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THE RECORD OF RF TRANSMITTER POWER SUPPLY MODULE MAINTENANCE IN NSRRC

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Abstract

The RF group constructed a second radio frequency (RF) system for the Taiwan Photon Source (TPS) RF system. This RF system employs a high-power RF transmitter to deliver RF energy to the cavity. The RF transmitter is composed of multiple power supply modules (PSMs) that are installed in series. PSMs are critical and fragile components of the RF transmitter.

This article presents the maintenance history of PSMs from 2011 to 2022 and provides guidance on how to troubleshoot and diagnose fault problems. Furthermore, this article proposes an improvement strategy for preventing any failure events.

INTRODUCTION

This paper analyzes the components that have a high failure probability in the power-supply module, to determine the reasons for their frequent failure. The goal is to improve the causes of component failure and reduce the likelihood of recurrence in the future.

MOTIVATION

Table 1 shows the count of damaged components in the power-supply module from 2011 to 2022. As per the table, three power-supply modules were damaged every year during this period.

Table 1: Damage Statistics

Fault Occurrence Date	Serial Number	Damaged Components
2013/3/13	#18	Transformer
2017/12/27	#36	Transformer
2017/12/29	#42	Transformer
2018/4/9	SRF#3 #41	Transformer
2018/8/6	SRF#2 #2	Transformer
2018/8/20	SRF#2 #40	Resistance
2018/10/2	SRF#3 #52	Transformer
2018/4/25	SRF#2 #41	Transformer
2019/6/24	SRF#3 #07	Transformer
2019/12/2	SRF#3 #08	Transformer
2019/12/2	SRF#3 #31	Transformer
2019/12/2	SRF#3 #69	Transformer
2021/3/8	SRF#2 #56	Transformer
2021/5/17	SRF#2 #52	Transformer
2021/5/21	SRF#2 #57	Transformer、TVS Diode
2022/5/3	SRF#3 #57	Transformer
2022/5/3	SRF#2 #38	Transformer
2022/10/17	SRF#3 #18	Cable of thermos switch、IGBT

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The causes of damage events were found to be similar, prompting the RF group to investigate and find a solution. The analysis in Table 1 revealed that the probability of transformer damage was significantly higher than other parts.

FAILURE ANALYSIS

It is crucial to gain a comprehensive understanding of the causes of device malfunction. Therefore, fault analysis was performed on the transformers. As a part of this analysis, all damaged transformers from the modules were disassembled and their appearance was observed. Figure 1 illustrates that some transformers have a crack at the bottom.

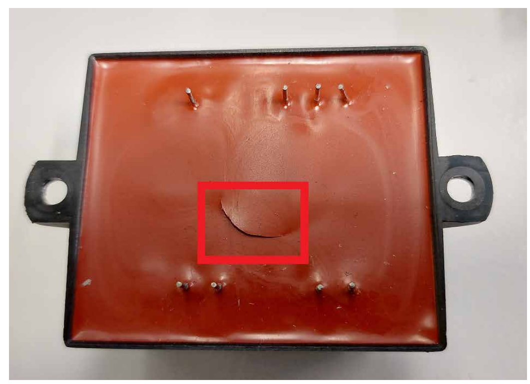

Figure 1: The bottom of a damaged transformer.

Power Transformer Specification

The original power transformer specification, which has a rated capacity of 6 VA, is illustrated in Fig. 2. We measured the input current value of the primary side of the transformer on the module, and the results are shown in Fig. 3. The input voltage value for the primary side is 570 V, and it can be calculated that the apparent power of the transformer is approximately 7.2 VA using Equation 1. The operational power was identified as being higher than the specification values for the transformer.

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Figure 2: Transformer specification.

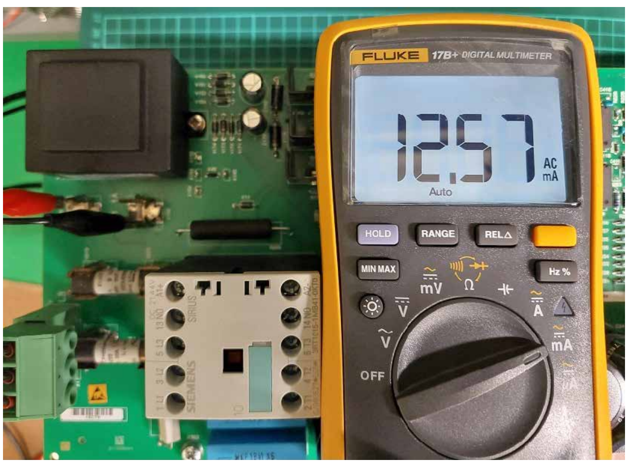

Figure 3: Measure the input current on the primary side.

$$S_{original} = \mathrm{V} * \mathrm{A} = 7.2\ \mathrm{VA}. \quad (1)$$

REASON FOR IMPROVEMENT

As previously mentioned, we discovered that the originally designed transformer had insufficient capacity. Therefore, we reformulated the specifications by increasing the rated capacity of the transformer from the original 6 VA to 12 VA. After developing the new specifications, it was entrusted with production. The new version of the transformer is depicted in Fig. 4. As the pin position of the new version of the transformer was incompatible with the original one, we used an adapter board for conversion.

OPERATION TEST

After replacing the damaged modules with the new version of transformers, they were tested in practice. The input current value of the primary side of the transformer is displayed in Fig. 5. The input current value is 7.78 mA, and it can be calculated that the apparent power of the transformer is approximately 4.4 VA using Equation 2. The actual operational value of the apparent power is within the newly established specification.

$$S_{new} = \mathrm{V} * \mathrm{A} = 4.4\ \mathrm{VA}. \quad (2)$$

Figure 4: New version of the transformer.

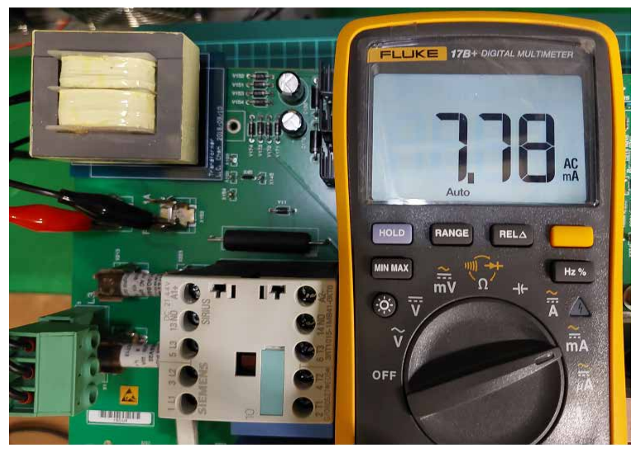

Figure 5: Measure the current on the primary side of the new transformer.

CONCLUSION

The second RF system for Taiwan Photon Source (TPS) has been in use for over 11 years, and its record of failed power-supply module repairs has accumulated 18 instances. Among them, sixteen failures were caused by transformers. After conducting a failure analysis, it was determined that the actual operating power of the transformer exceeded the specification limit.

To address the issue of transformer damage, the faulty transformer in the affected module was replaced with a new version. As a result, the repaired modules are no longer experiencing transformer damage. Furthermore, the input power of the modular transformer was reduced from 7.2 VA to 4.2 VA, which means that the efficiency of the new transformer is higher than that of the original transformer.

REFERENCES

[1] THOMSON Klystron Supply Unit KSU 55k V / 12 A Instruction Manual.