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DESIGN AND INTEGRATION ON THE TEST STATION FOR PSM OF A 300 kW TRANSMITTER

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Abstract

A test station for the THALES 300 kW transmitter PSM has been successfully constructed in NSRRC. Integrating the modules of power supply, control interface, interlock protection, and accessories into a single rack simplifies the examination procedure and makes signal observation easier. The layout and hardware realization of this test station, as well as important considerations and proper examination procedure in place to ensure safe and accurate operation are all presented in this article.

INTRODUCTION

Taiwan Photon Source (TPS) is a 3 GeV synchrotron accelerator for electrons [1]. The electron bunches orbiting in the storage ring replenish the energy lost through the 500 MHz radio frequency (RF) energy provided by the RF transmitters. TPS storage ring RF system [2] consists of two RF stations, each is equipped a THALES 300 KW transmitter. The transmitter uses 86 power supply modules (PSMs) as key components to generate an RF power up to 300 kW. Each PSM requires not only an AC input of 570 Volts but also a voltage control by an optical fiber signal for proper operation. An automatic rotation scheme is im-bedded in the transmitter control to operate a certain number of PSMs, but rotating the PSMs from rest to operation state and vice versa from time to time, to match a DC high voltage required for demanded RF power output. Once a PSM is damaged and detected by the transmitter control system, it will be removed from the rotational operation list and idle for repairing.

To save time and cost, we decided to build a test station for PSM examination in NSRRC, which aims to provide a convenient and safe way to examine and repair the damaged PSMs without the need to send them back to the original supplier, THALES. The PSM test station integrates all electronic components, operation devices, interlock protection and accessories into a single rack, greatly simplifying the examination procedure and signal observation. It includes several stands for power breakers, transformer, and PSM test, as well as a function generator for operation input and an oscilloscope for output monitoring. With this test stand, several PSMs have been examined and repaired, and technical details on the PSM have been learned by monitoring various signals during the examination process. Design, layout, hardware realization, and operation procedure of the test station of this self-developed PSM test station are briefly introduced herein.

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LAYOUT

Shown in Fig. 1 is the layout of the PSM test station. It is designed to generate AC 570 V power using a combination of breakers and a transformer stand. A contactor is used as the protection unit to switch off the power by the interlock signal that secures the doors of both the transformer and PSM test stands. The AC 570 V power is then fed to the PSM test stand, which includes a fiber optical transmitter module to convert the analog signal of a function generator to an optical signal. The output power of the PSM under test is connected to an electronic load.

Note that three breakers are used for the AC 3Φ380V input, with breaker-1 serving as the main input breaker, and breaker-2 and breaker-3 in parallel. The breaker-2 is equipped with a 100-Ω resistor at the downstream. More details for this design are available in the hardware realization section.

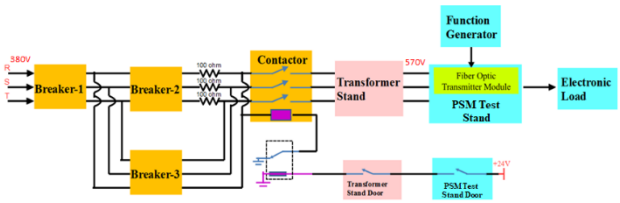

Figure 1: Layout of the test station.

Figure 2: Integration of the PSM test rack.

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HARDWARE REALIZATION

As shown in Fig. 2, this test rack is integrated in a single rack with a size of 56*60*150 cm. An operator can measure and control the output voltage of the PSM easily. Details of the breaker/contactor switch stand, transformer stand, and PSM test stand are described respectively.

Breakers/contactor switch stand

Three breakers are used for the AC 3Φ380V input. This 3-breaker design is intended to avoid power spikes on the contactor switch input during the power-on process. The current rating for both breaker-1 and breaker-3 is 32 A, whereas it is 16 A for breaker-2 and 40 A for contactor switch. However, it is a must to close the doors of both the transformer and PSM test stands before turn on the AC power. The sequence of power-on operation is: switching on the main breaker breaker-1 first, switching on the breaker-2 so that the 100-Ω resisters could eliminate the power spike, then switching on breaker-3 and finally switching off breaker-2. This indicates only Breaker-1 and Breaker-3 is switched on during a test on the PSM, thus they have the same current rating of 32 A, whereas the Breaker-s has a lower current rating of 16 A. The layout and photos of the breakers and contactor are shown in Figs. 3 and 4, respectively.

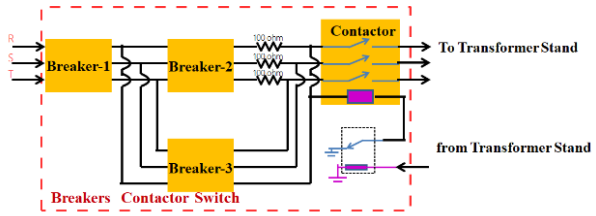

Figure 3: Layout of the breakers and contactor switch stand.

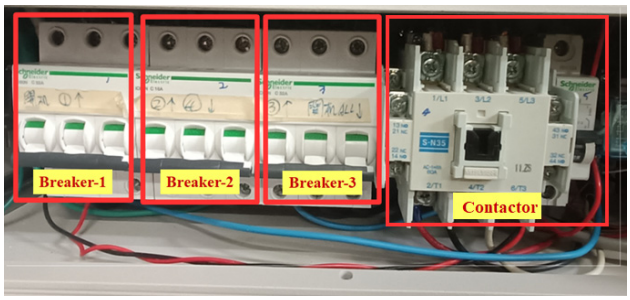

Figure 4: Photo of the breakers and contactor switch stand.

Transformer Stand

The transformer stand is used to generate AC 570 V power for the PSM test stand. The transformer inside it is specified of output 570 V/20.3 A at an input of 380 V/30.4 A. The transformer stand is equipped with a transparent door, which has a fan to dissipate the heat generated by the transformer to the air. The transparent door of the transformer stand has a magnetic switch installed to ensure that the door is properly closed during operation. This magnetic switch acts as an interlock, triggering a relay to open the contactor switch and cut off the input AC 380 V power if the door is opened during operation. Figures 5 and 6 are the scheme and photo of the transformer stand, respectively.

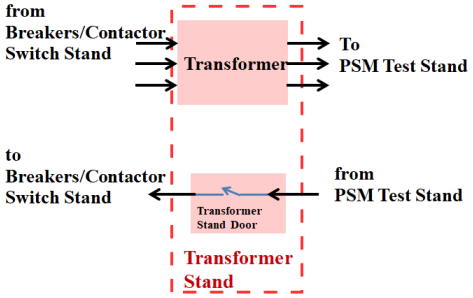

Figure 5: Scheme of the transformer stand.

Figure 6: Photo of the transformer stand.

PSM Test Stand

As the core part, the PSM test stand is used to examine a PSM using both AC 570 V power and a control signal from a function generator as the scheme shown in Fig. 7. The control signal is transmitted to the PSM by the fiber optical transmitter module board as shown in Fig. 8, which converts the analog signal from the function generator into a fiber optical signal.

During testing, the output of the PSM is not only absorbed by the electronic load but also monitored using an oscilloscope. The electronic load has a capacity of 10 kW. Shown in Fig. 9 are the function generation, oscilloscope, and electronic load. They are located on top of the test rack for operation convenience.

Similar to the transformer stand, the PSM test stand also has a transparent door, which is equipped with a magnetic switch and a fan. The magnetic switch is used to ensure that the door is properly closed during testing, and if the door is opened, it triggers a relay to shut off the contractor switch on the AC 380 V power input, stopping the test. The fan is used to cool the PSM during testing.

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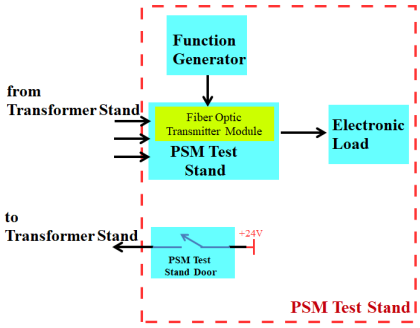

Figure 7: Scheme of the PSM test stand.

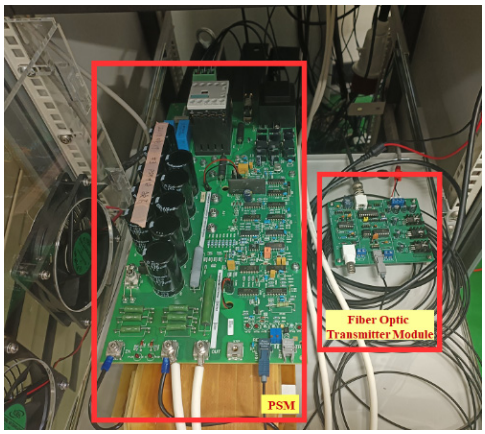

Figure 8: PSM and fiber optic transmitter module.

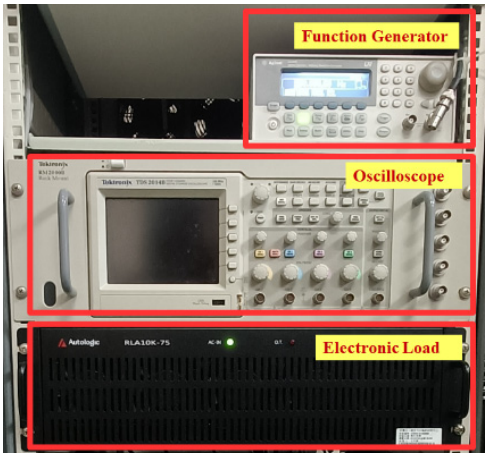

Figure 9: The function generator, oscilloscope, and electronic load on top of the PSM test stand.

OPERATION PROCEDURE

The PSM test station provides a great examination operation on PSMs with both the considerations on safety and simplicity. However, a proper operation procedure is required to ensure safe and effective operation of the PSM test station. A step by step consequence to operate this test station is listed as following:

1. Make sure all breakers are off and enable the electronic load.
2. Put the PSM into the PSM test stand, and plug in the power connector, optical fiber connector and electronic load connector.
3. Close doors of the transformer stand and PSM test stand.
4. Switch on the breaker-1, then breaker-2, and finally breaker-3 in consequence.
5. Switch off breaker-2.
6. Check if the cooling fans on doors of transformer stand and PSM test stand are running steadily.
7. Turn on the function generator and oscilloscope, and then start the examination on the PSM.

CONCLUSION

A PSM test station is successfully designed and integrated into a single rack, with considerations on operation convenience and safety. This test station includes several stands for power breakers, transformer, and PSM test, as well as a function generator for operation input and an oscilloscope for output monitoring. Abnormal PSMs can thus be tested in our laboratory to find out the damaged part. This not only saves time and cost but also provides us with the opportunity to learn more about the technical details of the PSM and improve its reliability. By examining and repairing several PSMs, we have gained valuable knowledge and experience, which can be applied to future projects. Improvements on some parts of the PSM are ongoing and promising.

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