REALIZATION OF A SYSTEM TO MONITOR WATER QUALITY AND FOR COOLING A TPS KEKB SUPERCONDUCTING CAVITY CPL/HOM

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Abstract

Taiwan Photon Source (TPS) is a 3-GeV synchrotron accelerator, built beside the present Taiwan Light Source (TLS) [1]. The stability of an electron beam is provided by a low-level RF control system to keep constant the RF gap voltage and phase to be constant[2]. The RF gap voltage for the accelerating electron beam is provided by a KEKB superconducting cavity. During routine operation of this cavity, water cooling is necessary to stabilize its accessory components to avoid damage or abnormal operation of the system. This article introduces the realization and integration of the water-quality monitoring and cooling system for the TPS superconducting cavity input coupler and high-order mode damper (CPL/HOM). After a brief description in the first section, the detailed architecture and function of the designed signal-monitoring system are discussed in the second section. The third section contains a further description of interlocks for the system protection. The final section of this article summarizes the water-quality monitoring and cooling system.

INTRODUCTION

At present, the RF system of TPS storage ring adopts KEKB superconducting cavities in two sets that can provide an accelerating voltage about 3.2 MV to the electron beam, but run about 2.8 MV in normal daily operation. In such operation, there is always a loss of RF power at a coupler and the absorption of high-order modes from the electron beam; this additional heat loss requires a water-cooling system for dissipation. Independent water-quality control and cooling systems are designed and made in NSRRC for safe operation of the superconducting cavities.

Inside the water-quality monitoring and cooling system of the TPS superconducting CPL/HOM, the generation of cooling water results from the internal cycling of a water cooler. To monitor the operational status of the water system, many analogue signal transducers are adopted, including modules for water flow, water pressure and temperature. Each module has its corresponding meter for the personnel to read directly. The alarm setting is also equipped within the meters. An alarm is activated when there is an abnormal event that occurs during the system operation. The triggered signal can turn off the related systems or immediately call experts with an alarm call system. This article describes mainly the function of these modules.

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SYSTEM ARCHITECTURE

The architecture of the designed and integrated system to monitor the water quality and for cooling is shown in Fig. 1. The main part of the system generates signals for water pressure and temperature. The water-cooling system is divisible into a HOM water-cooling system and a CPL-water cooling system. The cooling water is provided by a compressor to cool the accessories of the superconducting cavity. The water-cooling system consists of sensor modules for water flow, temperature, water pressure and water resistance, a water-level integrated module and interlock modules; all these modules are integrated within one rack. There are analogue outputs of each module to be sent to a data-acquisition system for long-term monitoring. Once an abnormal event occurs, the interlock module is triggered, which activates the alarm system to remind pertinent personnel to recover. Meanwhile, this alarm signal shuts down the RF power via SRF interlock modules on the SRF electronics rack for system protection [3]. Some special signals can turn off the compressor of the cooler and shut down the electrical power via a CPL/HOM interlock to protect the water-cooling system.

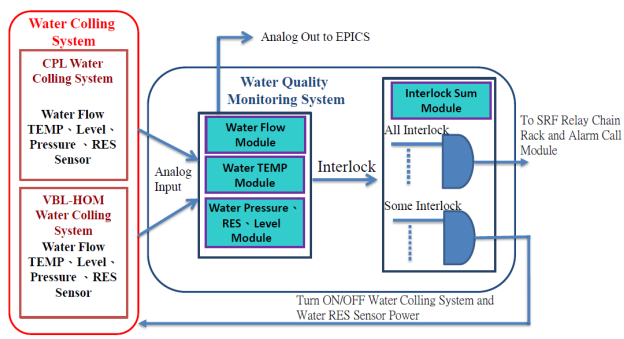

Figure 1: Designed system architecture.

HARDWARE REALIZATION

The system realized to monitor the water quality and for cooling is shown in Fig. 2, 3 and 4. The adopted sensor modules are described below.

Figure 2: Electronic rack of the TPS superconducting cavity CPL/HOM water-quality and cooling system.

Figure 3: Cooler and water manifold of the HOM water-cooling system.

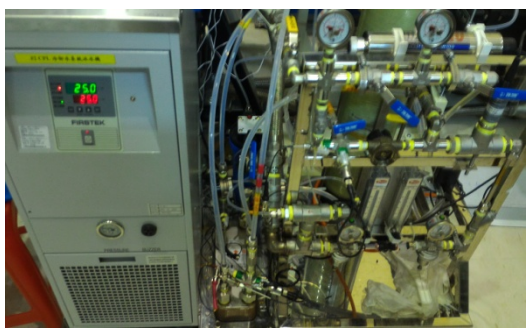

Figure 4: Cooler and water manifold of the CPL water-cooling system.

Water Flow Sensor Display Modules

The water flow sensor is a rotary type that can convert a water flow rate to pulse signals. The transducer circuit can accordingly convert these pulse signals to an analogue voltage and display the water-flow rate on a readout meter, as shown in Fig. 5. Table 1 lists the signal names.

Figure 5: Water flow-meter module.

Table 1: Signal names of the water flow-meter module

Signal name
CPL water-flow rate
CPL regeneration water-flow rate
CPL primary side HEX/ HOM inlet water-flow rate
HOM/SBP taper/bellows return water-flow rate
HOM/SBP HOM return water-flow rate
HOM/LBP HOM return water-flow rate
HOM regeneration water-flow rate
HOM primary side HEX water-outlet water-flow rate

Temperature Sensor Display Modules

The type of temperature sensor is PT100. The temperature signals are transferred to analogue voltage signals by a temperature transducer (Brodersen PXT-10); the corresponding temperature values are displayed as shown in Fig. 6. Table 2 lists the signal names.

Figure 6: temperature display meter module.

Table 2: List of PT 100 temperature sensor modules

Signal name
CPL inlet water temperature
CPL outlet water temperature
CPL secondary side HEX outlet water/return water of water cooler
CPL primary side HEX inlet water/VBL inlet water temperature
CPL primary side HEX outlet water/ VBL inlet water temperature
HOM inlet water temperature
HOM /SBP taper/bellows return water temperature
HOM /SBP HOM return water temperature
HOM /LBP HOM return water temperature
HOM /LBP taper/bellows return water temperature
HOM secondary side HEX outlet water/ water-cooler return water temperature
HOM primary side HEX outlet water temperature

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Module to Display Water Pressure, Quality, Level

This module can display the water pressure, water resistance and level of the water tank of the compressor simultaneously. The EC430 meter displays the water resistance value. The SG-3081 current/voltage conversion module transfers the current signal of the water-pressure sensor to an analogue voltage and displays the corresponding pressure value. A liquid-level meter reads and displays the value of the level sensor. The integration module is shown in Fig. 7. Table 3 lists the signal names.

Figure 7: Water pressure/quality/level display module.

Table 3: List of signal names of the water pressure/quality/level display module

Signal name
CPL inlet water pressure
CPL outlet water pressure
CPL water tank level
CPL inlet water resistance
HOM inlet water pressure
HOM outlet water pressure
HOM water tank level
HOM inlet water resistance

Interlock Module

The interlock module adopts a Fatek PLC (FBs-40MAT) as the main controller. The interlock trigger alarm signals generated by the display modules for the water-flow sensor, temperature and water pressure/quality/level are sent to the interlock module, which latches the triggered alarm signal. The first triggered signal is lit in blue LED for personnel to clarify the actual reason. When a trip occurs, to protect the superconducting cavity, the module also turns off the RF signal in the SRF system while other signals shut down the water-cooling compressor. The interlock module is shown in Fig. 8.

Figure 8: Interlock module.

SYSTEM PROTECTION LOGIC

In this system to monitor the water quality and for cooling, as any signal is interlock-triggered, besides latching it, a protection mechanism is activated. When a triggered event occurs, the system shuts off the RF power of the SRF system for systematic protection. Moreover, if the inlet water pressure is too large, the outlet pressure too large, the liquid level too low, or the primary-side water temperature too low, the electrical power to the water-cooling compressor, water pump, water resistance sensor is turned off to stop the water cycling immediately. If the inlet water is too low, the outlet pressure too small or the water resistance too small, or if signals persist for more than 5 min, the electrical power of the water-cooling compressor and water-resistance sensor is also shut off. The system protection logic is shown in Fig. 9.

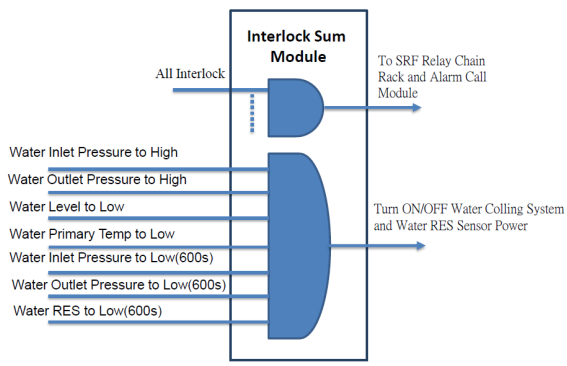

Figure 9: System protection logic.

CONCLUSION

The system to monitor the water quality and for cooling integrates the related signals of the water-cooling system of the CPL/HOM on the TPS superconducting cavity such as water flow, temperature and pressure. System protection is realized through an interlock module and an alarm call module. By means of the cooler of the TPS CPL/HOM water-quality monitoring and cooling system, the cooling water can be provided steadily and adjusted accordingly to maintain a stable water temperature. The personnel can read the signals directly or through a data-acquisition system. The TPS CPL/HOM water-quality monitoring and cooling system modules are integrated within a standard 19" rack and have flexible space for future extension.

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