Simulation of Satellite Communication System Based on MATLAB/SIMULINK

[redacted]

Abstract: Composition of satellite communication system is analyzed in brief. Losses and noises in communication system are estimated. The signal-to-noise ratio and bit-error-rate are provided as index of satellite communication system's performance. Relationship between the signal-to-noise ratio and bit-error-rate is researched through modeling. On the basis of satellite communication's theory, the communication system is simplified properly, the communication on baseband is modeled. And communication system of geostationary satellites is simulated with SIMULINK. Constellation diagrams, power spectrogram and bit-error-rate are acquired. The results show the rationality and reliability of system. It lays the foundation of simulating satellite communication system with SIMULINK.

1 INTRODUCTION

Satellite communication systems are based on terrestrial mobile communication technology, combining technology such as satellite, computer and microelectronics, and supporting the system of communication between users' terminals. Satellite communication system because of the complex system composition, data transmission loss and noise of a wide variety, simulation is complex. In this paper, the geosynchronous communication satellite is the research object, the components of the satellite communication system are analyzed, the transmission loss and noise of the star-earth link are estimated, and the satellite communication system is simulated under SIMULINK environment [1].

2 SATELLITE COMMUNICATION SYSTEM

As shown in Figure 1 on the following page, in the transmit subsystem, the initial signal generated by the source is modulated and passed through the upconverter. [2] The upconverter mixes the modulated intermediate frequency signal with the local oscillator carrier and loads it onto the satellite uplink RF frequency. The RF signal is amplified by the power amplifier and transmitted to the satellite.

In the receiving subsystem, the weak signal forwarded by the satellite is first processed by the low noise amplifier, and the downconverter converts the modulated RF signal from the low noise amplifier from the downlink frequency to the intermediate frequency, and the signal is demodulated and sent to the sink.

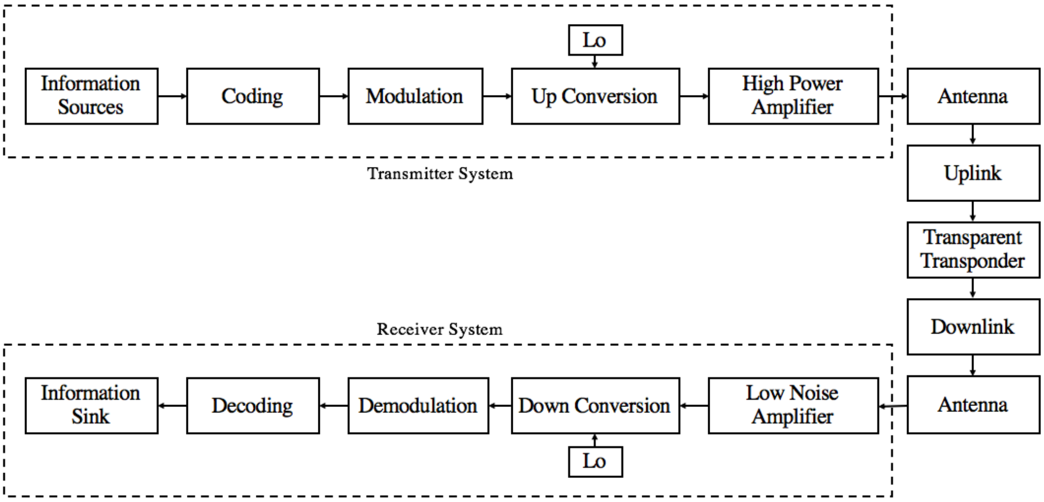


Figure 1. Block diagram of satellite communication system [3]

3 SATELLITE COMMUNICATION SYSTEM SIMULATION

3.1 Simulation preparation

In order to reflect the working principle of the satellite communication system and appropriately reduce the simulation workload, the satellite communication system is simplified during system simulation: Considering the carrier as a carrier and without any valid information, the baseband equivalent model is adopted throughout the simulation.

Suppose that a geosynchronous communication satellite is basically aligned with the antenna of the ground station, the communication distance is about 36 000 km, the uplink and downlink frequencies are 6/4 GHz, and the signal modulation pattern is QPSK. [4] The propagation loss and noise are respectively:

$$L_{P\mathrm{up}} = 92.45 + 20\lg 6 + 20\lg 36\ 000 = 199.25\ \mathrm{dB}$$

$$L_{P\mathrm{down}} = 92.45 + 20\lg 4 + 20\lg 36\ 000 = 195.62\ \mathrm{dB}$$

$$L_{\mathrm{estimate}} = 1.07\ \mathrm{dB}$$

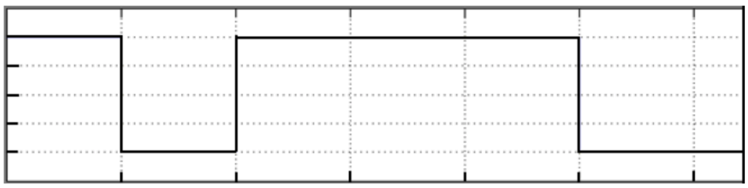
$$L_{\mathrm{up}} = 199.25 + 1.07 = 200.32\ \mathrm{dB}$$

$$L_{\mathrm{down}} = 195.62 + 1.07 = 196.69\ \mathrm{dB}$$

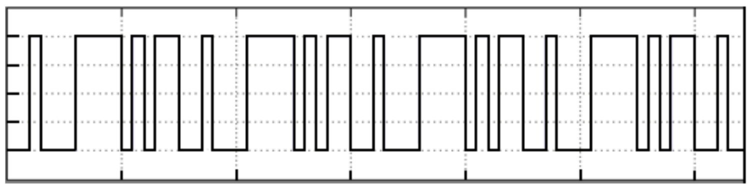
3.2 Code Division Multiple Access

Spread spectrum communication technology is a kind of information transmission mode, the bandwidth of the signal is far larger than the minimum bandwidth necessary for the transmitted information; the expansion of the frequency band is completed by an independent code sequence, realized by coding and modulation, independent of the transmitted information data; at the receiving end, the same code is used for synchronous reception, de expansion and recovery of the transmitted information data.

The basic methods of spread spectrum include direct sequence (DS), frequency hopping (FH), time hopping (TH) and chirp. [5] In this design, direct sequence spread spectrum (DS) is used. The principle of DSSS technology is to modulate the RF carrier signal with a fast-changing binary bit stream. This binary bit stream appears to be random, but it is actually generated by a digital circuit according to a specific algorithm, which is called pseudo-random code (PN sequence). Under the modulation of pseudo-random code, information is transmitted through the transmitter. The corresponding receiver can generate the same pseudo-random code, demodulate according to the inverse process of transmission, and analyze the effective information signal.



(a) Original Signal



(b) Direct sequence spread spectrum

Figure 2. Process of direct sequence spread spectrum

3.3 Simulation Implementation

Referring to the simplified block diagram of the satellite communication system, the simulation system shown in Fig. 3 is established in the Simulink environment [6], The simulation time is set to 50 s and the sampling time is 0.001 s.

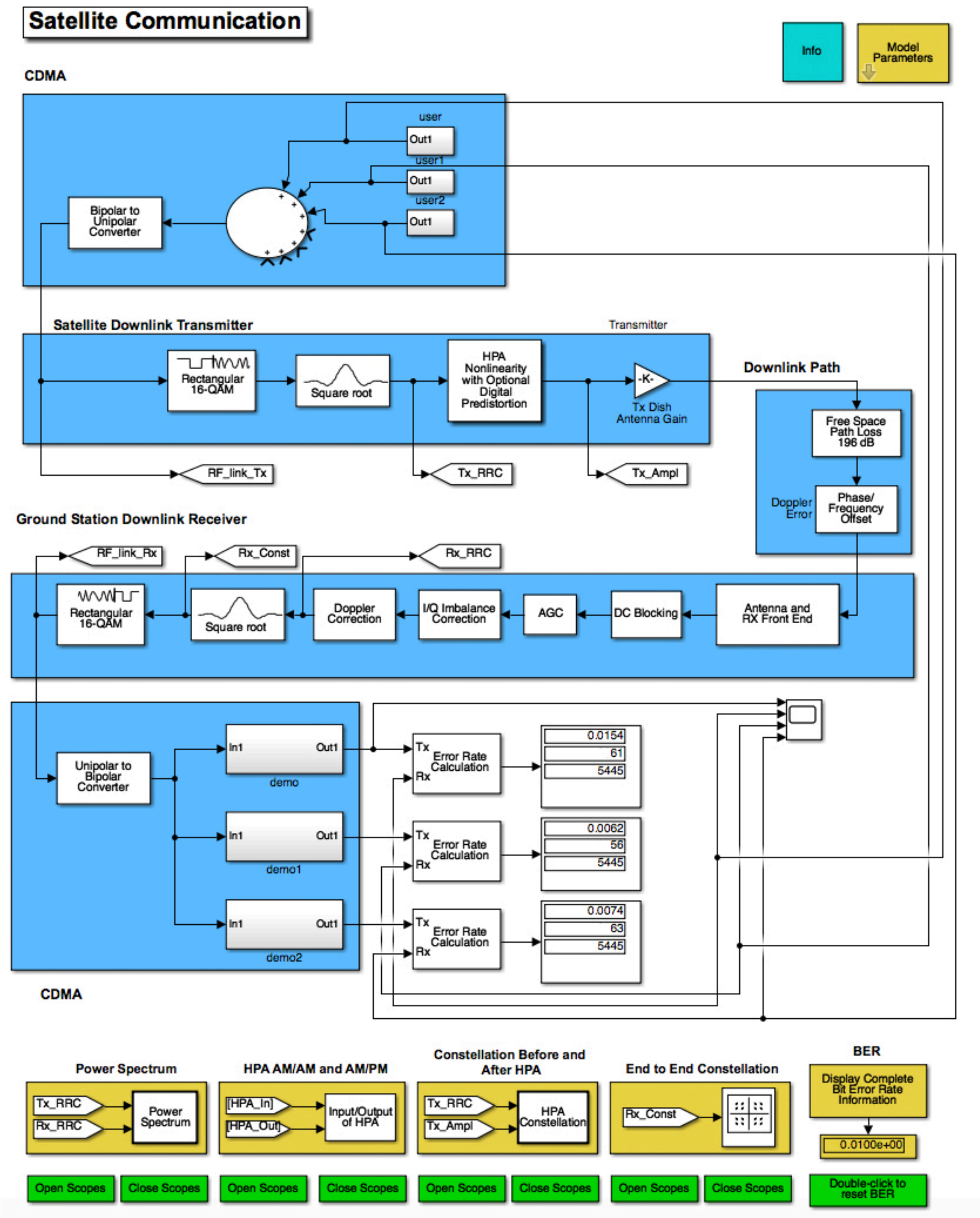


Figure 3. Simulink of satellite communication system

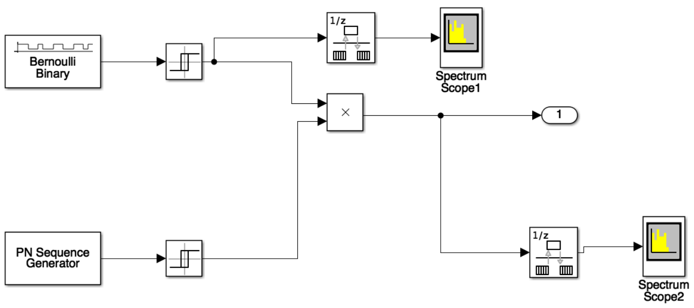


Figure 4. User module completes spread spectrum function

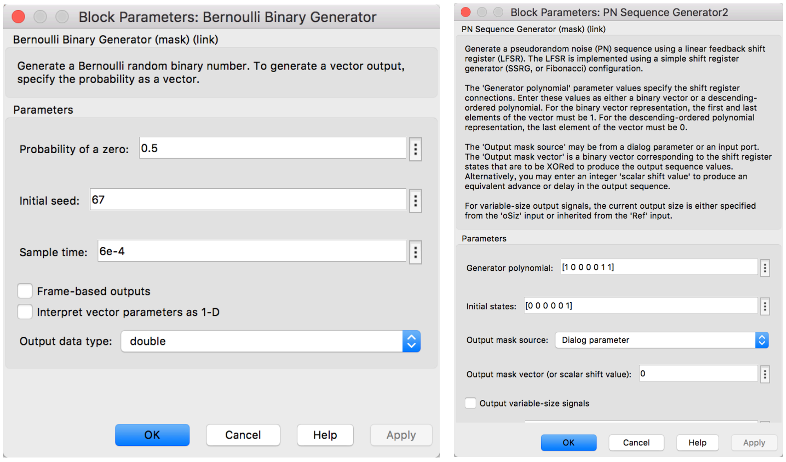


Figure 5. (a) Bernoulli binary generator parameters (b) PN sequence generator parameters

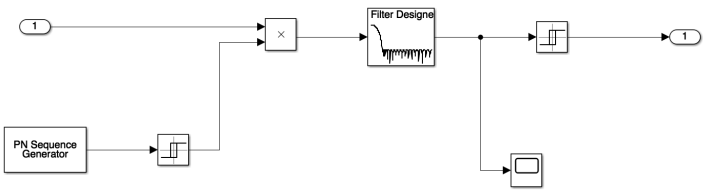


Figure 6. Demo module

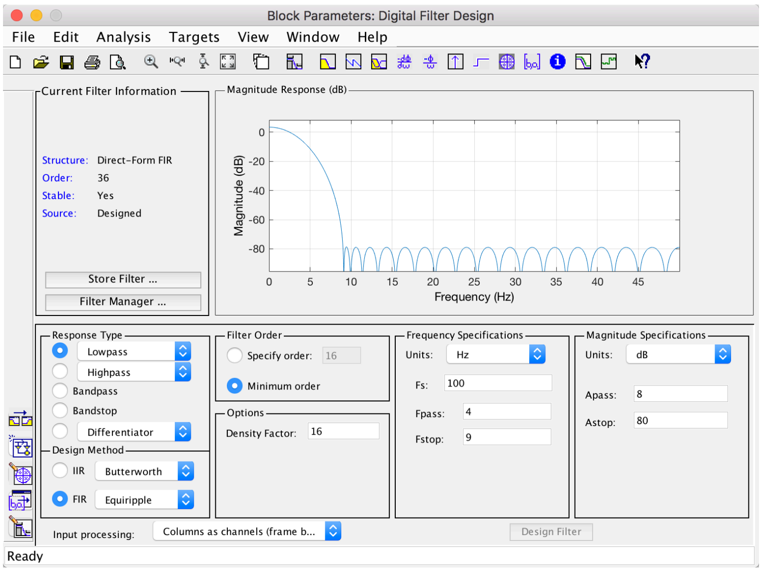


Figure 7. Digital filter design of demo module

3.4 Analysis of simulation results

3.4.1 Signal constellation

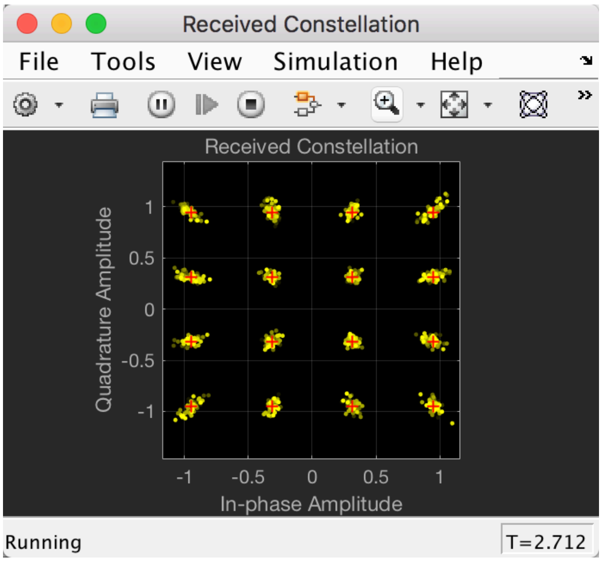


Figure 8. Signal constellation of 16-QAM signal

The constellation diagram is approximately located on the standard points, and the demodulated signal can resolve the phase information of the signal although it has a little phase distortion.

3.4.2 Bit Error Rate

Within 10 s of the simulation, the number of simulated data points is small, causing the communication error rate to fluctuate greatly. After 10 s, the communication tends to be stable, and the noise caused by antenna noise and transmission loss is the whole simulation process has a stable statistical feature, and the communication error rate is maintained at about 0.01. When the number of users import increase, the bit error rate also increases.

3.4.3 Spectrum

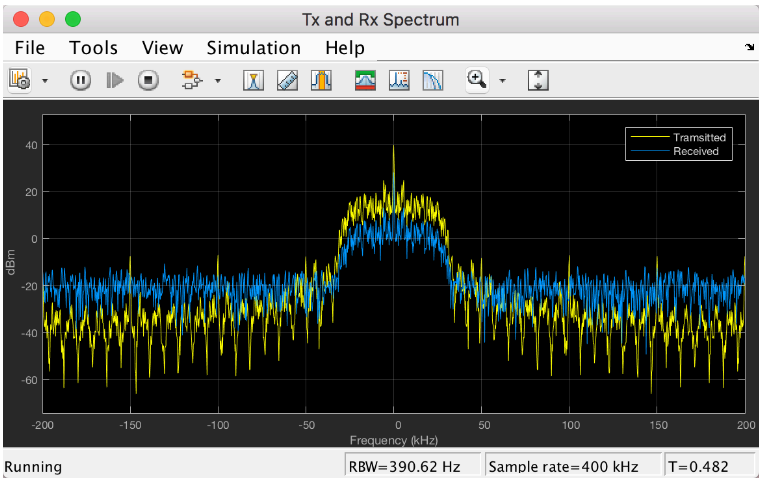
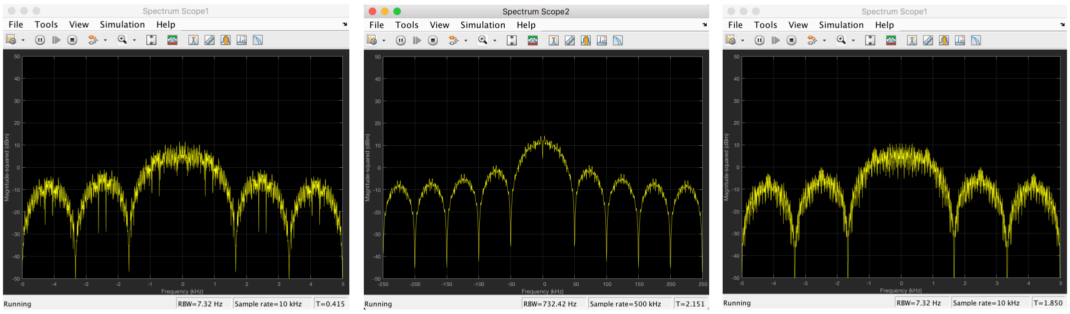


Figure 9. Spectrum of transmitted and received signals

After the spectrum of the signal waiting to be transmitted is expanded, the energy is evenly distributed in a wide frequency band, and the power spectral density is reduced; after the spread spectrum signal is de expanded, the wide-band signal is restored to narrow-band information, and the power spectral density is increased. As figure 11 shown, the original signal and the received are almost similar, under the situation where three users are imported with the BER 0.016.



(a) (b) (c)

Figure 10. (a) Original Spectrum; (b) Post spread spectrum; (c) Despreading filter spectrum

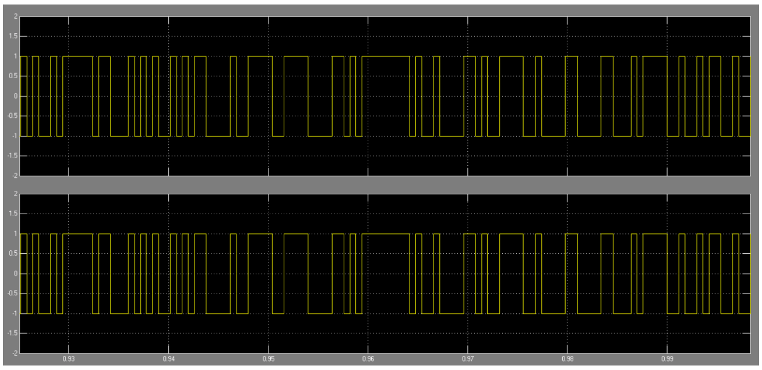


Figure 11. Original signal and received signal (Three users)

4 CONCLUSION

This paper firstly analyzes the composition of the satellite communication system. Then it estimates the loss and noise that may be encountered during the transmission process. Based on this, the performance index of the communication system is proposed. Finally, the communication simulation software SIMULINK is used to simulate the satellite communication system. The simulation results show the rationality and reliability of the model. It should be noted that the satellite communication system model constructed in this paper is a simplified model based on baseband signals. It only realizes the most basic functions of satellite communication. The model has a certain expansion space. This is needed when studying the specific problems in satellite communication. Add the corresponding module on it.

REFERENCE

[1] https://uk.mathworks.com/products/communications.html
[2] Ashoor, F. (2003). Satellite communication system.
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[4] XIZai-fang, & WUShu-yue, et al. (2006). Simulation analysis of modern communication systems based on simulink. Journal of System Simulation, 18(10), 2966-2968.
[5] Saleh, & A., A. M. . (1981). Frequency-independent and frequency-dependent nonlinear models of twt amplifiers. IEEE Transactions on Communications, 29(11), 1715-1720.
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