Shielding Effectiveness Measurement for Physically Small Enclosure in FAST Telescope

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Abstract

Five-hundred-meter Aperture Spherical radio Telescope (FAST) is a Chinese mega-science project to build the largest single dish radio telescope in Guizhou province, Southwest China. The construction of FAST will involve many kinds of analog and digital electrical equipments. The electrical equipments are potential threat to radio observation due to its ElectroMagnetic Interference (EMI) emission. The EMI should be safely shielded when FAST telescope operates. The shielding effectiveness of large shielding enclosures can be tested with two log periodic antennas, signal generator and spectrum analyzer. It is not suitable to test small shielding enclosure for that is not possible to put big antenna and signal generator inside. In this paper, an effective shielding effectiveness measurement system for the small shielding enclosure is introduced. This measurement system uses a frequency synthesizer of Valon Technology as signal generator which can measure the shielding effectiveness no more than 100dB in a frequency range of 23-6000MHz. Some of measurement results of shielding effectiveness are also presented.

1. Introduction

Five-hundred-meter Aperture Spherical radio Telescope (FAST) will be the largest single dish radio telescope which is under construction in Guizhou province, Southwest China [1]. The feasibility studies for FAST have been carried out for more than 14 years, supported by Chinese and international astronomical communities.

Being a modern radio telescope, there are many types of electrical equipments in FAST telescope, such as motor, motor controller, sensor, total station, signal generator, fiber transmitter and etc. The electrical equipments are the potential ElectroMagnetic Interference (EMI) source which is the intolerable threat to the radio telescope. Even the weakest EMI emitted by the equipment will take an effect on the sensitive astronomical receiver. To ensure the FAST telescope keep away from the EMI, a radio quiet zone (RQZ) of 30 km radius had been established in 2013[2]. As to the EMI emission of the equipments of FAST, some shielding enclosure like shielding room, shielding cabinet, shielding case and shielding cloth might be necessary. The required shielding effectiveness (SE) of screen enclosure is determined by three factors: the EMI strength of the enclosed equipment, the distance from equipment to the focus and the sensitivity limit of the receiver.

The SE of the screen enclosure is important factor for the radio telescope for the sensitive receiver could be influented by the EMI, especially the EMI of the equipment near the focus. All of the screen enclosure used in FAST telescope have been measured before they are installed. For the SE measurement of physically large enclosures, there is a procedure can be followed that is proposed in the IEEE 299 standard. However, the general SE measurement system is not suitable for the small enclosures due to the limitation of the space inside, especially for the frequency band 70-3000MHz of FAST. To test the physically small enclosures, a portable device is required.

2. Shielding Effectiveness Measurement System for Small Enclosure

The SE of the EMI tight enclosure normally is measured with two antennas, signal generator and spectrum analyzer [3]. The common setup is depicted in Figure 1. It is also can be applied to find the leakage of shielding enclosure by pointing the transmit antenna to the possible leakage part, such as the shielding door, welding seam, waveguide vent, EMI filter and etc.

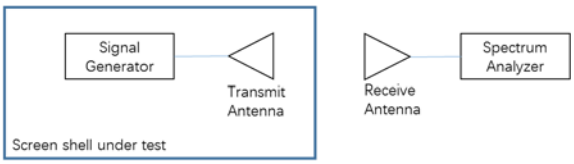

Figure 1. The common setup for shielding effectiveness measurement

To measure the SE of the small box and case, a portable SE measurement system has been designed. The SE measurement system used a Signal Analyzer N9020A of Agilent and a log periodic antenna as the receive part. The transmit part of the measurement system is shown in Figure 2. The transmit part is consisted of a frequency synthesizer from Valon Technology as signal generator, and a raspberry PI as lower control computer, a fiber ethernet converter to communicate, and a power bank as power supply. Besides this, an 11cm length probe as transmit antenna and some necessary cables are not shown in the figure. The maximum dimension of the small system is

about 14cm, so the enclosure under tested should larger than that.

Figure 2. the transmit part of the small SE measurement system including four elements: frequency synthesizer(top right), raspberry PI(bottom left), fiber ethernet converter(top left) and power bank(bottom right).

The Signal Analyzer N9020A has built-in Windows operation system and Matlab which can be used as the host computer to run the test scripts. The host computer and the raspberry PI can communicate through the fiber ethernet converter. The raspberry PI can set and read the output frequency of the Valon frequency synthesizer via an USB cable. The Valon frequency synthesizer can be configured by a Python code that is created by Patrick Brandt at NRAO. The small SE measurement system can sweep automatically in a preset frequency range. The sweep time is acceptable, about 3 seconds per measure frequency point.

The SE measurement will be performed in two steps: First, measure the strength of signal while the transmit and receive antenna in free space; Second, put the transmit part inside of the shielding enclosure and measure the signal strength again. The SE of the shielding enclosure is the difference of these two measured signal strength.

3. Applications of EMI Shielding Effect Measurement System

The small SE measurement system can be used for many applications, in particular, in the SE test of the small EMI tight enclosure and no AC power inside. For example, it is an exactly right choice for testing SE of the actuator electrically cabinet of the FAST reflector. There are about 2300 activators under the FAST reflector. The electrical cabinet is designed to be EMI shielding and the inside space is about 17x17x 40cm which is impossible to put a regular signal generator in it. The actuator is controlled via an optical fiber which can be used to connect the fiber convertor while SE testing.

The results of the actuator SE measurements are shown in figure 3. As shown, the SE of the actuator electrical cabinet is about 70dB. The results show that the SE measurement system have good repeatability and accuracy about +/- 2dB. The lower system sensitivity of below 100MHz is limited by the poor radiation of the 11cm length probe in low frequency.

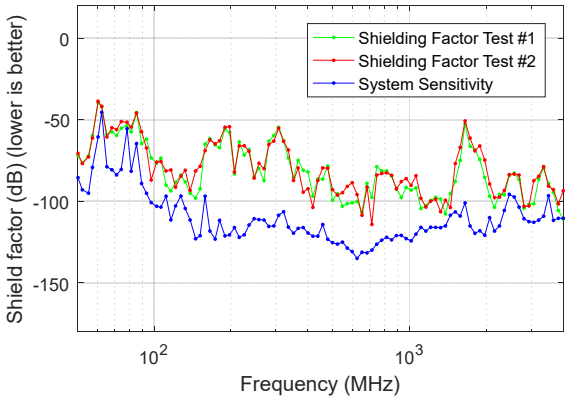

Figure 3. The measurement results of FAST actuator eletrical cabinet. Red and green line are the meausrement results of 2 times, blue line is the system sensitivity.

4. Conclusion

The small SE test system can measure the shielding enclosure larger than 14cm, and the system sensitivity is about 100dB and 15dB enhance with preamplifier to spectrum analyzer. It takes about 5 minutes to measure 100 frequency points. The measurement results give a stable repeatability meanwhile high accurate. The frequency coverage is limit by the frequency synthesizer, and can be extended to 23-6000MHz if the latest Valon product is involved. it can be used in many applications for its small size and portable.

5. Acknowledgements

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6. References

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