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Simulation Design of Baseband Optimal Digital Communication System with Non-Ideal Channel

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Abstract

This paper aims to discuss how to effectively suppress intersymbol interference by optimizing the filter design, so as to achieve a distortion-free output effect, and effectively compensate the transmission characteristics of the baseband transmission system in a non-ideal channel environment, so as to minimize the impact of intersymbol crosser. The simulation experiment model of digital optimal baseband transmission and the overall structure of the system are designed based on the Matlab simulation platform, and the parameters of each module in the simulation experiment model are set. The working process and performance of the digital optimal baseband transmission system are simulated, and the conditions and performance of the digital optimal baseband transmission system are verified according to the simulation results.

Keywords

Digital Baseband Transmission System, Intercode Crosstalk, Noise, Sampling Decision, Matlab, Simulation

1. Introduction

With the formation of modern communication systems, the perfect integration of computer technology and communication system makes digital signals play a vital role in it. A digital signal has many advantages. As a basic information transmission system, it covers the core problems, evolution and maturity of the system. Therefore, the research and design of digital baseband transmission systems are of great significance. With the continuous evolution of modern communication technology, digital baseband technology has become more and more widely used technical means, but in practical applications, the channel is actually not ideal, so the research of digital baseband transmission under non-ideal channels is particularly important. The purpose of this paper is to discuss how to effectively suppress intersymbol interference by optimizing the filter design, so as to achieve the distortion-free output effect, and effectively compensate the transmission characteristics of the baseband transmission system in the non-ideal channel environment, so as to minimize the influence of intersymbol crosser. On the basis of an in-depth analysis of the digital baseband transmission system model under a non-ideal channel, we analyze the basic principles and concepts of each process, build a complete simulation structure diagram, and use Matlab [1] [2] simulation platform, under the conditions of additive interference (Gaussian white noise) and multiplicative interference, Finally, the simulation of the digital baseband transmission system under the non-ideal channel is carried out, and a variety of methods such as bit error rate and eye map are used to test the system. Finally, the whole system eliminates inter-code interference and has the best anti-noise performance. The conditions and performance of the optimal digital baseband transmission system under the non-ideal channel are obtained, and the comparison and analysis are made.

2. The Composition and Principle of Transmission System

2.1. The Constitution of System

The composition of the digital optimal baseband transmission system under non-ideal channel is shown in **Figure 1**, which is composed of Manchester coding module, sending pulse shaping filter with square root characteristic of raised cosine spectrum, discrete filter, channel, receiving matching filter with square root characteristic of raised cosine spectrum, equalizer and sampling decision.

2.2. The System Achieves Optimal Transmission

In the circuit structure of the transmission system shown in **Figure 1**, the baseband transmission system consists of a transmitting filter, a baseband channel, a receiving filter, and a sampling decision. In order to achieve the optimal reception of digital baseband transmission system, the receiving filter should be designed as a matching filter, the sending and receiving filters should be designed as a filter with root-raised cosine characteristics, and the equalizer should be added after the receiving filter [3]. Principle analysis [4]: $G_T(f)$ is the transmission function of the pulse shaping filter, $G_R(f)$ is the transmission function of the receiving filter, and $C(f)$ is the transmission characteristic of the digital modulation and demodulation band communication channel. In an ideal case, $C(f) = 1$;

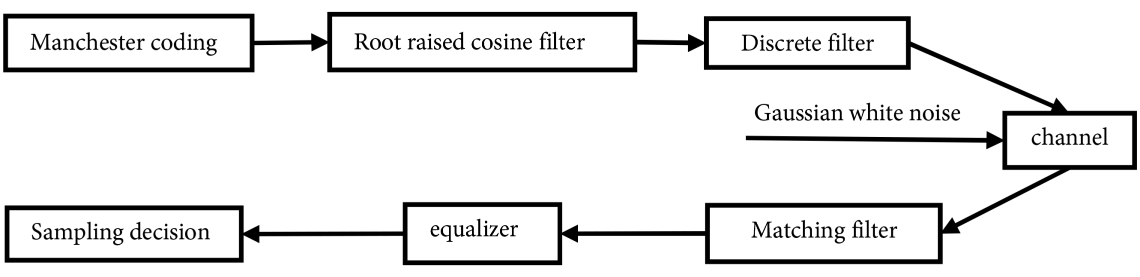

Figure 1. Block diagram of digital optimal baseband transmission system under non-ideal channel.

by the $G_T(f)$, $G_R(f)$, $C(f)$ of the total system composed of the transfer function $H(f) = G_T(f) \cdot G_R(f) \cdot C(f)$; to eliminate cross-talk between codes, $H(f)$ needs to conform to Nyquist's first criterion, and for optimal reception, $G_R(f)$ needs to be a complex conjugation of $G_T(f)$, namely $|G_R(f)| = |G_T(f)^*|$ given. So, the formula for $|GR(f)|$, $G_T(f)$ satisfies Formula (1).

$$|H(f)| = |G_R(f)| \cdot |C(f)| \cdot |G_T(f)| = |G_R(f)|^2 = |G_T(f)|^2 \tag{1}$$

It can be written as:

$$|G_R(f)| = |G_T(f)| = \sqrt{|H(f)|} \tag{2}$$

Therefore, Formula (2) shows that the transmit and receive filters are designed with the square root characteristics of the raised cosine spectrum to achieve optimal reception.

In the transmission system shown in **Figure 1**, the function of the discrete filter is to make the channel a non-ideal channel, and the digital base-band channel transmission system realizes the optimal reception with the maximum output signal-to-noise ratio of the matched filter output, and makes the total transmission function of the system comply with the first criterion of Nyquist [5], that is, to achieve zero crosswise between the sampled time codes. At the same time, the total transfer function $H(f)$ of the system is designed as the raised cosine roll down transfer function, which is physically realizable. Moreover, the channel is a non-ideal channel, and the intercode crosstalk of the transmission system is not completely eliminated, and an equalizer is added to further eliminate the intercode crosstalk. Therefore, the digital baseband transmission system which is cascaded with matching filter and equalizer at the receiving end is a digital optimal baseband transmission system which eliminates the cross-talk between codes and achieves the optimal reception in non-ideal channels.

3. The Simulation Design of Transmission System Based on MATLAB

The baseband transmission rate is usually between 0 and 10 Mb/s, and 1 Mb/s to 2.5 Mb/s is commonly used [6]. In this paper, the common standard of baseband transmission is used in the simulation design at the beginning, but the simulation results cannot be clearly displayed because of the high speed. Therefore, in the actual simulation process, a low-rate model is adopted, in which the source sampling frequency is set to 0.5 s, and the system adopts Manchester encoding and decoding.

The transmission channel in the system is set as Gaussian channel, the added noise is weighted Gaussian white noise, and the signal-to-noise ratio is 20.

3.1. The Design of Source Generator Module

In the design, Manchester code is a coding method that uses level hopping to represent 1 or 0. The coding rule is very simple, that is, each code element is represented by two level signals of different phases. Binary bipolar code is used here, so "1" is compiled into "+1 − 1" code, and "0" is compiled into "−1 + 1" code. The designed Manchester coding model is shown in **Figure 2**.

Set Bemoulli Binary Generator parameters: Set the probability of a zero to 0.5 and Sample time to 0.5. Set Pulse Generator parameters as follows: Set Period to 0.5 and Pulse width to 50%. Relay Output when off is set to −1.

Retain the default values for other parameters.

3.2. The Matching Filter/Equalizer Module Design

The acceptance and transmission filters "Discretefilter" adopt the square-root-raised cosine, in order to reduce inter-code crosstalk, make the output to achieve the maximum signal-to-noise ratio, and reduce the interference generated by noise to the channel. According to Nyquist's first criterion, the output condition without intercode crosstalk can be obtained. If the total transmission characteristics of the system are known, it can be obtained by inserting a filter, so that the sum of the frequency characteristics of the interpolated filter and the total transmission characteristics of the system is a constant, and the intercode crosstalk can be eliminated. In this paper, before the sampling decision, a filter whose frequency characteristics are reciprocal with the frequency characteristics of the crosstalk filter is inserted, as shown in **Figure 3**.

Denominator Set parameters in Discrete Filter: "Numerator" is [1], and "denominator" is [1 - 0.8]. Error Rate Calculation: Set Receive delay to 2 and Output data to port. Denominator Setting "Discrete filter" parameters: "Numerator" is "rcosine (2, 10, 'fir/sqrt', 0.5, 10)". Denominator is "1". Denominator uses white Gaussian noise, and set "AWGN Channel" parameters: Set Mode to SNR and SNR to 20.

Retain the default values for other parameters.

3.3. The Design of Sample Decision Module

The sampling decision Generator consists of Pulse Generator, Relay, Period and Output when off. The Pulse Generator parameter is set as follows: Set Period to 0.5 Pulse width to 1%. Retain the default values of other parameters. Relay Output

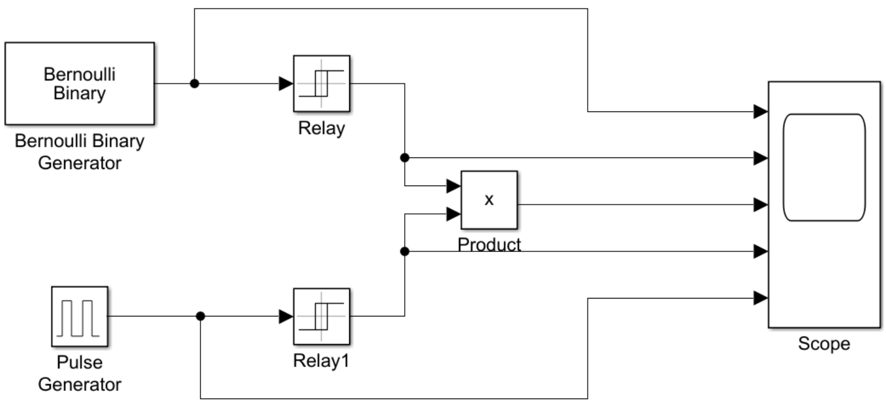

Figure 2. Manchester coding module.

when off is −1.

3.4. The System Simulation Model Implementation

The simulation circuit model of the digital optimal baseband transmission system under the non-ideal channel is shown in Figure 4, which consists of Manchester coding module, transmit filter module, discrete filter module, channel, receive filter module, equalizer module, sample decision module, Manchester decoding module and other parts.

4. The Simulation and Analysis of Transmission System

Among them, the first waveform in Figure 5 is the waveform output by the

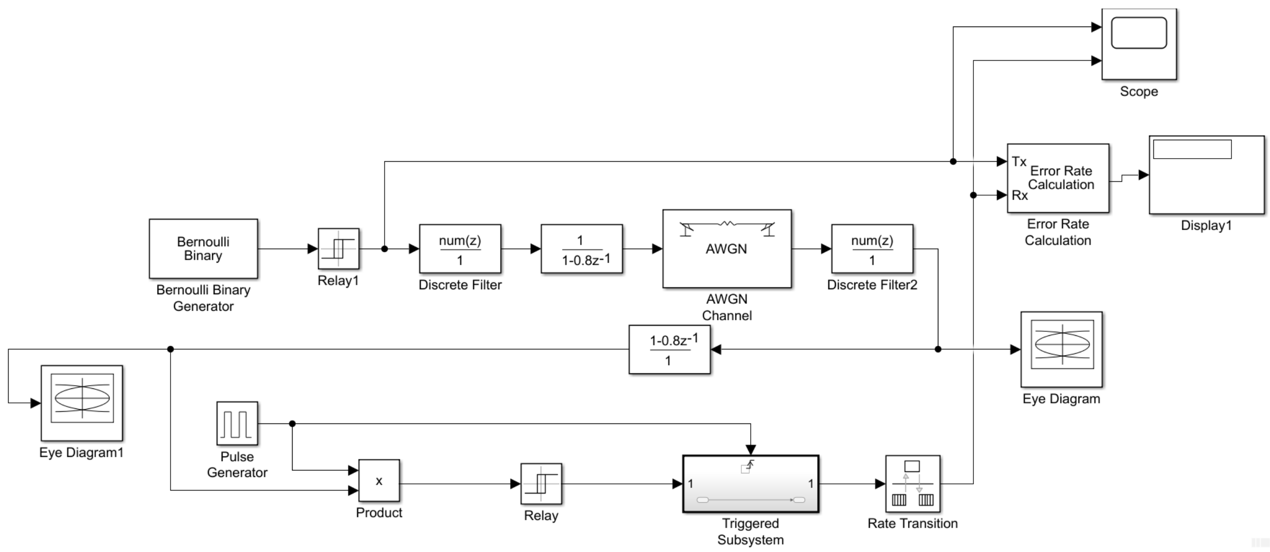

Figure 3. Simulation circuit after adding equalizer.

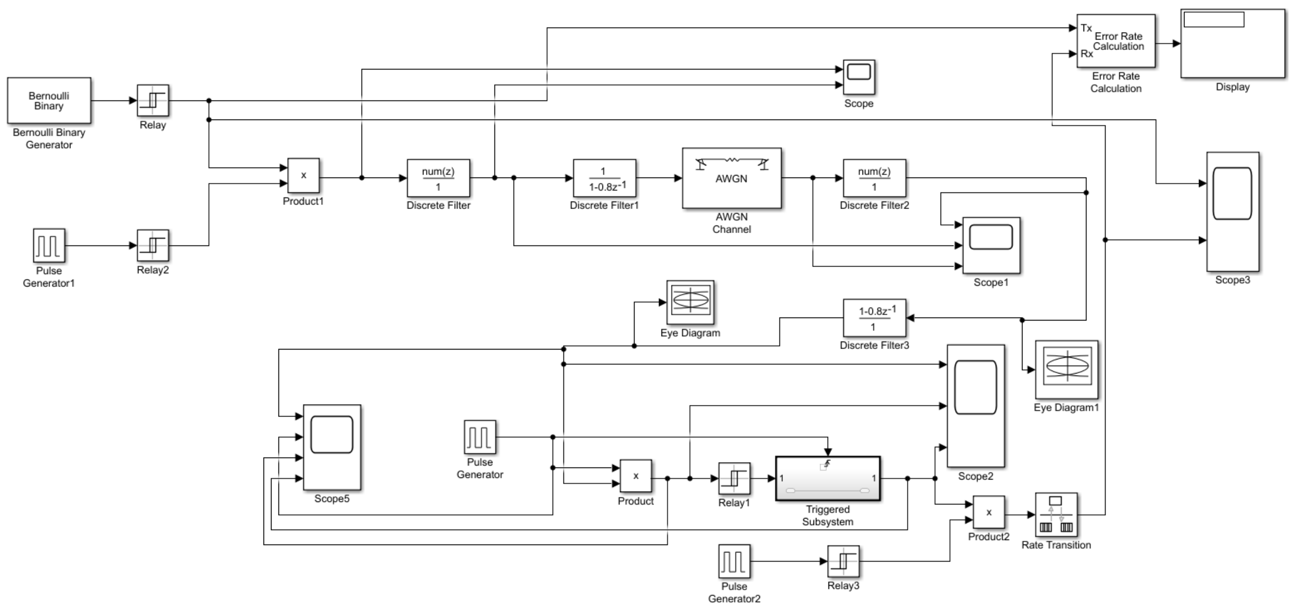

Figure 4. Optimal simulation model of digital baseband system under non-ideal channels.

information source, and the second waveform is the waveform output by decoding after balancing. It can be found that the two waveforms delay several code elements, which is displayed through "ErrorRateCalculation", and the bit error rate is 0. The expected effect has been achieved. By comparing the eye images before and after the equalizer in Figure 6 and Figure 7, it is found that the eye images are confused before adding the equilibrium, and become clear after

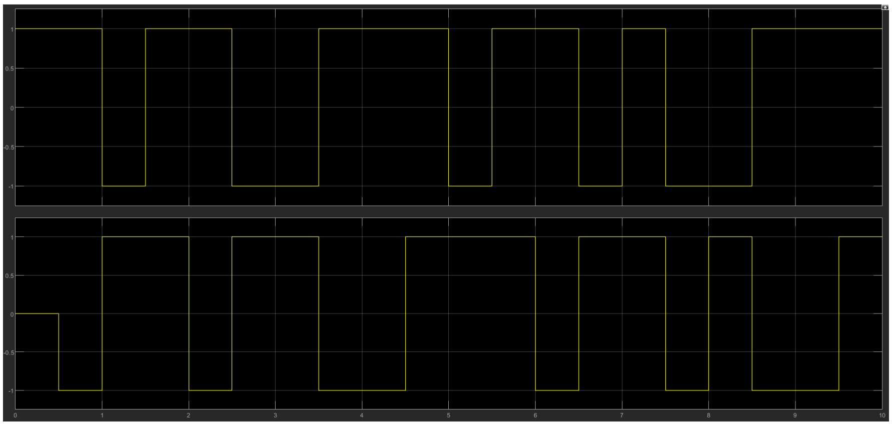

Figure 5. Input and output signals.

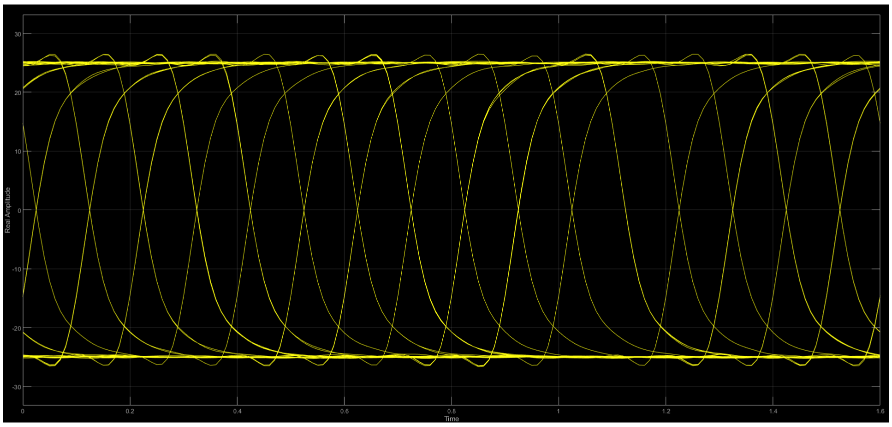

Figure 6. Pre-equilibrium eye view.

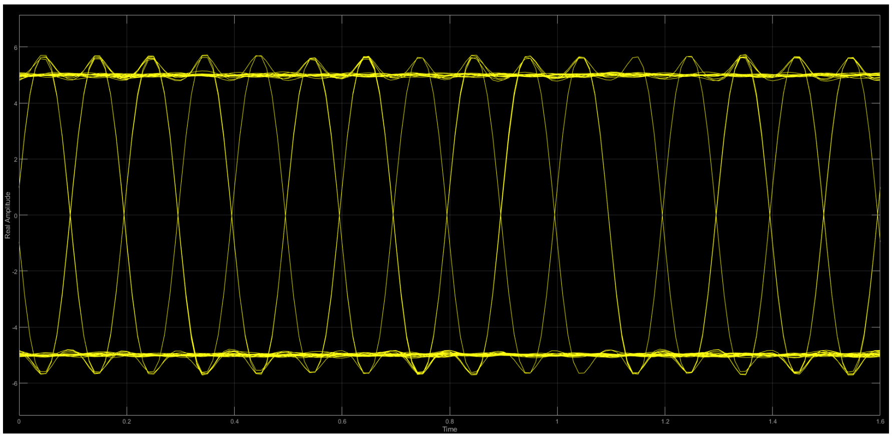

Figure 7. Eye view after equilibrium.

adding the equilibrium, indicating that the equilibrium effect is achieved. Therefore, it can be seen that the whole system design is reasonable, the digital frequency band transmission system reaches the best-receiving state, and the simulation results verify that the designed digital baseband transmission system under the non-ideal channel has completed its functions and meets its design requirements. The results of simulation research in this paper will help us understand how to optimize and design the optimal digital baseband transmission system under non-ideal channels in practical applications, which has important application value.

5. Conclusion

The simulation verifies the structure and function of the designed digital optimal baseband simulation experimental system under the non-ideal channel. In the theoretical knowledge of communication principles, the content of each link of the digital optimal baseband transmission system under a non-ideal channel basically contains all the main content of the communication principles and theories, and understanding and mastering the theoretical content, working process, performance parameters and design process of the digital optimal baseband transmission system under non-ideal channel is a more comprehensive grasp of the communication principles and technologies. Therefore, the purpose of designing the simulation experiment system of the digital optimal baseband transmission system under the non-ideal channel is to let the enthusiasts who study and learn communication technology use our existing laboratory conditions and design this simulation system to practice the design of this complex communication transmission system by themselves, and realize the theory to practice in the design process from simple to complex to innovative. In the actual design, some communication technologies used in the actual communication, such as analog inter-code crosstalk, eliminating inter-code crosstalk, baseband transmission, optimal reception, etc. can be deeply understood in theory and realized in simulation design. In short, through this simulation design experimental system applied to the experiment, the purpose of realizing people's deep understanding of the structure, performance and principle of the digital optimal baseband transmission system under the non-ideal channel will be very helpful for our enthusiasts to study and learn the communication theory and improve the effect.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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