The Extraction and Processing of Optimal Impulse of Railway Remote Simplex Control Communication Signal

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Abstract: This paper analyzes an acquisition model of railway remote communication signal, extracts and processes the optimal impulse of the railway remote simplex control communication signal, completing the communication transmission of the train operation control system. A new algorithm is proposed in this paper, which can effectively extract optimal impulse response and improve the communication quality of train operation control system, proved by simulation analysis.

Chinese Train Control System (CTCS), playing a key role in train to ground communication, is used for information management and scheduling command, recording command information in detail. It can also automatically report position, generate logs and record delays, which is very powerful. The ground subsystem of CTCS is composed of track circuit and radio communication network. CTCS-3is a dispatching management system used to control communication between train and ground. Aiming at improving the communication capability of CTCS to ground and ensuring the safety and stability of railway dispatching, this paper studies an acquisition model of railway remote communication signal which cannot meet the IDE requirements of simplex communication with bidirectional information transmission characteristics, resulting in the decline of communication capability and reliability of train operation and scheduling. Therefore, this paper proposes a new algorithm based on the single frequency envelope instantaneous value statistics of the remote simplex control communication signal optimal impulse. First, the model of train operation control system is built, on which the optimal impulse is extracted. Finally, the superiority of the algorithm to extract pulse signal is proved by simulation experiments.

1. Train - ground communication transmission model

1.1 Train - ground communication transmission model of CTCS

CTCS are divided into 4 levels due to different functions. The signal acquisition model constructed in this paper is based on CTCS-3 and designed structure iscomposition of CYCS-3. The ground subsystem of CTCS is composed of Global System for Mobile Communications-Railway (GSM-R) and Train Control Center (TCC), etc[1]. The communication channel of TCC is composed of locomotive signal and monitoring recording instrument. A GSM-R can be set up to check CTCS and complete the acquisition of the train remote simplex control communication signal.

1.2 Signal extraction model of CTCS

Firstly, suppose the signal of the channel to the train operation control center is:

$$S(t)=\mathrm{Re}(s_l(t)e^{j2\pi f_c t}) \tag{1}$$

$s_l(t)$refers to the communication signal of on-board equipment input module,f_c represents carrier frequency of continuous information.

The ground subsystem carries out information interaction through CTCS, whose on-board equipment generates the statistical communication signal. And the obtained signal is expressed as:

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$$Y(t)=\sum_{n=1}^{L} a_n(t)s[t-T_n(t)] \tag{2}$$

Where $a_n(t)$indicates the nth ground communication path attenuation, $T_n(t)$ is the nth track circuit path delayand L indicates the simplex communication path number.

After low-pass equivalent processing, s(t) is expressed as:

$$S(t)=Re[\tilde{s}(t)e^{j2\pi f_c t}] \tag{3}$$

Here, $\tilde{s}(t)$ indicates that the signal s(t) is convolved, and the train control center line sends a command to the CTCS to obtain the directional characteristics of the train communication signal envelope:

$$Y(t)=Re\{(\sum_{n=1}^{L} a_n(t)e^{-j2\pi f_C T_n(t)}\tilde{s}(t-T_n(t)))\}e^{j2\pi f_c t} \tag{4}$$

Then the multipath channel characteristics are obtained:

$$\tilde{c}(T;t)=\sum_{n=1}^{L}\tilde{a}(t)\delta(t-T_n(t)) \tag{5}$$

Here $\tilde{c}(T;t)$ represents the channel response of the pulse at time t at the time t-T.

2. The best shock pulse extraction algorithm

The inverter is controlled by the linear frequency of the communication system model and after the signal passes through the detector, it becomes an electrical signal[2]. In the CTCS-3 train operation control system, the QAM modulation can obtain the vector of the output data, and the combined signal can be obtained to process different fading replicas of the same communication signal. In the simplex communication process, the iterative process is regarded as the variable step. The factory's LMS algorithm yields a copy-related signal:

$$X' = \sum_{v=1}^{v} b_v X_v \tag{6}$$

Since railway communications are subject to high-speed train noise, the communication system linearly filters these signals after receiving the signals. If you want to extract the pulse with the best impact, you should take the signal main-lobe deviation amplification method and calculate the directivity gain of the receiving end, expressed as:

$$Y(t)=r\bullet h(t)\otimes s(t)+z(t) \tag{7}$$

In this equation, v represents the signal envelope directivity, and the directivity gain is expressed as:

$$C(v)=\int_0^v \cos\left(\frac{\pi}{2}x^2\right)dx \tag{8}$$

After the above operations, the extraction of the best impact pulse can be completed, and the vehicle-ground communication transmission of ctcs-3 train operation control system can be completed.

3. Simulation analysis

Next, we verify the above algorithm through simulation analysis. Based on the test background of high-speed railway remote simplex communication, ctcs-3 train operation control system was constructed. In the high-speed train operation control system, control signal collection method is used to complete simplex communication between the train and the train control center[3].In this process, some communication signals are collected for analysis as samples, and statistics are made by using statistical model to simulate the channel reverberation received by ground control center[4].The results are shown in figure 1.

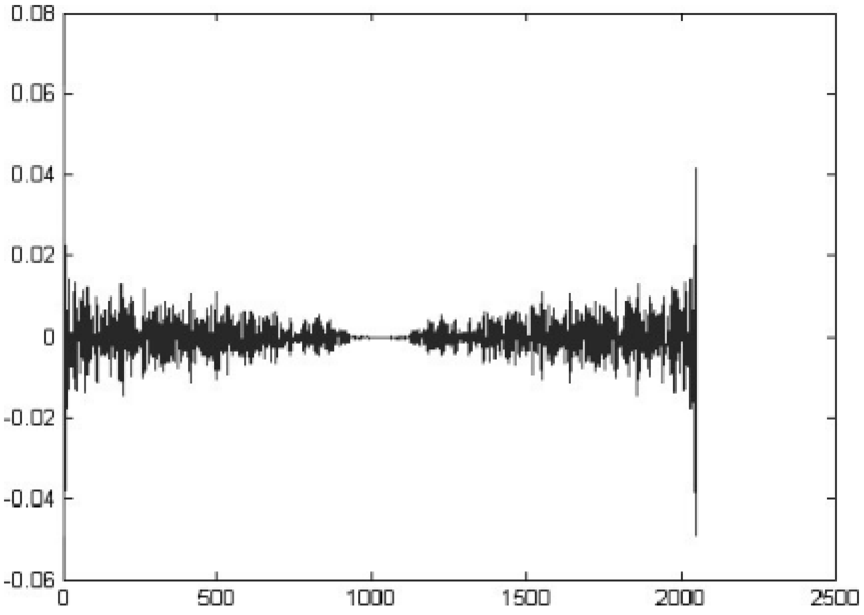

Figure 1. CTCS channel reverberation received by the column control center

Through the analysis and study of figure 2, it is found that the original communication signal is affected by the thermal noise of the system, and the impulse of the signal cannot be accurately reflected, thus reducing the communication performance [5].The train remote simplex control communication signal is used in the single-frequency impulse response to extract the optimal impulse response. The results are shown in figure 2 below:

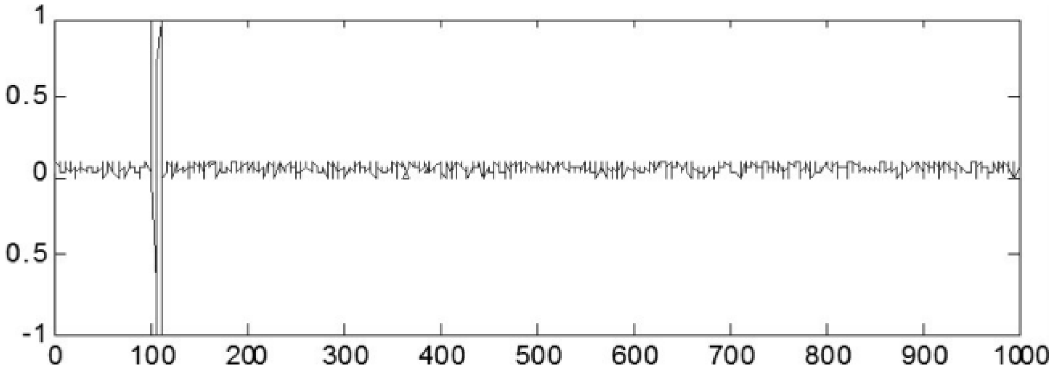

Figure 2. Optimal impact pulse extraction results of train remote simplex control communication signals

Through the analysis of figure (3), the best impact pulse of the train simplex control communication signal is extracted, which can effectively filter out the influence of various noises. Which can efficiently response envelope changes and ensure the quality of the vehicle-to-ground communication of the CTCS-3 train operation control system [6].

In summary, the paper analyzes a train remote communication signal acquisition model and simulates the model. The optimal pulse of the train remote simplex control signal is extracted and the communication transmission of the CTCS-3 train operation control system is completed. In this paper, the algorithm for extracting the best impact pulse is proposed. By constructing the system model and modeling, the optimal shock pulse is extracted. Finally, the algorithm can effectively simulate the CTCS channel reverberation received by the ground control center, and extract the best impulse response pulse to effectively filter out some noise interference.

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