A Study on Reception Improvement in LTE DownLink Mobile Communication

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Abstract

LTE is a wireless mobile communication standard developed by 3GPP. It aims at high speed and large capacity communication for mobile phones and so on. However an exact channel estimation is difficult under the noisy high Doppler shift mobile environment. Then the communication loss degrades a bandwidth of LTE communication. Then it is necessary to improve a channel estimation accuracy to enable high-speed and large capacity communication.

This paper proposes to add two types of channel estimation improvement methods onto LTE downlink channel estimation. The one is MMSE noise reduction and the other is ICI Canceller. We have successfully applied those two methods to the conventional receiver system and confirmed 2.0dB improvement in BER vs. CNR performance for two wave multipath Doppler channel.

Keywords: LTE, DownLink, Channel estimation

1. Introduction

Recently, mobile or smart phone based wireless communication has been progressed from third generation W-CDMA to 4th generation LTE globally. One of the difficult tasks in receivers is an exact channel estimation since the channel is distorted by random noise or Doppler induced Inter Carrier Interference noise. But, it is necessary to improve a channel estimation accuracy to realize high-speed and large capacity communication. In this paper, we have applied two different types of noise reduction method for LTE DownLink.

2. LTE DownLink Process

Figure 1 shows a block diagram for LTE Down Link communication [1]. First, data is mapped onto OFDM subcarriers and IFFT, which is OFDM modulation, is applied in the transmitter side, then Cyclic Prefix (CP) is added. By inserting CP between OFDM symbols, inter symbol interference can be reduced. After that, the OFDM wave is passed through channel and noise is added. In the receiver side, first the CP is removed and FFT, which is OFDM demodulation, is carried out, then channel estimation and equalization is performed. Finally, by demapping process, data is recovered.

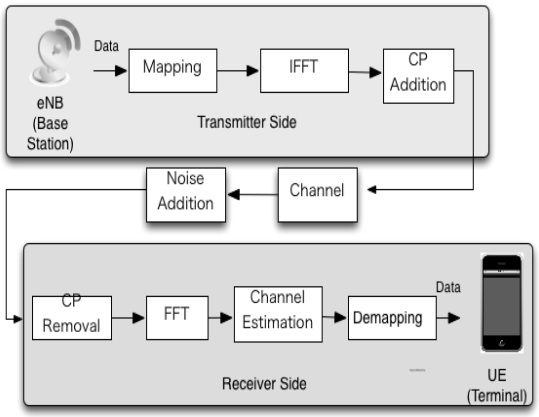

Fig 1: LTE Downlink Process Block Diagram

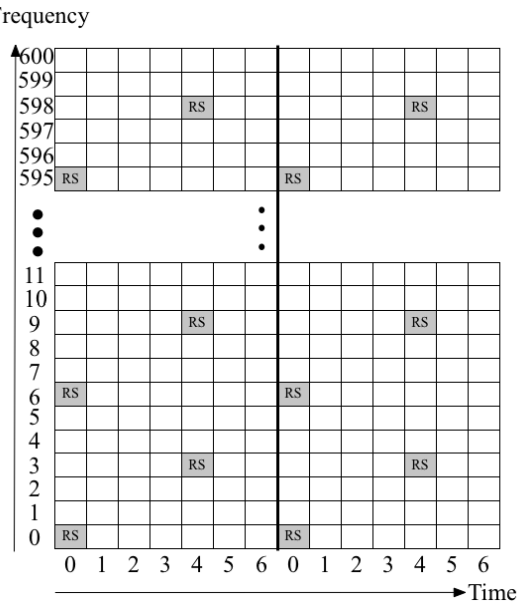

Fig 2: Reference Signal

3. Reference Signal

Reference Signal (RS) is a signal used to estimate channel transfer function (CTF). Figure 2 shows RS allocation of LTE DownLink. All rectangle cells are called as Resource Element. The black resource elements are Reference Signals, which are placed every 6 subcarriers and at only time index of 0 and 4 in normal CP mode.

4. Proposal Method 1

Figure 3 shows the proposed channel estimation method 1. First, complex division is performed to determine channel transfer function (CTF) at the location of the RS. The value of the RS is shared by both base station and User Equipment. After the complex division, CTF at RS position can be obtained. The other CTF values will be estimated by frequency domain interpolation and time domain interpolation.

In this proposal method 1, those dark two signal processing blocks are added. First block is MMSE noise reduction and the second block is ICI canceller. The MMSE noise reduction removes random noise on Channel Transfer Function (CTF) at Reference Symbols. Since the MMSE process is located before frequency domain interpolation, the noise reduction is applied on every six subcarriers. In addition, by calculating CTF change in time domain, ICI canceller tries to remove Doppler induced ICI. Details are explained in the following sections.

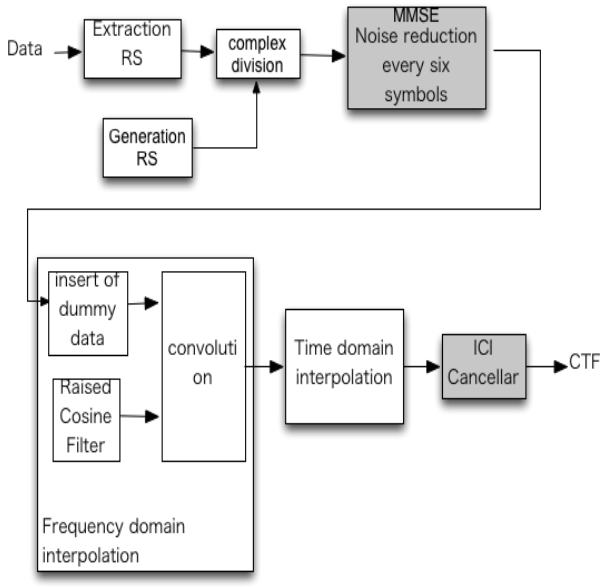

Fig 3: Proposed Method 1

4.1. MMSE Noise Reduction

The MMSE noise reduction is to predict neighbor CTF values using Carrier correlation. By averaging the predict value, random noise component can be reduce. In this paper, we applied Edfors's method [2] to use correlation value of neighborhood CTF on frequency domain.

4.2. Interpolation

The following figures 4 and 5 shows how to obtain whole Channel Transfer Function by the interpolations. Figure 4 shows frequency domain interpolation. All rectangle cells are called as Resource Element (RS). CTF at only RE positions can be measured at receiver. In order to obtain all channel transfer function, firstly frequency domain vertical interpolation is performed.

Figure 5 shows time domain interpolation. After the previous frequency domain interpolation, horizontal time domain interpolation is performed in order to get whole CTF values.

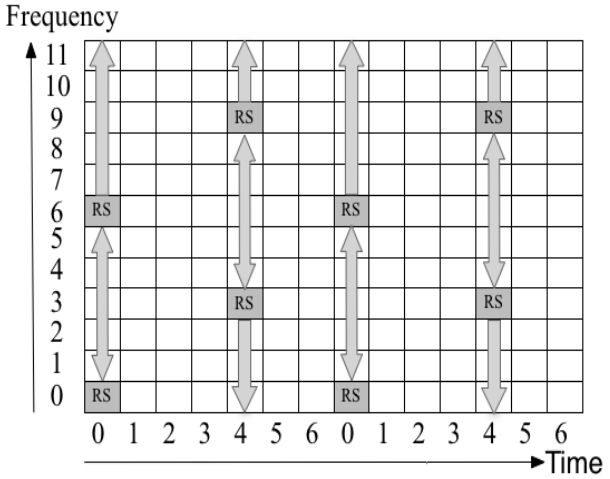

Fig 4: Frequency domain interpolation

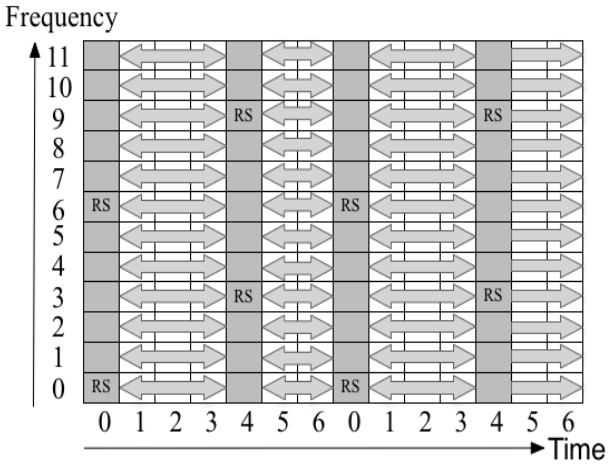

Fig 5: Time domain interpolation

4.3. ICI Canceller

Because LTE has to operate in mobile environment, Doppler induced frequency shift is inevitable. Therefore, the OFDM signal can not maintain its orthogonality.

Then one subcarrier data cause interference to neighbor subcarriers. Such interference is called as Inter Carrier Interference (ICI). In order to compensate it, ICI canceller [3-4] is introduced based on Mostofi's method, which estimates ICI components by CTF change on time domain.

5. Proposal Method 2

Figure 6 shows another proposed method 2. In the proposal 2, an additional MMSE noise reduction process is introduced onto proposal 1. Since the additional MMSE noise reduction is applied after time domain interpolation, the noise reduction is applied on every one subcarriers such as all subcarriers.

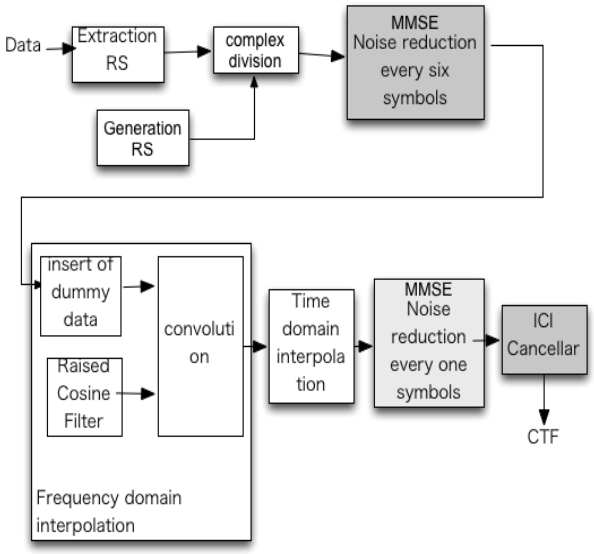

Fig 6: Proposed method 2

6. Simulation Parameters

The proposed method is evaluated by computer simulation using MATLAB. Table 1 and 2 show the simulation parameters of OFDM related parameters and channel condition, respectively. We have assumed 10MHz bandwidth LTE down link and tone spacing of 15KHz OFDM. Assuming high bandwidth DL condition, 64QAM modulation is used. In order to simplify the discussion, we have used two waves multipath channel with Doppler frequency shift.

Table 1: Simulation parameters

System Bandwidth (MHz)	10
Effective Bandwidth (MHz)	9.0
Guard Bandwidth (MHz)	1.0
Subframe (ms)	1.0
Tone Spacing (kHz)	15
Sampling Rate(MHz)	15.36
Modulation	64QAM
FFT Size	1024
Subcarrier Number	600
CP Length (NS)	4.69 5.21
Channel Model	ETU
Maximum Doppler frequency	300Hz

Table 2: Two wave multipath channel

Delay time (NS)	Power (dB)
0.3	0.0
0.8	-3

7. Simulation results

Figure 7a is Bit Error Rate (BER) comparisons for the conventional method without MMSE noise reduction and that with MMSE noise reduction. The horizontal axis represents CNR, and the vertical axis represents BER. Based on BER = 10^-2 criteria, it shows roughly 2.2dB improvements than conventional method. Figure 7b is BER comparison for the conventional method without ICI Canceller and that with ICI Canceller. In the result, it shows roughly 0.5dB improvements than conventional method. Figure 7c is BER comparison for conventional method and two proposed methods. The proposal method 1 and 2 shows roughly 2.0dB improvements than the conventional method. The proposed method 1 shows slightly better performance than the proposed method 1. BER has been improved about 27% for proposed method 2.

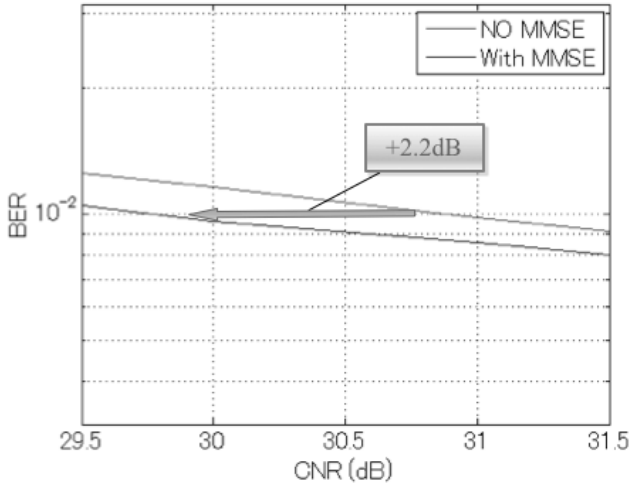

Fig 7a: Simulation Result (1)

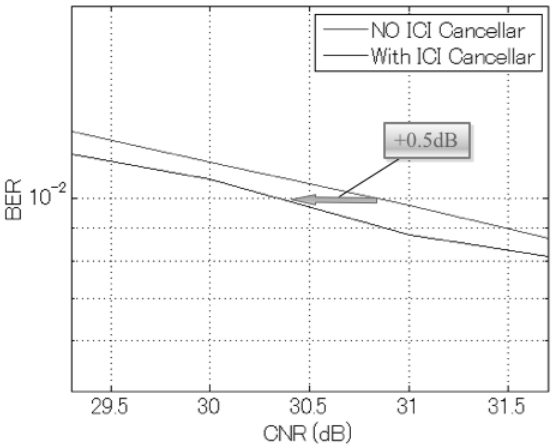

Fig 7b: Simulation Result (2)

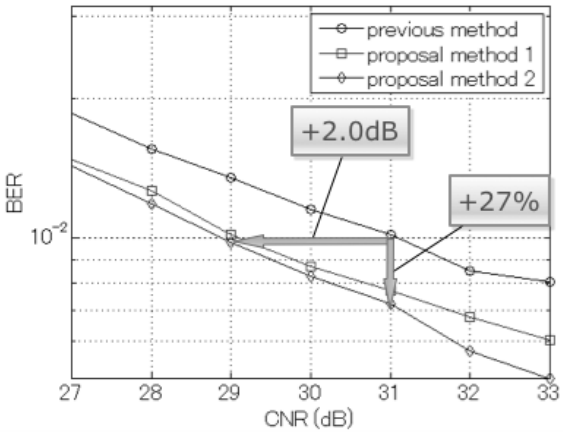

Fig 7c: Simulation Result (3)

8. Summary

In this work, we have applied two channel estimation improvement methods to LTE downlink channel estimation. The one is MMSE noise reduction and the other is ICI Canceller. We have successfully applied those improved methods and simulated result shows roughly 2.0dB improvement than the conventional method is confirmed.

References

[1] 3GPP TS 36.104 v9.5.0 (2010-10) .

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