Simulation and Analysis of Transmission Performance of JTIDS

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Abstract—As a very important part of Link-16, Joint Tactical Information Distribution System (JTIDS) has a good performance. In this paper, the primary technologies of JTIDS are presented and their Transmission performance are simulated and analyzed. And in the different conditions, the bit error rate simulation is tested based on the rationale of JTIDS. In the end of this paper, anti-jamming ability of JTIDS is simulated and the results show that JTIDS has high performance of anti-jamming.

Keywords- JTIDS; Simulation; performance analysis

I. INTRODUCTION

JTIDS is a high-speed large-capacity, confidential and TDMA information distribution system developed by the U.S. military to adapt to the combined operations.

JTIDS could provide interactive aspects like anti-jamming, confidential digital voice information and data information and has outstanding advantages of multi-user, large capacity and viability compared with the replaced low-speed wireless tactical data network.

Besides, it is conducive to provide real-time battlefield information exchange and situational awareness in bad radio communication environment for combat troops, which greatly enhances the combat effectiveness of troops.

On the future battlefield, the vast majority of information will go on real-time and accurate exchange and transmission with tactical data link. In order to adapt to the needs of the modern electronic information warfare, it is particularly important to have performance analysis on the JTIDS and other data link systems [1]. This article simulates and analyses several key technologies in the JTIDS data transfer process, and evaluate the system performance under different transmission environments; using different sequence generators when spread spectrum and frequency hopping techniques are combined, the system also has a certain anti-single-frequency interference ability.

II. KEY TECHNOLOGIES OF JTIDS DATA TRANSMISSION

The key technology in the JTIDS data transmission process is used to improve the anti-interference ability of the system. The JTIDS system mainly uses channel coding technique，frequency hopping technique，direct sequence spread spectrum technique and minimum shift keying (MSK).

A. Channel Coding Technique

The JTIDS uses CRC cyclic coding technique[2]. This way of encoding has only the capability of error detection without the capability of error correction. When the receiving end detects a transmission error, it doesn't correct the error of transmission but requires the transmission side re-transmit this signal sequence. The CRC coding techniques can ensure that the user receive the correct information, which has played a very important role in the use of military communications. JTIDS uses CRC (237,255) coding as a cyclic redundancy code.

The JTIDS also uses the RS error correction coding technique. It uses a (31,15) RS encoding, and can ensure that even if half of the data is lost during transmission, the error detection and correction mechanism is also able to restore the integrated original data. JTIDS uses the (31,5) interleaving coding technique after RS coding. It can eliminate the circumstance that the number of errors exceeds the error correction capability of the RS coding due to the consecutive burst interference within a group. Using interleaving, we can transform burst interference into random interference, distribute errors to each group and fully exploit the error correction capability of the RS coding.

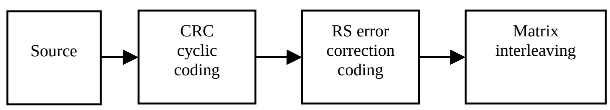

Figure 1. Channel coding model.

B. MSK Modulation Technique

Minimum Shift Keying (MSK) is also known as the fast frequency shift keying (FFSK),"Min" means that this form of modulation can obtain orthogonal modulation signal with a minimum modulation index (O.5),"fast" means that the modulation scheme, for a given frequency band, the data transfer rate of MSK is higher than 2PSK, and the attenuation of spectral components outside the band is faster than the 2PSK [3].

This makes the side lobes of MSK decrease quite rapidly and more energy is concentrated in the main lobe. These advantages can reduce the interference of the TACAN and

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IFF system. MSK occupies narrow spectrum and have significant bandwidth effectiveness, which is an important reason for JTIDS to choose MSK modulation.

C. Direct Sequence Spread Spectrum and Frequency-Hopping Technology

JTIDS signal is a spread spectrum signal and it adopts the method of combining direct sequence spread spectrum and frequency hopping.

Direct Sequence Spread Spectrum (Direct Sequence Spread Spectrum) is called as DS for short. The JTIDS system doesn't use 5 bit binary data to modulate carrier to form a pulse when transmitting every 5 bit of information [4]. Instead, it is replaced by the pseudo-random sequence of 32h, which widens the modulated signal spectrum width 6.4 times and improves the capability of anti-jamming.

The use of frequency hopping (FH) could make interference signals do not know the law of frequency hopping. The irrelevance between hopping frequency and the frequency generated by the local frequency synthesizer enables the system to have the ability of resisting single frequency and parts of narrow-band interference. The performance of hopping depends on the changes and the speed of frequency points. More frequency points mean wider signal bandwidth; the wider the hopping bandwidth and the higher the hop rate, then the stronger the capacity of resisting disturbance. As the Link-16 channel, the carrier frequency of JTIDS signal pulse is selected among 51 frequency points between 960 MHz~1215 MHz pseudo-randomly and the minimum interval is 3 MHz. Between adjacent pulses, the interval of the selected frequency is greater than or equal to 30 MHz [6]. In practice, JTIDS hopping points are distributed in the three bands, namely 969 MHz to 1008 MHz (14 frequency points), 1053 MHz to 1065 MHz (5 frequency points), and 1113 MHz to 206 MHz (32 frequency points) [2].

Direct expansion (DS) and frequency hopping (FH) system both have a strong anti-jamming ability, and they are two spread spectrum technologies which are the most frequently used. Frequency hopping system's ability is not strong in selective fading resistance and resistance to multipath, direct expansion technology just makes up for the shortcomings; direct expansion system is influenced greatly by "far-nearly" effects, and this is the advantage of frequency hopping technique. The two methods have their own unique feature, but also have their own defects, if they are organically combined together, it can greatly improve the JTIDS system's performance.

III. SIMULATION SYSTEM BASED ON SIMULINK

Since the JTIDS is for the active service equipment of the American military, it is impossible to carry out data acquisition and performance analysis of the actual system, but through software simulation, certain assumptions are made when setting the system's parameters, quantitatively or qualitatively to describe the system's performance, and according to the simulation results analysis and optimization of the system will be made. In this paper, the Simulink software is the platform of simulation， through the simulation we can analyze the JTIDS transmission performance. During the process of simulation, we think that the system's modulation and demodulation are always kept synchronized.

A. The simulation of MSK modulation's performance

Figure 5 is the Simulink simulation model of MSK modulation, the JTIDS source sampling frequency is 0.2 x 10-6 s/bit, in order to calculate conveniently, the sampling time of this simulation system is 0.002s[7]. MSK modulation module's settings are the same with the demodulation module's, and the "Traceback length" of demodulation module and the "Receive Delay" of error rate statistics module are set to 16.

From figure 2 we can see that after MSK modulation and demodulation, the error rate of the system decline fast with the channel bit error rate increasing, under normal communication conditions it can meet the military communication anti-jamming, security requirements.

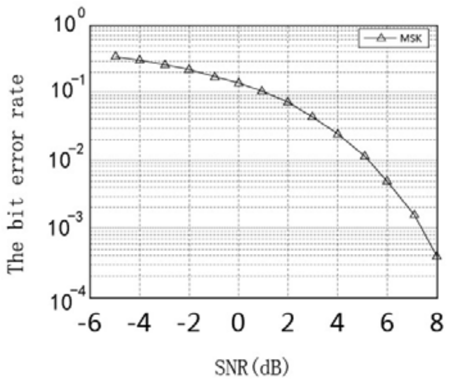

Figure 2. The bit error rate of MSK modulation system

B. The simulation of channel coding performance

Subsystem1 subsystem adopts the CRC-12 cyclic redundancy coding, RS (31, 15) coding, (31, 5) matrix mixed three modules to enable the joint compilation, the Subsystem2 subsystem uses the corresponding decoding module of system1 to compile. BSC means binary symmetric channel, the system's error rate is calculated through the error rate calculation module[8]. Figure 6 is the model of the simulation.

From figure 3 we can see that after the system adopts the channel coding technology, bit error rate is accelerated to decline with channel error rate decreasing. When channel error rate is less than a certain value (0. 06), the system's bit error rate begins to significantly reduce; when channel error rate is larger which means that the transmission environment is very bad, the coding technique makes a small contribution to improve the system's transmission performance.

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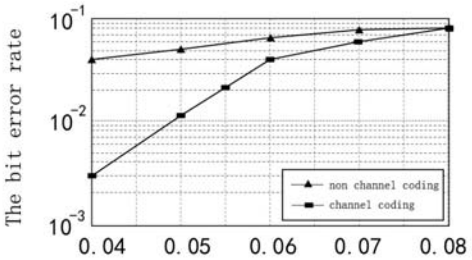

Figure 3. Channel coding performance

C. The simulation of spread spectrum and frequency hopping system's performance

The simulation system's binary source data are produced by the Bernoulli Binary Generator and spread spectrum codes are produced by Hadamard code Generator (applicable to the sender and receiver strictly synchronous communication system), the system's jump frequency control section is produced by PN sequence whose output is set according to the frame, the Frame Conversion module converses the frame format to sampling signal, then use Bit to Integer Converter to converse every five code piece to a random Integer as an output, the three modules are encapsulated in Subsystem3 subsystem as frequency hopping carrier point control signals. Frequency hopping device uses M-FSK Modulator Baseband1 to finish, through the setting parameters it can change the frequency point and jump frequency rate of the pseudo random jumping frequency carrier signal. In the simulation system, frequency hopping output passes a white Gaussian noise channel, Sine Wave module produces a 30 Hz single frequency sine wave as a interference source. In the demodulation end, the multiplication of the local jump frequency carrier signal's conjugate signal and the receiving signal completes the dehopping.

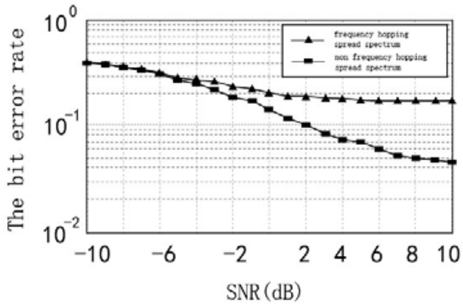

Figure 4. Frequency hopping spread spectrum technology simulation performance

From figure 4 we can see that when bit error rate is up to -6 dB, the performance of the simulation system is beginning to ascend with channel bit error rate rise, and frequency hopping spread spectrum technology has good ability of resistance to single frequency interference. In the process of simulation, we also found that when the frequency of the single frequency interference source is set to integer times of the jump frequency interval, the anti-interference ability of the system has been weakened.

IV. END

The paper mainly puts three key technologies: MSK modulation technique, channel coding techniques, frequency hopping and spread spectrum combined technique which are used for the JTIDS data transmission process into Simulink simulation and analyzes the error performance of the simulation system, it can be seen that the adoption of these technologies can effectively improve the data transmission performance of the system, and different serial number generators are used in the simulation process of the combination of spread spectrum and frequency-hopping technology, therefore the system has a good ability to resist the single frequency interference. The simulation study of the JTIDS transmission performance provides a basis for further assessment of the JTIDS link performance under different operational environments.

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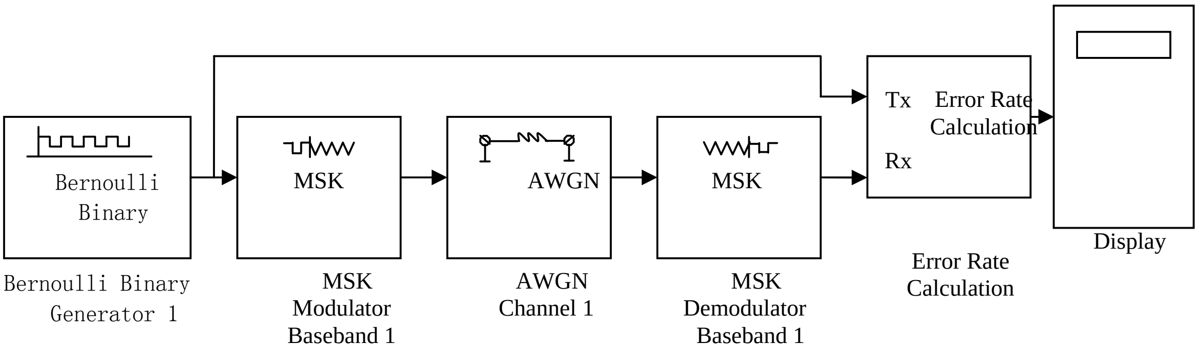

Figure 5. MSK modulation simulation model

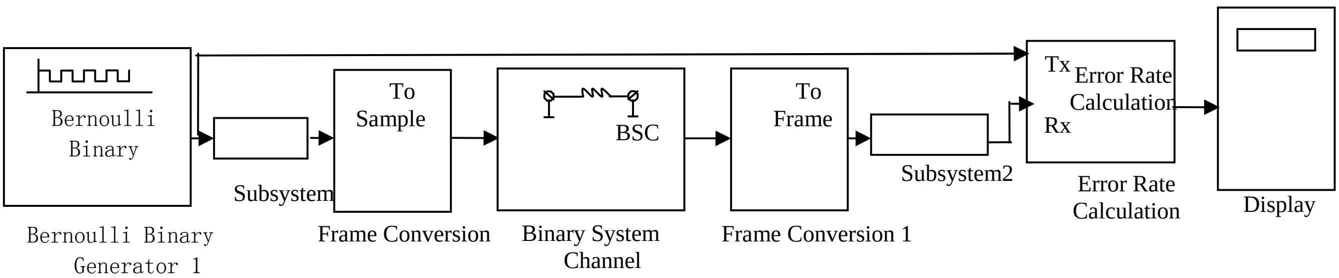

Figure 6. Channel coding simulation model

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