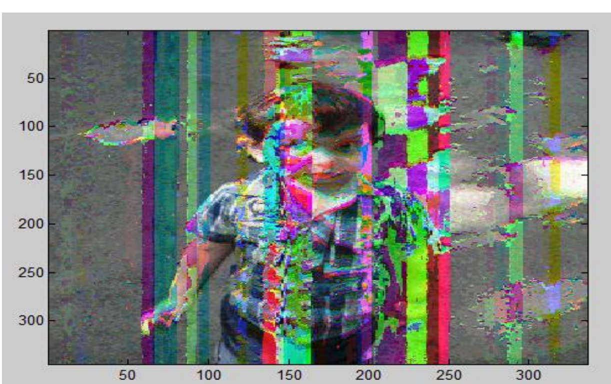


Fig. 8 BER& constellation of equalized vs. non-equalized

4) Image Quality of Received vs. Original: The received image is obtained at SNR = 15dB, as shown in figure 9(a) we see that there are some random noise and block noise in the image and also some overlaps due to the presence of white Gaussian noise, phase estimation error in a coherence time, and ISI caused by frequency selective fading channel [7].



(a)



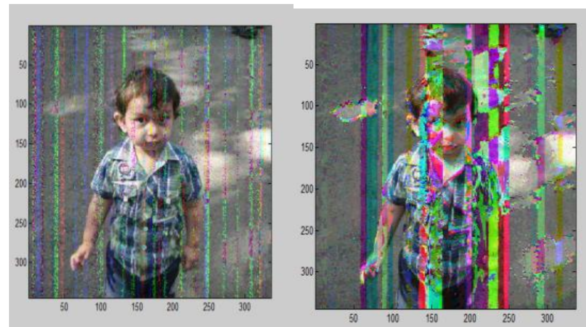
(b)

Fig. 9 (a) Received image (b) Equalized image

C. Comparison between Two Channels

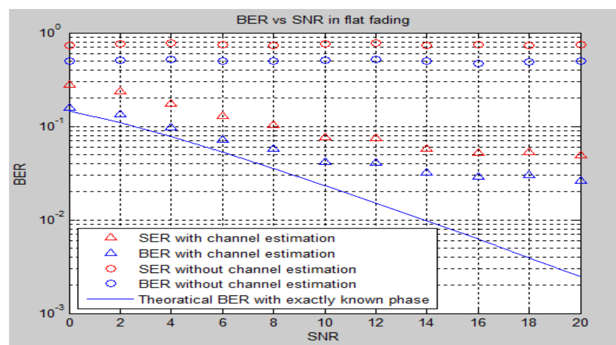
1) Image Comparison: The image is corrupted by random noise and block noise in flat fading channel whereas in frequency selective fading channel image is degraded by overlaps including random noise and block noise.

2) BER Performance Comparison: On the basis of BER performance flat fading channel is better than frequency selective channel.

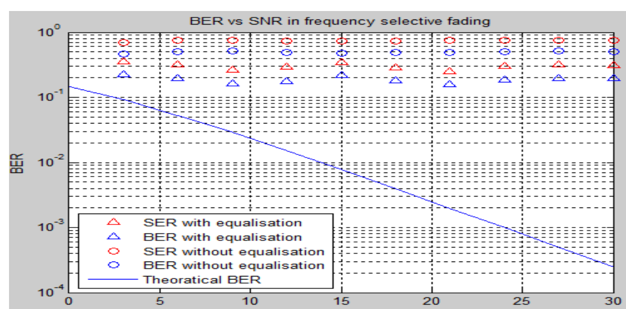


(a) (b)

Fig. 10 (a)Flat fading channel (b)Frequency selective fading channel



(a)



(b)

Fig.11 (a) Flat fading channel (b) Frequency selective fading channel

V. CONCLUSION

Thus using MATLAB simulation comparison between flat fading channel and frequency selective fading channel has been carried out. This paper investigates the effect of two channels flat fading channel and frequency selective fading channel on an image under two scenarios. It was found that

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channel estimation error significantly affects the BER. The performance of both the channels is evaluated through simulation and compared with the help of BER and constellation plots. Results clearly show that flat fading channel performs better than frequency selective fading channel.

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BIOGRAPHY

Noor Fatima received her Bachelor's degree in Electronics and Communication Engineering from Rajasthan Technical University, Jaipur, India in year 2011. Presently, she is pursuing M.Tech degree in Electronics and Communication Engineering from Amity University, Lucknow, India. Her research interests include digital signal processing, control system and digital communication.

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