A Test System for Cabled Ocean Observatories

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***Abstract*—As is known to all, the cabled ocean observatories system is becoming more and more important in ocean exploration and research. To build a long-term, real-time cabled ocean observatories network, reliability of each netting facility including the junction boxes and science instruments should be guaranteed before deploying on the seafloor. This paper aimed at how to evaluate the reliability of the whole system and then do some work for better performance. A test system for observatories network called shore station simulation test system (SSTS) is presented, which aims at building a platform to evaluate the reliability of netting facility before deployment.**

Keywords-observatories; test; ocean exploration; reliability; platform

I. INTRODUCTION

Research on the world's ocean system can bring us a better understanding of the Earth environment and the marine ecosystem. Although the oceans occupy a large amount of Earth's surface, scientific research on oceans is insufficient. However, in recent years, the study of the sea has entered a new era. With the development of ocean exploration and research, there is a growth need for a long-term, real-time and highly reliable cabled ocean observatory. Actually, one of the most challenging issues in the design of a cabled ocean observatory is the underwater reliability of the system over its planned life. Due to the high cost of maintenance and difficulties to retrieve instruments in case of failure, it is necessary to do pre-tests on the reliability of the instruments sufficiently on shore. And in this way, we could cut down the cost of maintenance.

Up to now, the researchers had carried out a lot of tests on the junction-boxes and the science instruments, such as inrush current test, over voltage test and ground fault detection, before the instruments were deployed. However, an instrument used to do all of the tests had not been developed. This paper is mainly about the shore-station simulation test system (SSTS) that is used to solve this problem.

II. TOPOLOGY DESCRIBE OF THE TEST SYSTEM

Due to the high cost of maintenance, it is necessary to test the reliability of the instruments sufficiently on shore, which include the electrical and communicatory detection as well as the negative interaction test between the instruments and junction-boxes. A simulation system that is designed based on the observatories network has the same structure, communication protocols and power supply with the network. It provides the SSTS a simulate test platform to validate the test results of the instruments and junction-boxes. The block diagram of the SSTS configuration (Electrical) is shown in Fig.1.

The SSTS contains four parts: Sampling Module, A/D Module, Data Processing Center and Host Computer Procedure. The sampling module samples the voltage signals of the electrical transmission lines. The A/D module receives the analog quantities of voltage from the sampling module, and transmits them to digital quantities. And original data processing happened in the lower computer, named data processing center. In the host computer, the data experienced a final process, and then come out with the test results.

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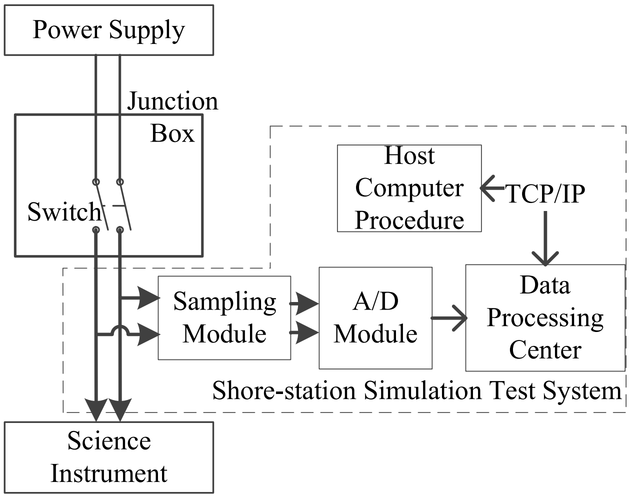

Fig. 1. The block diagram of the SSTS

A. Sampling Module

The observatory station provides different ports so as to satisfy various instruments' demand for power supply. Hence, at each port, the power has to reduce to 375V or 48V which is available to most instruments. The sampling circuits of this module can be changed while the power supply is changed. So that SSTS could be used in different voltage levels.

B. Data Processing Center

Sample data's preprocessing, filtering, interpolation processing, integrating, FIFO high speed storage, etc. are happened in this module.

C. Host Computer Procedure

The communication protocol between the host computer with the data processing center is TCP/IP. In the host computer, the results of the test are shown in the format of image or data sheet. The human-computer interaction interface is shown in Fig. 2. In this interface, we build a new task and then come out with the test results which is shown as an image or a data sheet. By analyzing these images and data, we can judge whether the instruments are ready to be attached to the junction-box, and qualified to be deployed on the seafloor. E.g. if the inrush current of the instrument is out of the prescribed range, we will reject the connection of the instrument to the junction-box.

Connect the input of the SSTS to the output of the port which provides 375V or 48V. And then connect the output of the SSTS to the input of the Science Instrument which is prepared to link to the system. And then close the switch of the power monitor and control system in the Primary Junction-Box. From the upper computer of the SSTS, we could obtain the test results of the instrument that is being test.

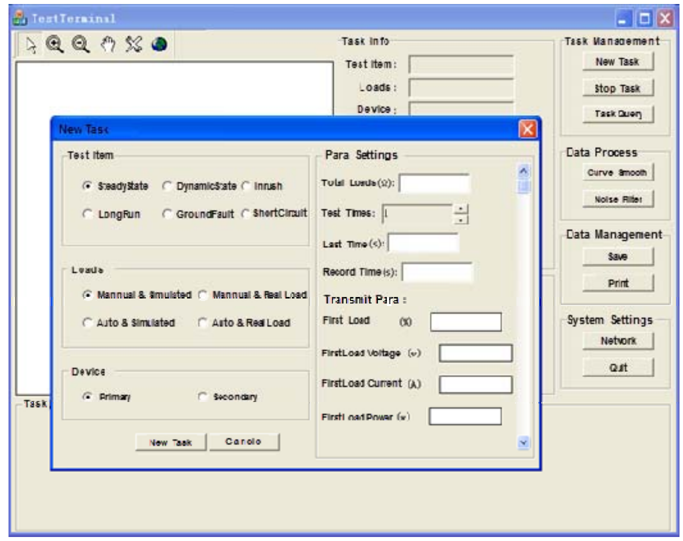

Fig. 2. The human-computer interaction interface

III. Connecting of the SSTS with Junction-Box

The observatory station provides different ports so as to satisfy various instruments' demand for power supply. Hence, at each port, the power has to reduce to 375V or 48V which is available to most instruments. The power provided at each port is specially defined, for the purposes of ensuring that limited resources are properly distributed to the instruments. The SSTS can be used to test all of the ports' characters in different voltage levels. Because of the changeable sampling circuit, in different voltage levels, the SSTS is suitable. The management of different SSTSs are independent of each other, so we could test different instruments simultaneously. The connection diagram is shown in Fig. 3.

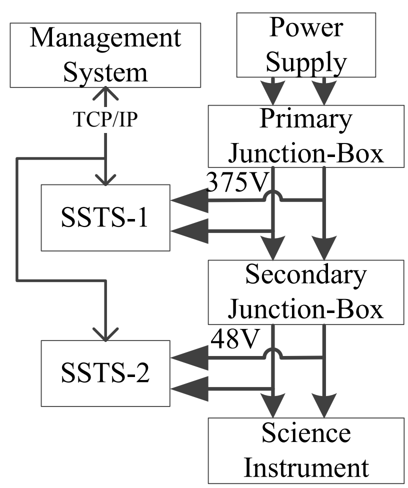

Fig. 3. Connection diagram of the SSTS with other equipments

The management and control system of SSTS-1 and the SSTS-2 are independent of each other. The SSTS-1 in Fig.3 is used to test the secondary junction-box' characters. The supply voltage of the secondary junction-box is 375V. While the SSTS-2 here is used to test the science instrument. The supply voltage of science instrument is 48V. The SSTS-1 and the

SSTS-2 use the different sampling circuit. So, the test results (images and data) of the SSTS-1 and the SSTS-2 are disparate. After the test, according to the different test results, we analyze the secondary junction-box and the science instrument respectively.

IV. DETECTION CHARACTERS OF SSTS

Under different loads, the electrical standard characters needed to be tested are different. E.g. the detected characters the secondary junction-box's are not the same as those of the science instrument, at is shown in table. I. According to fig.3, SSTS-1 is used to test the secondary junction-box, while SSTS-2 is used to test the science instrument. The detected characters of secondary junction-box are comprised of transient characteristics, steady-state characteristics, ground fault and self-protection. While the science instrument's detected characters are comprised of load characters, operating power, inrush current, ground fault and long-term operation. So the new tasks to be built are different.

A. Transient Characteristics

The transient characteristics here are comprised of inrush current and surge voltage. As we can see from the Fig.1, when we closed the switch, because of the capacitive reactance of the load, there would be an inrush current happened on the input line of the load. If the inrush current has a high amplitude and a long duration, it would be harmful to the switch. Therefore, to ensure the safety of connection, we had come out with some defined characters. The test results must be within the range. E.g. the maximum inrush current at each port is 15 A and 3 ms maximum duration.

B. Ground Fault

If the power transmission lines have good isolation with the ground, the reliability of the system has greatly improved. In our tests, the minimum grounding resistance is 40MΩ.

C. Operating Power

Limited by the system stability and the parameters of components, the operating power is also defined. E.g. the continuous power supply at the output port of primary junction-box is limited to 2kW, and the maximum operating power at the out port of secondary junction-box is 250W.

D. Self-Protection ability of the junction-box

If the load connected to the junction-box is leaking, it is dangerous to the cabled ocean observatory system, because leakage will lead to short circuit, which in turn generate an inrush current of large amplitude. So the junction-boxes must have the ability of self-protection. It can shut down the switch automatically when the current is out of defined range.

All these characters should be detected because these characteristics reveal the reliability of the electrical equipments which guarantee the smooth operation of the system. The communication between the instruments and the station is important to achieve the remote control. Through the remote control, the station managers can control the breakers' opening and closure, and ensure real-time data transmission from the seafloor to the shore station. The mission of SSTS is to decide whether the instruments or junction-boxes are suitable to be deployed on the seafloor and competent to the undersea exploration. These characters are defined by the observatory for the purposes of ensuring the reliability of the whole system. The tests are individually designed for the primary junction-box, the secondary junction-box and the science instruments which will be attached to the observatory system. Due to different voltage, current and other requirements, the standard characters that will be tested are different for the junction-boxes and instruments.

TABLE I. DETECTION CHARACTERS OF THE SSTS

NO.	***Detection Characters***
SSTS-1	Transient characteristics, Steady-state characteristics, Ground fault detection, Self-protection and Inrush current.
SSTS-2	Load characters, Operating power, Inrush current, Ground fault detection and Long-term operation

V. EXPERIMENTS

Before the deployment of the junction-box, we should test the characters of all the equipments sufficiently. Reliability is the key property when building long term cabled observatory system. Before the experiments of laboratory and deep sea, characters above were tested. The junction-boxes and the science instruments meet the defined requirements, and they are suitable to be deployed. Efforts were carried out to build prototype and tested in lab since 2013.

A. Laboratory Test

Sufficient tests about the characters were carried out in the laboratory to ensure each part was operating properly, such as the vibration test, high and low temperature test, pressure tests of pressure casing, transient characteristics of the instrument, et. al. The power feed equipment as well as the power monitor and control system were built up in the shore station. The shore-station simulation system was used to test all of the electrical characters that were defined above. E.g. through the test, we acquired that the inrush current of the secondary junction-box is 6.8A/1ms, and the grounding resistance is 200MΩ. The high and low temperature test are shown in Fig. 4. A cabled system providing multi-port with one primary junction-box and one secondary junction-box was assembled in the laboratory(Fig. 5). The power and communication were transmitted to the junction-boxed through 1.5km armored cable. This laboratory water tank test started from June 27, 2013, last 5days, and stopped in July 2, 2013. All of the junction-boxes and the science instruments functioned properly in the duration. Lab tests mainly focused on its working performances.

Fig. 4. High and low temperature test of the system

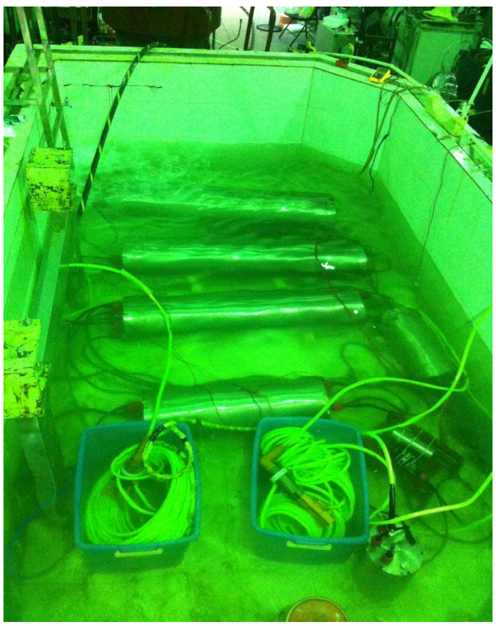

Fig. 5. Laboratory water tank test with 1.5km armored cable

B. *Sea Trial preparing*

After the test in lab, we are preparing to deploy the node on the seafloor of the South China Sea. Through 75km armored cable, the power and communication were transmitted to the seafloor. A sea trial in the South China Sea in August 2013 is being prepared. It shall be single node cabled system plugged with two science instruments. The junction-box including the marine environment monitoring system were fixed at a 4 m x2.5 mx1.5 m test frame weighing 3T (Fig. 6). Before the deployment, we had a test in the water tank for 12 hours with 75km armored cable. All the instruments were operating properly in the duration (Fig. 7).

Fig. 6. Preparing for the sea trial in South China Sea

Fig. 7. Laboratory water tank test with 75km armored cable

VI. CONCLUSION

The Shore-Station Simulation Test System is an integrated system that can detect most of the characteristics. The characteristics are related to the electrical characters which are important to the normal operation of the undersea system. The detecting results are instructive for the improvement of the junction-boxes or instruments. Because of the difference between the terrestrial and submarine environment, the instruments that are operative on land may fail underwater. Sometimes the reason is the ground electrode of the circuit has a fault connect. The shore-station test system of undersea cabled observatory plays quite an important role in guaranteeing continuous operation of the seafloor network through pre-test and fault rectification.

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