CONTROL ENVIRONMENT FOR THE SUPERCONDUCTING INSERTION DEVICES AT NSRRC

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Abstract

To enhance hard X-ray capability in the 1.5 GeV storage ring of NSRRC to serve the rapidly growing X-ray user community in Taiwan, the storage ring was installed two superconducting insertion devices. A 6 Tesla superconducting wavelength shifter was installed in mid-2002. A 3.2 Tesla superconducting wiggler was installed in December of 2003. Control system and operation environment have been set up to support the operation of superconducting insertion devices. The implementation and operation experiences will be summarized in this report.

INTRODUCTION

The basic elements of a superconducting insertion devices system are the power supplies, the cryogenics instruments, quench detector and interlock protection system. The control system of superconducting insertion devices is a VMEbus based system. Figure 1 illustrates the structure of control environment for the superconducting insertion devices. The VME crate includes a PowerPC single board computer module. Control interface of the system includes analog input/output and digital input/output modules, and a RS232 serial bus as an intelligent local controller (ILC). Control consoles communicate with the VME host module via the control Ethernet. The user interface is provided in the control consoles.

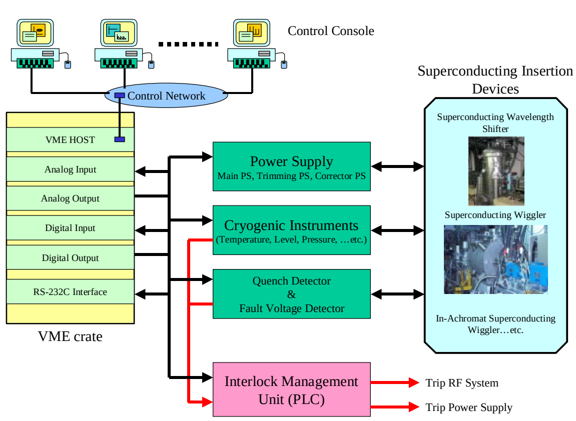

Figure 1. Control environment for superconducting insertion devices.

The control system of superconducting wavelength shifter (SWLS) had been operated from 2002 [1]. Installation and commissioning of the control system of the superconducting wiggler (SW6) was on Dec 2003 [2]. The picture of control system is shown in fig. 2.

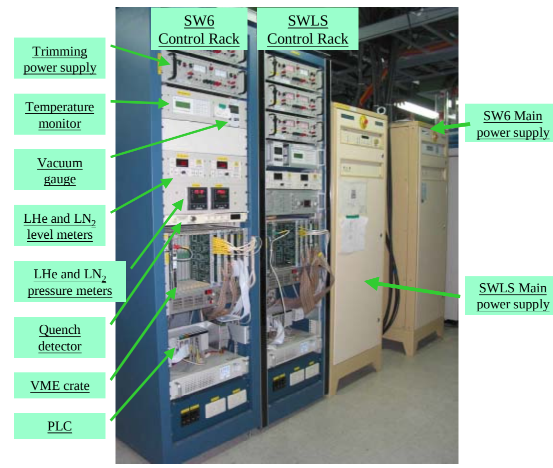

Figure 2. The control system of superconducting insertion devices in equipment area at NSRRC

THE CONTROL ENVIRONMENT

Software Environment

The PowerPC module runs the Unix-like LynxOS real-time operating system. Application programs and user interfaces are provided to support routine operation.

User Interface and Application Program

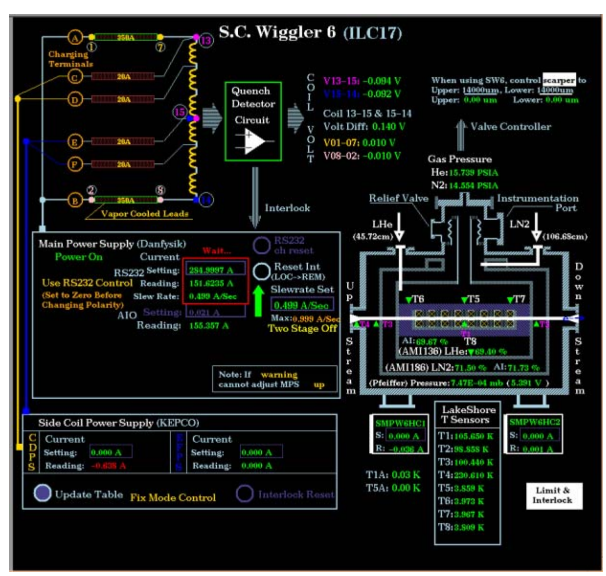

Figure 3. The page of superconducting insertion device operation.

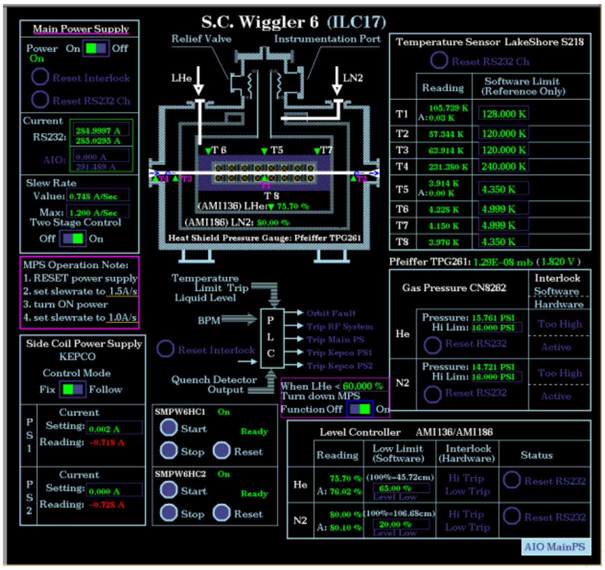

Figure 4. The page of alarm limits and interlock information.

The user interface of the system for superconducting insertion devices have two pages. Figure 3 and 4 show the user interface of SW6. The user interface provides a convenient manipulation for controlling and maintenance. The first page shows operational conditions that include temperature, level, pressure, the voltage of magnet coils and the charge current of power supplies. The value of alarm limit and interlock status are shown in the second page of user interface. The control system does not only provide the hardware protection by the interlock management unit (PLC) but also provide the software protection from application programs. The operator can set the alarm value of operation for superconducting insertion device.

Hardware Structure

The control system coordinates the output of main power supply and trim power supply. In order to prevent the quench event of magnet coil, the control system monitors the cryogenic parameters of magnet. A fast scan programmable logic controller (PLC) [3] is used as an interlock management unit to provide protection.

Power Supply Control

A bipolar main power supply and two trim power supplies are used to charge/discharge the magnet. The control system coordinates the output current of main power supply and trim power supplies. The purpose is to nullify the first field integral. The control system provides a “two stage control” process. In beginning of the process the slew rate of main power supply is small until the output current arrives the ten percent of setting value.

The charge scenario of SWLS and SW6 are shown in the fig. 5 and fig. 6, respectively. The top plot is the output current of main power supply. The time of the SWLS charges to 5.0 Tesla (230 A) around 25 minutes and the SW6 charges to 3.6 Tesla (285 A) about 11 minutes. The middle plot is the slew rate of main power supply. The slew rate of main power supply in SWLS charge is set to 0.6 A/s and in SW6 charge is set to 1.0 A/s. The “two stage control” is applied to the charge scenario. The bottom plot is the voltage of coil end to coil center of magnet. The voltage of coil end to coil center is around 1.5 V in SWLS charge scenario and 1 V in SW6 charge scenario.

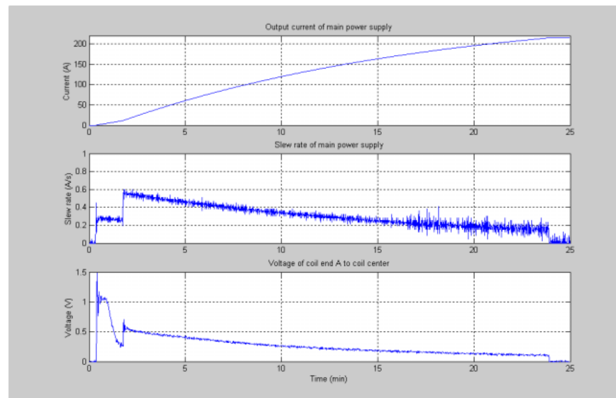

Figure 5. A typical charge scenario of SWLS.

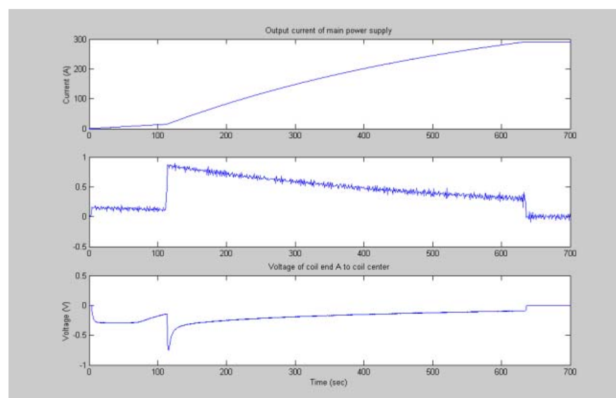

Figure 6. A typical charge scenario of SW6.

Cryogenic Instrumentation

The cryogenics instruments of SW6 include a temperature monitor, level meters for liquid helium and liquid nitrogen, pressure meters for helium gas and nitrogen gas and a vacuum gauge for shield. Because of the SLWS is cooled by a cryocooler, the system only monitors the temperature of magnet.

The temperature variation of SWLS charge scenarios are shown in fig. 7. In top plot, the temperature of current lead is balance about one day from beginning of charge. The temperature of magnet coils takes about one hour to be balance as shown in bottom plot. The parameters variation of SW6 charge scenarios are shown in fig 8. The top left and the top right plots show the temperature at the center and the upstream of magnet coil. The middle left and the bottom left plots show the liquid helium (LHe) level and helium (He) gas pressure in the He vessel. The liquid nitrogen (LN_2) level and the nitrogen (N_2) gas pressure are shown in the middle right and bottom right plots.

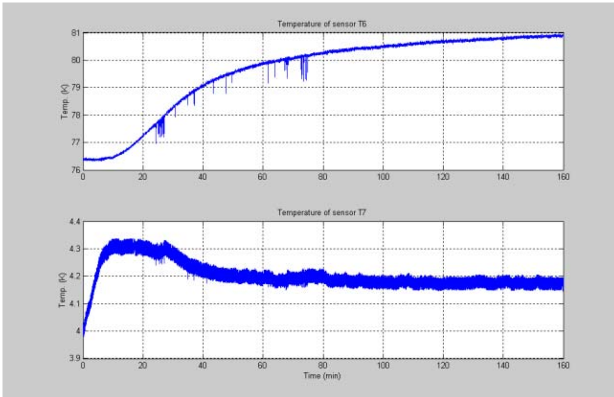

Figure 6. The variation of temperature when SWLS charge.

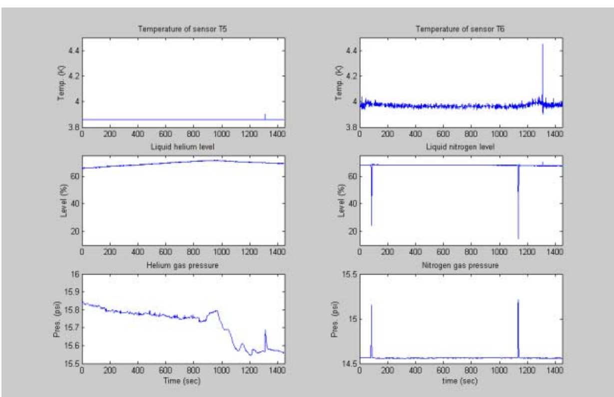

Figure 7. The variations of cryogenic parameters when SW6 charge.

Quench Detector and Interlock Protection

A traditionally bridge circuit is used to detect a quench event. When the coils of magnets approaches quench, unbalance of the coil arm voltage and the resistor arm voltage lead the signal of the quench detector to trigger the protection logic in PLC. The hardware quench protection circuit consists of cold diodes and stainless steel resistors that connect the coil. The protection diodes will conduct bypass current. The resistors in series with the diodes assist in dissipating the store energy in the coils. The interlock logic is integrated in a PLC. It collects data on the temperature, the LHe levels and the pressures of the He gases in the vessel. The quench detector and the lead voltage monitor are treated as hardware interlock signals.

The parameters variations of SW6 quench event are shown in the fig. 8. The magnet coils of SW6 are soaked in liquid helium. The exceed heat was dissipated by liquid helium when the main power supply shutdown by the interlock management unit. The top left and the top right plots show the temperature at the center and the upstream of magnet coil. The temperature increases less than 0.1 K at center and 0.5 K at upstream. The middle left and the bottom left plot show the LHe level and He gas pressure in the He vessel. The LHe boil-off in the quench event and make the level reduce around 5%. The helium vapor makes the gas pressure increase over 20 psi. The LN_2 level and the N_2 gas pressure are shown in the middle right and bottom right plots.

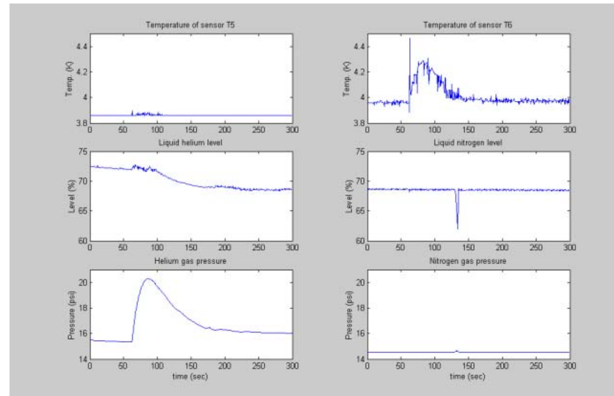

Figure 8. The variations of cryogenic parameters when SW6 quench.

SUMMARY

The control system is implemented to support the routine operation and provide the quench protection for the superconducting insertion devices. The other three superconducting wigglers (IASW) are planned to install near the second bending magnet of the triple bend achromat sections of the storage ring at NSRRC in the future. Despite there are some difference for the configuration of these superconducting insertion devices, the control system will share the same structure. According to the operation experiences from SWLS and SW6 show the control system working well. Performance and reliability of the control system is improved continuously to ensure smooth operation.

REFERENCES

[1]. Jenny, Chen., et al., "Control System for the Superconducting wavelength shifter of NSRRC," EPAC'02, Paris, France, June 2002, p. 2010-2012.

[2]. Jenny, Chen., et al., "Control System for the Superconducting wiggler of NSRRC," APAC'04, Gyeongju, Korea, March 2004.

[3]. http://www.aromat.com/.