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Design and Realization of Baseband Signal Down-Sampling in LTE System

Li-hua Wu[1],Xiu-li Zhang[2]

The higher educational key laboratory for Measuring & Control Technology and Instrumentations of Heilongjiang Province, Harbin University of Science and Technology, Harbin 150080, China
{Li-hua Wu, wulihuasc@126.com}

Abstract. The received signal of PRACH reception process requires a large number of arithmetic processing, such as IFFT and FFT. This paper introduces a half-band filter with cascading method in the random access channel of LTE system down-sampling process. The paper also designs a decimation filter to improve the computational efficiency. By Matlab-simulation and FPGA implemental scheme, the effectiveness of this method is verified.

Keywords: LTE; Down-sampling; Half-band filter; FPGA

1 Introduction

This paper first introduces the principle of down-sampling, and then regarding to the sampling process in random access channel it discusses the multi-level half-band filter extraction method. Finally, it comes up with an implementation structure for such down-sampling method.

2 Overview PRACH Channel

The receiver schematic of PRACH channel is shown in Fig.1. According to this figure, down-sampling plays an important role in the process of receiving the PRACH signal. In the premise that no aliasing sampling in the down-sampling process occurs, it can greatly reduce the complexity of the any following up signal processing.

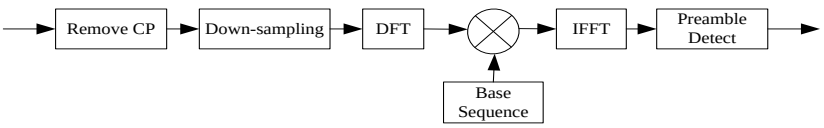

Fig. 1. The PRACH receiver schematics

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3 Signal Extraction Principle

The original signal *x(n)* is extracted every *l-1* data signal. After I times extraction, the corresponding spectrum of *x(n)* is I times extended. Shift the spectrum by $2\pi/I$ times and add each resulting spectrum to the original.

The signal after extraction will produce aliasing if no filter is employed. Therefore, a low pass filter with bandwidth of π/I is applied after extraction. Fig. 2 shows the extraction process.

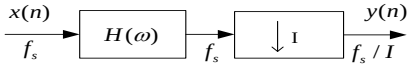

Fig. 2. Signal extraction realization diagram

4 Filter Design

With high computational efficiency, being easy to implement and suitable for down-sampling, CIC (Cascaded Integrator Comb) filter and half-band filter are widely used in down-sampling process.

As the design of CIC filter requires small bandwidth scale factor which LTE system does not fulfill, it is not applicable in LTE system. PRACH needs to transform its received signal with FFT and IFFT, both of whose factors are integer power of 2. With the above consideration, this paper uses half-band filter to realize PRACH signal down-sampling.

4.1 Nature of Half-band Filter

The nature of half band filter：

a) Passband ripples and stopband ripples are equal, i.e., $\delta_p = \delta_s$;

b) $w_p+w_s=\pi$ 。 Passband frequency F_p and stopband frequency *Fs* are symmetrical about $f_s/4$, namely $F_p+F_s=f_s/2$. For digital frequency it is expressed as: $w_p+w_s=\pi$.

4.2 Design method of low-pass filter

Methods such as equal-ripple and windowing may be used for design of half-band filter. Due to the complexity of equal-ripple, this paper uses the method of windowing design.

5 Design of PRACH Down-sampling

The decimation factor of the filter must be 8 because when random access signal has a 1.08MHz bandwidth and system has 20MHz bandwidth, sampling frequency f_s=30.72MHz.

A half-band filter can only support twice the decimation or interpolation. Therefore, this article uses three half-band filter cascade method to achieve the down-sampling process of PRACH signal.

According to the previous steps to calculate the N value, the stop-band attenuation *As* is 60dB. The obtained results are shown in Table 1.

Table 1. filter order number N

First level filter order	Second level filter order	Third level filter order
10	11	14

According to the known parameters of the filter, the filter coefficient can be obtained with the analysis of Matlab software.

6 Realization Based on FPGA

The realization of synthesis was completed by the development software of QUARTUSII. This process is explained in Fig.3.

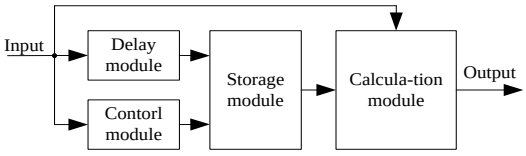

Fig. 3. The realization of schematic diagram based on FPGA

The input signal for simulation is produced through Matlab. The bandwidth of sine signal which overlaps the Gaussian white noise is 10 kHz. As shown in Fig.4(a) (Horizontal axis being time, vertical axis being amplitude). The produced original signal is quantized, and it is stored as the input files *.vec which needed for simulation by the QuartusII as the input data of FPGA.Save the waveform file generated after the simulation as "*. TBL" format. Read the data into Matlab, the graphics is shown in Fig.4.(b).

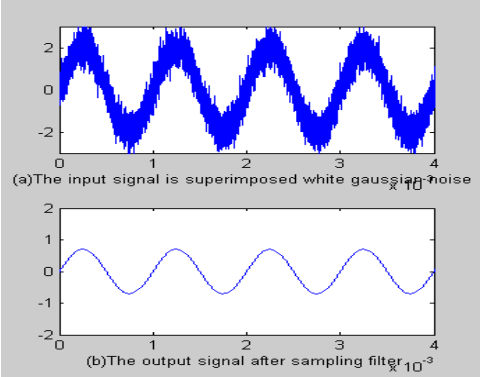

Fig. 4. Input and output signal

As can be seen from the result of the experiment, the output has realized the effective extraction of the input signal.

7 Conclusion

Considering the uplink random access channel in LTE system, the paper uses the method of half-band filter cascade to take the signal down-sampling. This method has high calculation efficiency, simple structure and is easy to realize. The Simulation results show that design is applicable to the down-sampling process of the random access channel.

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