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Software Testing Method Based Mobile Communication Equipment of Maritime Satellite

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Abstract. Focusing on the different performance of communication links between satellite and mobile terminals, this paper creates an adaptive channel model for satellite mobile communication, which can accurately reflect the multipath, shadowing and other problems in signal propagation and effectively forecast and evaluate the modulation, demodulation, coding and constellation distribution of satellite mobile communication systems. Then, the author put forward a software testing method for mobile communication equipment of maritime satellite. The proposed method achieves comprehensive verification and evaluation from the aspects of equipment applicability, reliability, durability, etc. The research findings provide a software test approach and the evaluation basis for improving the performance of communication equipment.

1. Introduction

The maritime satellite is responsible for the radio communication between the sea and the land. It integrates the routine, distress/safety and special/combat communications on the seven seas[1-5]. The mobility of the maritime satellite helps improve the accuracy of car-mounted and ship-borne terminals and other equipment. In to develop new terminals and value-added services, car-mounted, shipborne, and aeronautical broadband terminals are being used to expand new aggregable functions, laying the basis for value-added service platforms and applications for Inter-net-based satellite communications. As we all know, the maritime satellite plays an important role in emergency response. However, China is relatively weak in the independent development of maritime satellite communication terminals. To break foreign monopoly and enhance the performance of self-made terminals, it is necessary to set up a system that comprehensively verifies and evaluates communication performance. In other words, the system should be able to verify the rationality of the communication protocol, test the performance of equipment, and support the performance improvement of various emergency communication devices.

The maritime satellite mobile communication system consists of a communication satellite, a communication channel, a communication terminal and a communication simulator. Among them, the simulator mainly simulates the mobile communication terminal, uplink channel, signal repeater, downlink channel, laptop (PC and workstation) and various application software. The most well-known satellite simulators include Spirent (UK) GSS and STR series, CAST (US) 1000, 2000 and 4000 series, and WelNavigate (US) GS100, GS600 and GS1010 series. In China, Beihang University, sponsored by National Natural Science Foundation of China, pioneered the research into GPS satellite signal simulators. LinkStar designed three high-performance GPS satellite signal simulators with

Chinese independent intellectual property rights, namely, NS600 12-channel simulator, NS60112-channel scene-customizable simulator and NS700 multi-channel programmable simulator. The new simulators solve the lack of accurate test measures for high-end chips and receivers in China, and provide complete test plans to verify the performance of these devices.

Currently, there are many software for evaluating communication channels. Both domestic and foreign studies on satellite mobile communication channels follow the same principle: proposing new test methods or new channel modes based on the previous research. Channel measurement is divided into narrowband measurement and wideband measurement. The feature data of the channels are acquired using satellites, planes and balloons are launch platforms and ground receiving devices (e.g. fixed receivers or car-mounted receivers at different elevation angles) in different environments (e.g. downtown, suburbs, rural areas, mountainous regions and expressways) as receiving platforms. Since the 1970s, the European countries have been measuring the signals in different channels. So far, the signals in the L, S, Ka and UHF bands have been measured, yielding fruitful results. Many other countries have also engaged in channel measurement. For example, Hess, funded by NASA, measured the additional path loss in the 860MHz and 1,550MHz bands of ATS-6 geosynchronous satellites in different local environments (e.g. Chicago and San Francisco); Communications Research Laboratory (Japan) identified the channel features of Engineering Test Satellites-5 and -6 (ETS-V and ETS-VI) in Tokyo and Kyoto. In recent years, the high-frequency and large-bandwidth Ka (20/30 GHz) band has been targeted in the tests on the propagation features of radio waves. Most of these tests rely on Olympus (ESA), ITALSAT (Italy) and ACTS (US) satellites; China Institute of Radiowave Propagation conducted signal tests under tree shadowing and multipath fading in the bands of 468.924MHz and 1,691MHz, using the Japanese meteorological satellite GSM140E. Meanwhile, the product testing techniques are being updated with the development of satellite communication. The product tests mainly cover the overall quality of the products related to satellite communication, especially the receiver, and the compatibility between the receiver and software. The comprehensive and accurate software evaluation of satellite communication signal simulator and satellite communication devices is essential to enhance the competitiveness of China’s independent communication products.

2. Methodology

In this paper, an adaptive channel model for satellite mobile communication is established in view of the performance of the devices related to maritime satellite, while the spurious spectrum, the carrier phase noise and carrier frequency stability in satellite communication equipment tests. On this basis, the author presented a software test method for satellite communication hardware.

Considering the wide area and time variation of the satellite mobile communication channels[6-9], the link of the radio wave from the transmitting end to the receiving end of satellite mobile communication can be roughly divided into two processes, i.e. the spatial propagation from satellite to terminal and the ground mobile propagation. The former process exhibits such channel features as propagation attenuation, time delay and doppler shift, while the latter features the shadow fading caused by ground obstacles and multipath fading resulted from the surrounding scatterers. In light of the shadow fading and multipath fading of the ground mobile propagation, the fading features of satellite mobile communication signal were investigated according to the relationship between the signal and the channel-related bandwidth. Based on these features[10-14], a simulation model of phase and amplitude variation was constructed, which covers such factors as link delay, Doppler shift, multipath effect, shadow effect, fading and noise. Then, the model was proved as capable of accurate simulation of the channel features in real-world transmission environment.

Based on the channel model for satellite mobile communication, the signal features of satellite communication equipment were simulated under different scenarios. The dedicated satellite signal library, the signal fading simulation system, the communication protocol stack simulation system and the simulation management system were adopted to generate various dedicated satellite signals. The generated signals were faded by the signal fading simulation system. The satellite signal transmission was simulated with the communication protocol stack. Moreover, the baseband signals of the satellite’s analogue signals were obtained according to the simulation parameters, and subjected to

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intermediate frequency carrier modulation to digitize the intermediate frequency signals. The high-precision combined reference device, containing a base station, a mobile station, an antenna, an inertial measurement unit and post-processing software, was adopted to provide precise and reliable positioning results in actual environment and serve as the reference for terminal accuracy tests.

In view of the diversity of satellite communication devices, the difference of the devices in test indices and the complexity of accuracy tests, the author put forward an automated test method suitable for satellite communication equipment. Inspired by the approach and flow of signal analysis in satellite communication equipment tests, a signal analysis subsystem was proposed to test the following indices: spurious spectrum, carrier phase noise, frequency stability of modulated signal carrier and third-order intercept. The automatic test method completes the automatic tests of the indices by controlling the test instrument and the radio frequency switch according to different types of test equipment. The hierarchical and modular design facilitates system maintenance and upgrade. Functionally, the test system can be split into four aspect: system management, real-time testing, signal analysis and signal test.

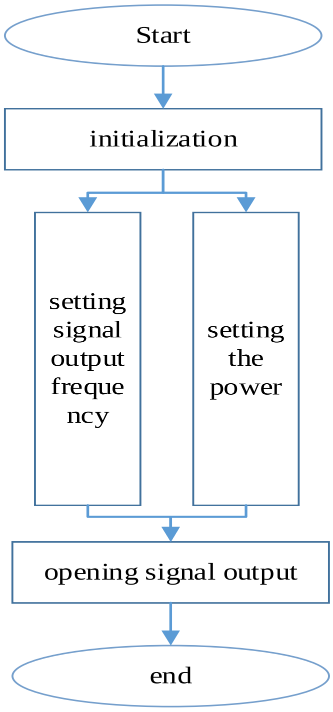

Figure 1. Generation of single carrier signal

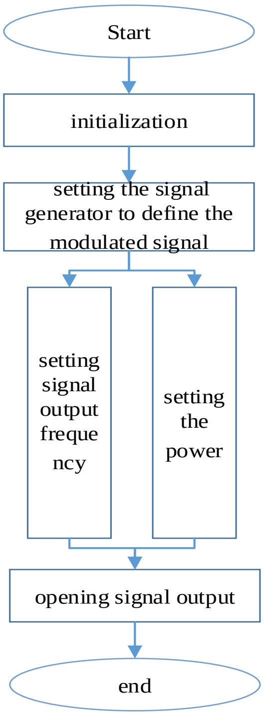

Figure 2. Generation of modulated signal

3. Communication Network Performance Tests

The satellite communication network was simulated by a test platform involving satellite channel simulator, router, switch and other devices. The performance data of the network were acquired through tests and subjected to evaluation. Based on the test data, the set of key parameters that directly bear on the network performance was determined[15-18], providing a reference for network transmission. The data acquisition part collects various data through the performance tests on the satellite communication network, while the data analysis part extracts and processes the original data. The key index part identifies the parameters that have the greatest impact on the current performance. For example, the delay and bit error rate of the simulator were separately changed and the network link bandwidth was adjusted via the PCM, so that the index variation of the network could be measured and the key parameters could be obtained according to the current performance of the network (e.g. transmission time of TCP file, loss rate of UDP packets and video quality).

Figure 3 illustrates the connections, instruments, signal flow direction and the test points T1~T4 on the signal flow of the test equipment. The test points on the power consumption of the four target devices are denoted as P1~P4, respectively. In Figure 4, the devices in red line boxes are third-party products, and those in purple line boxes are test instruments, i.e. a digital multimeter, an oscilloscope, a signal source, a spectrum analyser, a vector signal analyser, and a 100dB attenuator. Specifically, the bandwidth of the input signal simulated by the oscilloscope should not be less than 10MHz. The digital multimeter should be able to measure AC signal voltage and current. The signal source, spectrum analyser and vector signal analyser should cover the 1.5-1.7GHz band and boast a frequency stability no worse than 0.05ppm. The 100dB attenuator should cover the 1-2GHz band. The following technical indices were measured by the spectrum analyser: signal frequency, signal spectrum features, signal power level, local oscillator frequency stability, receiver equivalent noise coefficient, in-band amplitude fluctuation, Doppler frequency, signal-to-noise ratio (SNR) and relative amplitude of multipath signals. The channel time delay was identified by the oscilloscope. The power consumption of the simulator was determined by the digital multimeter. The signal modulation format was ascertained by the vector signal analyser. The equivalent noise coefficient was tested using the signal source, the spectrum analyser and the 100dB attenuator.

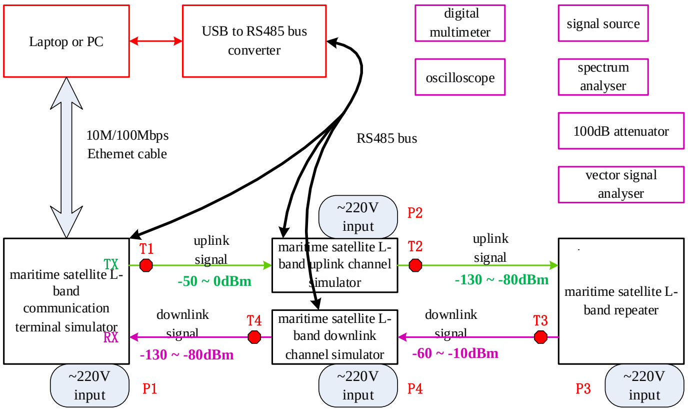

Figure 3. Test equipment connections and instruments

The key to the software simulation of satellite communication equipment lies in the determination of the test objects, the test scenarios and the test method. The technical roadmap is presented below as Figure 4.

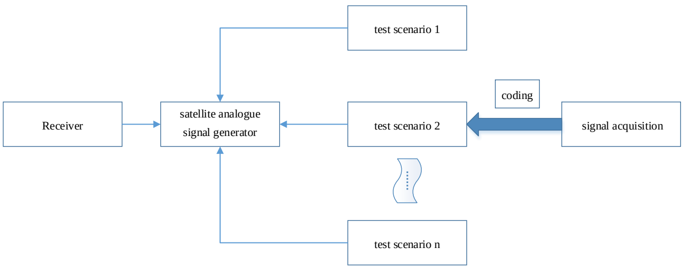

Figure 4. Technical roadmap for software simulation of satellite communication equipment

The test scenarios were generated by encoding the collected signal data, and used to test the performance of product. The simulation objects include sensitivity, time, positioning accuracy and overall performance. During the software simulation of satellite communication equipment, the test environment was maintained constant such that the test process and results are objective and accurate. Suffice it to say that the objects and method of the tests provide a unified and effective way to evaluate the quality of the receiver.

With the development of satellite communication, the related product testing techniques are rapidly evolving. The current product tests are focused on the overall quality of the products related to satellite communication, especially the receiver and the compatibility between the receiver and the software. Nevertheless, it is difficult to ensure the controllability and repeatability of the test signals due to the constraints of multiple factors, which affects the objectivity, fairness and consistency of the test.

Fortunately, the proposed adaptive channel model for satellite mobile communication can synthesize multi-channel signals, consider multiple complex environments (e.g. multipath, satellite occlusion and tunnel) in test scenarios, and accurately simulate the channel features of satellite mobile communication link. Based on these features, the resource coordinated management and other functions of the maritime satellite communication system could be simulated accurately on software, and the signal repetition could be mimicked using the repeater.

Currently, the mobile link of maritime communication satellite operates in the L-band, with an uplink of 1,626.5-1,660.5MHz and a downlink of 1,525-1,559MHz. The L-band uplink/downlink mobile communication channels of maritime satellite were simulated by the uplink/downlink channel simulator. In the mobile communication terminal, the communication between the L-band mobile terminals were simulated using the following parameters: 2.4-512kbp of data rate, BPSK/QPSK modulation mode and 1/2 or 3/4 convolutional coding mode. The configurable devices include a monitoring interface of a half-duplex RS485 serial bus, and the computer and simulation devices worked in a master-slave mode. The satellite communication terminal provides a full-duplex RS485 serial data interface and a 10M/100Mbps Ethernet interface. In the maritime satellite simulation system, the coordinated management of mobile communication network resources was completed on computer software.

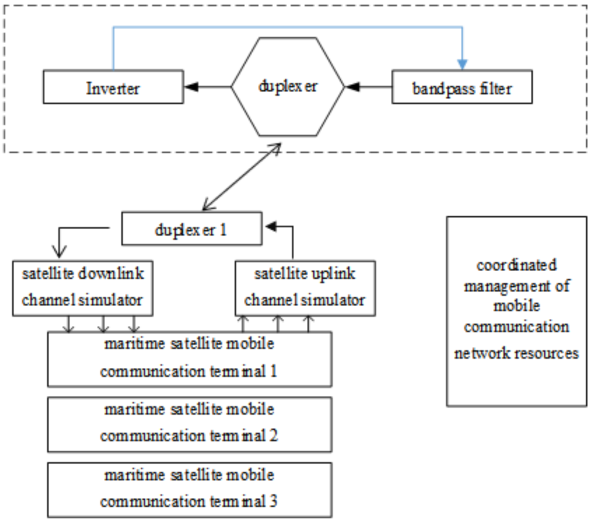

Figure 5. Simulation structure of maritime satellite mobile communication

The comprehensive evaluation system for maritime mobile communication was established based on the test equipment connections and instruments, main testing techniques and room temperature test results, considering the main technical indices of the mobile communication terminal simulator, the uplink channel simulator, the repeater and the downlink channel simulator of the maritime satellite. Next, the principles of the evaluation index system were presented, the influencing factors of the tests were analysed, revealing their impacts on the system, and the performance indices of the system were determined one by one.

4. Conclusions

After exploring the mobile communication performance of maritime satellite, the author designed a scientific, advanced verification and comprehensive evaluation approach from the aspects of applicability, reliability, durability, operation friendliness, usability, and practicability. The proposed method could promote the standardization of the evaluation of mobile communication equipment for maritime satellite, and provide support to the performance enhancement of various emergency communication devices.

5. Acknowledgment

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