Journal of Theoretical and Applied Information Technology
10th January 2013. Vol. 47 No.1

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

# CHANNEL CODING SIMULATION RESEARCH OF INTER-SATELLITE SPREAD SPECTRUM COMMUNICATION SYSTEM

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*Received 3 January 2012; accepted 22 November 2012*

**ABSTRACT**

This paper considers proposing the mathematical model and simulation mode of inter-satellite channel based on the reliability of inter-satellite communication system. The Monte Carlo method is adopted to develop the spread spectrum communication system of two consumers. In order to reduce the bit errors of inter-satellite communication, both spread spectrum communication technology and channel coding technology are brought forward under inter-satellite channel. A simulation is given to illustrate that the combined application of spread spectrum communication technology and channel coding technology can achieve ideal performance.

**Keywords:** *Spread Spectrum Communication, Convolutional Code; Channel Coding; Sine Interference*

## 1. INTRODUCTION

It is well known that satellite network has high civil value and great military value. In particular, satellite communication network can be independent of the ground through inter-satellite link in wartime. Since the satellite network has these advantages, the satellite communication link has become the weak link of satellite network system security and anti-jamming. With the increasingly fierce space electronic countermeasure, the satellite communication security and anti-jamming technology has been received intensive research [1-6]. Although the satellite communication system with spread spectrum technology could enhance system robustness and security, fading, noise, interference and delay are affected inevitably in satellite communication. Therefore, channel coding is the key technology to ensure the reliability of the communication satellite communication. For satellites, especially the small satellite, body weight and transmitting power is limited. When it joins the good channel coding, large channel coding gain will be obtained to relax the pressure of antenna and transmitting power. In this sense, investigation of the optimal channel coding method to obtain more coding gains, has great practical significance to reduce the satellite quality and power restriction [7].

In recent years, the research results of spread spectrum communication technology research have been published in a large number of references. Literatures [8] introduce the coding principle of spread spectrum communication, which puts forward the spread spectrum system by using the autoregressive filter method from the source sequence to extract AR self coded of spread spectrum code. Literatures [9] established the dynamic simulation model of multi-user chaotic sequence spread spectrum communication system, where the proposed model is to address three kinds of chaotic spread spectrum sequence spread spectrum code. Literatures [10] consider the problem that the low elevation wideband ground-air communication channel has large multi-path time delay and fast time-varying. It put forward a novel scheme of M-ary spreading communication system which used filter-banks for frequency domain equalization (FB-FDE). In [11-12], some key technologies is introduced to improve the performance of spread spectrum communication system. This article establishes a satellite channel mathematical model and simulation model from the satellite communication reliability problems. The Monte Carlo method was used to put up spread spectrum communication system based on dual users. The spread spectrum communication technology is combined with channel coding technology in the satellite channel. Simulation

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

Research is performed in the presence of sinusoidal interference cases.

## 2. INTER SATELLITE COMMUNICATION SIMULATION RESEARCH BETWEEN SPREAD SPECTRUM AND CHANNEL CODING

### 2.1 Satellite Channel Model

Attenuation, time delay, Doppler frequency shift and noise and so on inevitably lead to decay in inter-satellite link channel. Therefore, it is necessary to summarize the spatial transfer properties of radio waves, inter-satellite link channel statistics, and then establish the statistical channel model [13]. According to wave propagation characteristics in space, the model is given in Figure 1. The model of the channel is divided into three modules: Doppler frequency shift module, module, space loss module and noise simulation module.

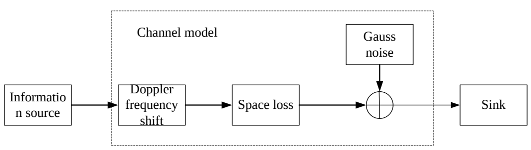


*Figure 1: Block Diagram Of Spatial Channel Transmission*

#### 2.1.1 Mathematical model of satellite channel model

Because the impulse response of the channel is a stochastic process, the channel can be modeled as a time varying filter. The input modulation signal is denoted as $s(t)$, a signal received at the receiver for a filtered signal plus noise, noise variance is Gauss white noise of $N_0/2$, the receiving signal can be expressed as:

$$r(t)=\int_{-\infty}^{+\infty} h_c(t;\tau)s(t-\tau)+n(t) \qquad (1)$$

Assuming that the channel is frequency selective channel, the time variable channel transfer function $h_c(t;\tau)$ can be regarded as complex-valued which is independent of the frequency. Channel impulse response $h_c(t;\tau)$ is simplified as $h_c(t;0)\delta(\tau)$. Therefore receiving signal can be expressed as:

$$r(t)=\int_{-\infty}^{+\infty} h_c(t;0)\delta(\tau)s(t-\tau)d\tau+n(t)$$
$$=h_c(t;0)s(t)+n(t)=\alpha(t)[\exp(i\Phi(t))]\cdot s(t)+n(t) \qquad (2)$$

The received signal can be expressed as: transmitting signal multiply $h_c(t;0)$ which represents the complex-valued random process of the channel time-varying characteristics. $h_c(t;0)=\alpha(t)[\exp(i\Phi(t))]$ represents the channel fading process. $\alpha(t)$ represents the equivalent low-pass channel envelope process, $\Phi(t)$ represents the equivalent low-pass channel phase process, the two are the real random process.

Suppose that the channel fading varies very slowly, thus the channel fading process can be regarded as a constant by one symbol intervals. In this sense, the above formula can be further simplified to:

$$r(t)=\alpha[\exp(i\Phi)]s(t)+n(t) \quad 0\le t\le T \qquad (3)$$

Which: $T$ is modulation code width; $\alpha$ and $\Phi$ indicated the equivalent low-pass channel amplitude and phase, both of which are the real random process. About characteristics of probability distribution of $\alpha$ and $\Phi$, predecessors do a lot of transmission characteristic measurement by Olympus satellite, Italsat satellite and ACTS satellite, and have accumulated a large amount of data. Signal envelope and phase probability distributions are Gauss distribution, their probability density function are expressed as:

$$p(r)=\frac{1}{\sqrt{2\pi}\sigma_1}\exp(-\frac{(r-m_1)^2}{2\sigma_1^2}) \qquad (4)$$

$$p(\Phi)=\frac{1}{\sqrt{2\pi}\sigma_2}\exp(-\frac{(\Phi-m_2)^2}{2\sigma_2^2}) \qquad (5)$$

Which: $p(r)$ is the probability density function of signal envelope; $p(\Phi)$ is the phase of signal probability density function; $\sigma_1$ and $\sigma_2$ are the signal envelope and phase variance; $m_1$ and $m_2$ corresponding to the mean value respectively.

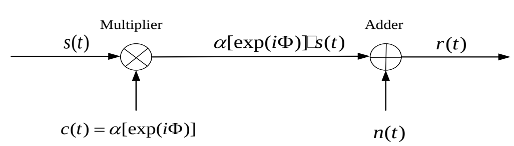


*Figure 2: Mathematical Channel Models Of Statistic Characteristics*

#### 2.1.2 Inter satellite link simulation model

According to the above mathematical model, the simulation model can be set up as shown in Figure

Journal of Theoretical and Applied Information Technology
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ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

3 below. Gauss 1 and Gauss 2 are two independent band limited, zero mean Gauss random process in Figure 3. The variance are respectively equal to $\sigma_1$ and $\sigma_2$. After Gauss 1 add with $m_1$ which is produced by constant generator 1, Gauss stochastic process $\alpha$ is generated by mean value $m_1$, variance $\sigma_1$. Similarly it can generate Gauss random process $\Phi$. $\Phi$ generates $\exp(i\Phi)$ through index of generator, and multiplies $\alpha$, and obtain multiplicative disturbance vector $c(t)=\alpha[\exp(i\Phi)]$. AWGN expresses channel additive white Gauss noise $n(t)$. It represents a different channel, only needs to change the variance settings of the Gauss 1 and Gauss 2, or the parameter settings of real constant generator 1 and real constant generator 2.

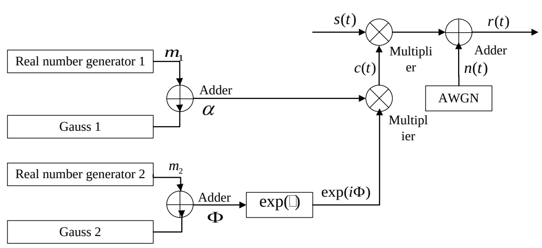


*Figure 3 Channel Simulation Model Of Statistic Characteristics*

The satellite channel model establishes the foundation for follow-up computer simulation, and saves time, at the same time, other inter satellite communication system can be further studied by the model.

## 2.2 Monte Carlo communications system simulation model

In this section we uses the Monte Carlo communication system model to carry out simulation analysis for anti-interference performance on direct spread spectrum system. In order to obtain more information, the simulation is implemented by dual subscriber. The simulation model is showed as Figure 4.

Single user simulation process is chosen to describe in Figure 4. A series of binary information ($\pm 1$) are generated by random number generator, each bit of information to repeat $L_c$ times, $L_c$ corresponds to each bit of information contained in the pseudo code number. $L_c$ repetitive sequences of every bit multiply with PN sequence $c(n)$ which is generated by another random number generator. Then the sequence is superimposed by variance $\sigma^2 = N_0/2$ Gauss white noise and forms for the $i(n) = A\sin\omega_0 n$ sinusoidal disturbances, while $0<\omega_0<\pi$, and sinusoidal interference signal amplitude satisfies the condition $A<L_c$. In the demodulator for PN sequence correlation operation, and $L_c$ samples of the composition information bits are added. The output of adder is send to decision device, the signal and the threshold 0 is compared, to determine the transmitted data for +1 or -1, error counter is used to record the number of erroneous for judgment device.

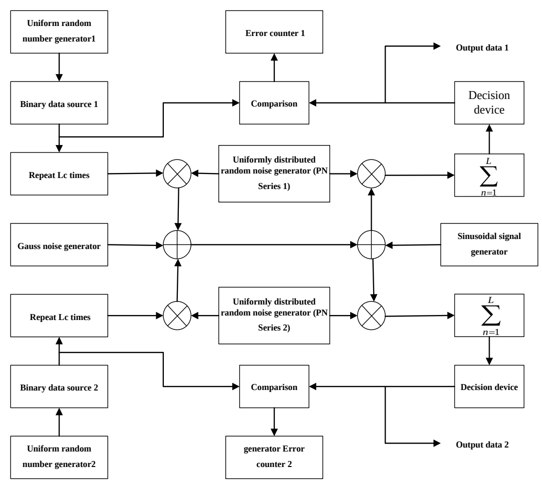


*Figure 4 Simulation Model Of Two-User DSSS Communication System*

## 2.3 Satellite Communication System Simulation Research

### 2.3.1 Spread spectrum compare with convolutional code in inter satellite communication system

Spread spectrum technology inhibits sinusoidal disturbances of satellite communication, improves the system BER. And channel coding itself also can reduce bit error number in channel with interference. Subsequently, the simulation shows that contrast with channel coding and spread spectrum technology on sine interference suppressing effect.

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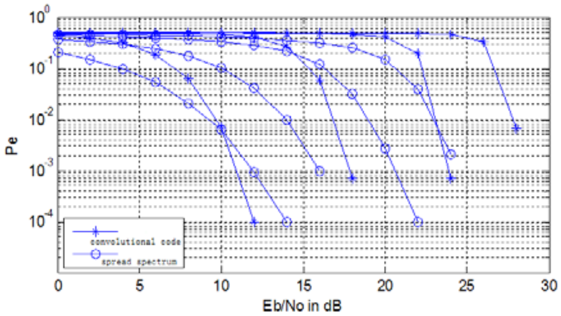

*Figure 5 BER Comparisons Between DSSS And Convolutional Code In Isls*

The simulation results of Figure 5 show the spread spectrum technology and channel coding technology can reduce the system bit error rate. When sinusoidal interference amplitude value is zero, convolutional code improves system performance much better than the spread spectrum technology. When presenting sinusoidal interference, the spread spectrum technology is better than convolutional code. And with the sinusoidal interference amplitude increasing, the effect of convolutional code is reduced.

**2.3.2** Spread **spectrum and convolutional code in satellite communication combined application**

Spread spectrum technology and channel coding technology can improve the reliability of inter satellite communication. As seen in Figure 6 below, the bit error rate curve is given by combining different constraint length convolutional code with spread spectrum technology. Sinusoidal interference amplitude values takes 0, 3, 7 and 12, convolutional code chooses (2, 1, 4) and (2, 1, 7) respectively in the simulation. The simulations are given in Figure 6.

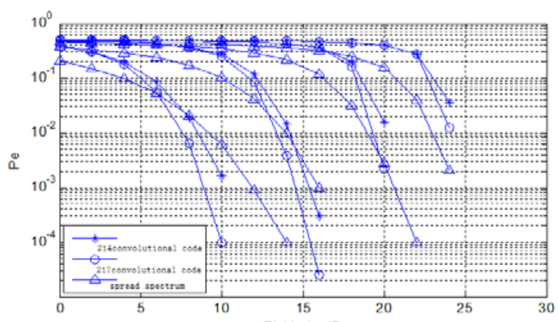

*Figure 6 Combination Of Convolutional Code And Spread Spectrum Technology Over Isls*

The four sets of curves of Map from left to right represent sinusoidal interference value 0, 3, 7 and 12. The simulation results show: with the convolutional code constraint length increasing, the error rate improves significantly stronger.

Comprehensive considerations, the application of channel coding technology are advantage in real system. When the sinusoidal interference value is larger, we should consider whether add convolutional code to spread spectrum system, according to signal noise ratio which the actual system can provide.

## 3. CONCLUSION

In this paper, inter satellite channel mathematical model and simulation model are established. In addition, Monte Carlo method is used to establish spread spectrum communication system based on dual subscribers. Spread spectrum communication technology and channel coding technology are combined application, when sinusoidal interference exists in inter satellite channel. The simulation results show that the improvement effect of system BER increases in turn by using convolutional code, spread spectrum technology and combination of both. The combined application of spread spectrum and coding technology can achieve the best results in inter satellite communication system.

## ACKNOWLEDGEMENTS

This work is supported by the National High Technology Research and Development Program of China (No.2012AA120601), National Natural Science Foundation of China (No. 11202044, No. 11072044) and the Fundamental Research Funds for the Central Universities.

## REFERENCES:

[1] G.Y. Li, “Wavelet notch filter design of spread-spectrum communication systems for high-precision wireless positioning”, *Circuits, Systems, and Signal Processing*, Vol. 31, No. 2, 2012, pp. 651-668.

[2] E. Andrea, Z. Francesca, B. Gabriele, L. Marco, “Spread-spectrum continuous-phase-modulated signals for satellite navigation”, *IEEE Transactions on Aerospace and Electronic Systems*, Vol. 48, No. 5, 2012, pp. 3234-3249.

[3] H.F. Cao, R.X. Zhang, F.L Yan, “Spread spectrum communication and its circuit implementation using fractional-order chaotic system via a single driving variable”, *Communications in Nonlinear Science and*

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

*Numerical Simulation*, Vol. 18, No. 2, 2012, pp. 341-350.

[4] U. Rahat, L. Shahid, "Improving the security level in direct sequence spread spectrum using dual codes (DC-DSSS)" *International Journal of Security and its Applications*, Vol. 6, No. 2, 2012, pp. 133-136.

[5] K. Jayanthi, P. Dananjayan, "Improving antijamming characteristics of spread spectrum communication systems", *International Journal of Autonomous and Adaptive Communications Systems*, Vol. 5, No. 1, 2012, pp.77-87.

[6] M. Kuribayashi, "Interference removal operation for spread spectrum fingerprinting scheme", *IEEE Transactions on Information Forensics and Security*, Vol. 7, No. 2, 2012, pp. 403-471.

[7] Y.C. Wu, "Error control coding application in satellite communication", *Telecommunication Engineering*, No. 1, 2001, pp. 3-7.

[8] M. Wei, Z.L. Li, F. Yin, "Analysis and simulation of AR-SESS system performance", *Journal of University of Electronic Science and Technology*, Vol. 34, No. 5, 2005, pp. 585-588.

[9] H.K. Sun, J.L. Zhou, J. Mo, "Design and performance analysis of multi-user chaotic sequence spread-spectrum communication system", *Journal of Electronics & Information Technology*, Vol. 29, No. 10, 2007, pp.2436-2440.

[10] M.F. Fei, K.C. Yi, "A M-Ary spreading spectrum system using FB-FDE", *Journal of University of Electronic Science and Technology*, Vol. 37, No. 3, 2008, pp.382-385.

[11] J. Bas, A. Perez, A. Miguel, "Differential fuzzy filtering for adaptive line enhance in spread spectrum communications", *Signal Processing*, Vol. 86, No. 5, 2006, pp. 984-1009.

[12] S. Seda, A. Aydin, Luis, "Time-frequency channel modeling and estimation of multi-carrier spread spectrum communication systems", *Journal of the Franklin institute*, Vol. 342, 2005, pp. 776-792.

[13] M.J. Wang, S.B. Zhu, "Research on the inter-satellite link channel model", *Journal of Institute of Command and Technology*, Vol. 16, No. 4, 2005, pp.984-1009.