A Performance Improvement of Power Supply Module for Safety-related Controller

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1. Introduction

The purpose of this paper is to improve the redundant performance of power supply module(NSPS-2Q). It is one of components in POSAFE-Q which is a PLC(Programmable Logic Controller) that has been developed for the evaluation of safety-related.

Power supply module provides a stable power in order that POSAFE-Q can be operated normally. It is possible to be mounted two power supply modules in POSAFE-Q for a redundant(Master/Slave) function. So that even if a problem occurs in one power supply module, another power supply module will provide a power to POSAFE-Q stably.

In this paper, in relation to voltage shortage state when power supply module is a slave mode, the performance improvement by modifying a PFC(Power Factor Correction) circuit is presented.

2. Power Supply Module in POSAFE-Q PLC

POSAFE-Q, which meets international standards such as IEEE 7-4.32 and EPRI TR-107330, is a safety grade Q Class 1E PLC for application to the safety-related system in a nuclear power plant. It is applied to the comparative logic processor, simultaneous logic processor, and automatic cycle test processor in the reactor protection system. It is also used in group and logic controller for engineered safety feature (ESF).

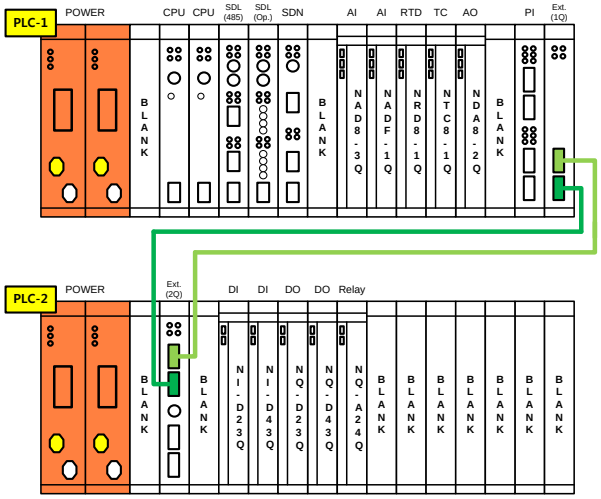


Fig. 1. The Structure of POSAFE-Q.

The structure of POSAFE-Q is shown in Fig. 1. POSAFE-Q has input/output modules that handle various input/output signals in both analog (voltage, current and temperature) and digital (AC, DC and pulse) form. In particular, the loop back self-diagnosis for the input/output channels, the hot swap function, and the plug-in terminal blocks allow the user to service and maintain the system easily and conveniently even online. POSAFE-Q also has special function modules, including a redundant power supply module, a processor module and a bus extension module.

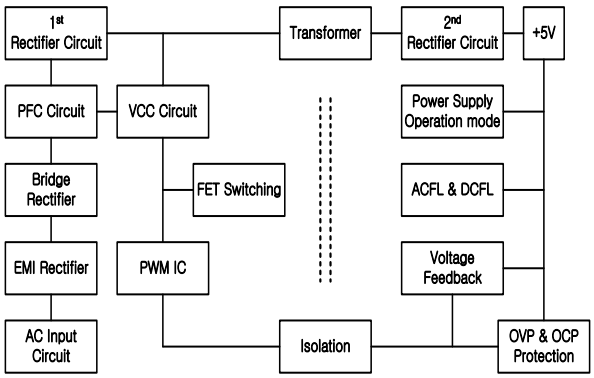


Fig. 2. Power Supply Module Sequence

Power supply module receives AC power 85~264V from outside, and provides DC power 5V for operating a control component of safety-related. (Fig. 2) Also, it supplies a dip switch setting for determining the master or slave operation of the power supply module. In addition, it checks the status information of itself. So operation information(Run/Standby) of power supply module is exposed by LED and sent that information to processor module(NCPU-2Q) simultaneously.

3. Methods and Results

3.1 Conventional and Improved Power Supply Module

Using the conventional and improved power supply module, operation test in a slave mode is executed. Prototype of the conventional power supply module that has been manufactured is shown in Fig. 3.

Fig. 3. Prototype of the Conventional Power Supply Module.

In a slave mode which has lower output voltage than a master mode, a weak current is flowed to the transformer of the PFC circuit. Consequently, the PFC controller IC cannot receive a sufficient amount of input voltage for a normal operation. As a result, a scratchy noise is occurred when the PFC controller IC switches on and off. Also the output current from the PFC controller IC is unstable as well.

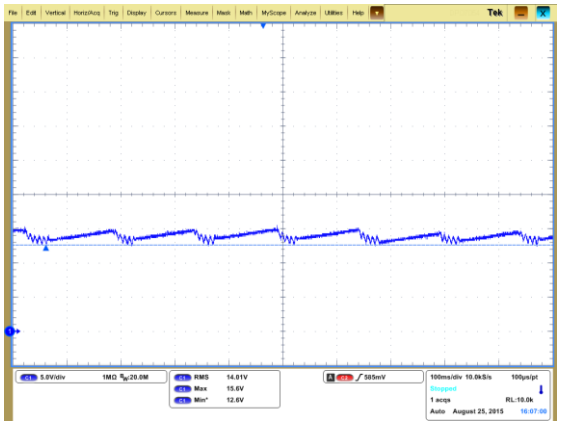
The switcher IC in the PFC circuit also cannot receive an ample amount of input current by the low output voltage from the PFC circuit. So the tiny noise on another transformer is arisen.

These phenomena do not affect the normal operation of the power supply module. Nevertheless in order to complement the state as above, VCC supply circuit is added next to the AC input power line on to the improved power supply module. With this new circuit, the improved power supply module is designed to allow a sufficient current to flow to transformers of the PFC circuit.

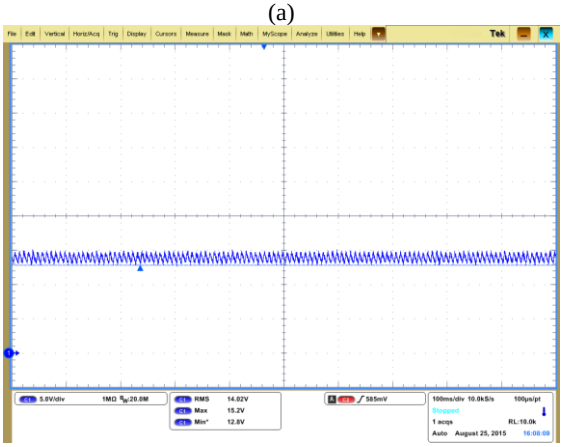
Fig. 4. Prototype of the Improved Power Supply Module.

3.2 Comparison of Performance between two types

For comparing the characteristics of two power supply modules, the input voltage of the PFC controller IC is verified by an oscilloscope. As can be seen in Fig 5, conventional module indicated an insecure input voltage graph because of insufficient input current.



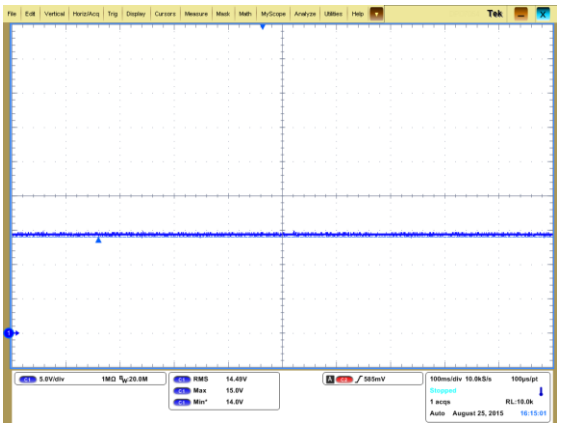
(a)



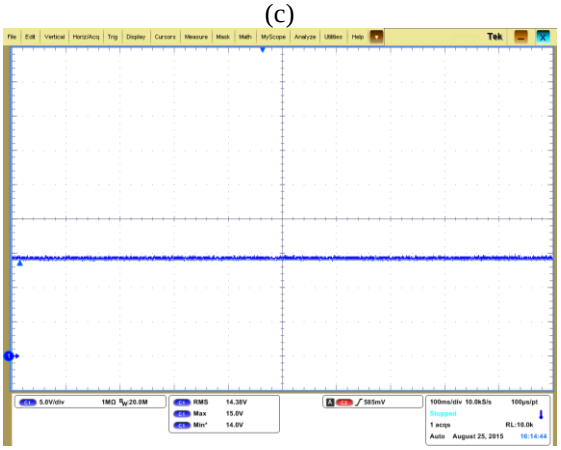
(b)

Fig. 5. Voltage Measurement of Conventional Module in a Slave mode(a) and Master mode(b).

On the other hand, in Fig 6, improved module presented a steady input voltage graph which is stable. In addition, the scratchy noise occurred on the transformers is gone.



(c)



(d)

Fig. 6. Voltage Measurement of Improved Module in a Slave mode(a) and Master mode(b).

4. Conclusions

With the modification of the PFC circuit, the performance improvement in respect of the voltage shortage state when the power supply module is a slave mode is checked. As a result, POSAFE-Q PLC can ensure the stability with the redundant power supply module.

REFERENCES

[1] EPRI TR-107330, Generic Requirements Specification for Qualifying a Commercially Available PLC for Safety-Related Applications in Nuclear Power Plants.

[2] Kwanwoo Yoo, Donghwa Yun, Sungjae Hwang and Dongil Lee, A Development of Auto Calibration Analog Input Module for Safety-related Controller, Transactions of the Korean Nuclear Society Autumn Meeting poster, 2014.