

ELECTRONIC SYSTEM FOR SUPERCONDUCTING RF MODULE AT THE SYNCHROTRON RADIATION RESEARCH CENTER

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Abstract

The electron storage ring at the Synchrotron Radiation Research Center, as a third-generation light source, is routinely operated with a maximum beam current of 200mA with two DOIRS cavities. One major machine upgrade is being undertaken at SRRC. It involves replacing the existing Doris cavities with a single CESR-III superconducting module. A maximum beam current of 500 mA in a high-order-mode under well damped conditions is expected, and will significantly enhance the spectral brightness and stability of beam. Commissioning is scheduled for the spring of 2003. Two SRF modules of the Cornell design will be delivered from ACCEL. The associated electronics protect against the window arcing and cavity quench, and support cryogenic control of cryostat conditions. An existing low level RF system is being modified and expanded for functional integration with the SRF modules. The electronic integration of the SRF modules is reported.

1 INTRODUCTION

A Superconducting RF cavity which is designed by Cornell University and has been tested at Cornell Electron Storage Ring (CESR) will be installed at the Taiwan Light Source (TLS)[1-3]. The 500 mA beam current upgrade project at the TLS is expected to achieve the goals of reducing the longitudinal bunch instability and doubling the storage beam current.

The SRF station includes the cryomodule consisting of one single-cell superconducting niobium cavity in the cryostat and a cryogen distribution valve box[4]. The SRF electronic system consists of many electronic devices to support functions of protection, control, data acquisition, and diagnostics. This system is going to be integrated with the SRF module. The overview of this system is given here, while some home-made circuits are also introduced.

2 SRF ELECTRONIC SYSTEM

The SRF electronic system can be divided into five main sub-groups:

- 1) Electronic devices on cavity module and valve box.
- 2) Carriage break-out box and valve box break-out
- 3) SRF electronic racks
- 4) Interlock ready chain
- 5) Low-level RF system

2.1 Electronic devices support cavity module and valve box

An SRF cavity module is equipped with a set of sensors to monitor temperature at various points, helium level and pressure in the helium bath, cavity vacuum, RF signals, cooling water flow, insulation vacuum, etc. Two kinds of temperature sensors are used as cryogenic temperature thermometers: Cryogenic Linear Temperature Sensor (CLTS) and carbon sensor. A tuner system provides frequency compensation by mechanically deforming cavity. RF probes pick up RF signals, including forward power, reflection power and transmitted power. The liquid helium level is measured by the level sensor and associated level meter.

The valve box contains some pressure transducers to measure the supply pressure of liquid helium and the return line pressure of HEX. Meanwhile, a cryogenic venturi-type flow meter is used to measure the cold gas mass flow in the helium return line. The pneumatic supply valve and return valve in the valve box regulate the liquid helium level and the helium bath pressure inside the He vessel, respectively.

2.2 Carriage break-out box and valve box break-out

As shown in Fig. 1, the major function of the carriage break-out box and the valve box break-out is to process some transducer signals at the cavity module and the valve box, including thermometers and flow meters. Also the other signals between the cavity module and SRF electronic racks are transferred through them.

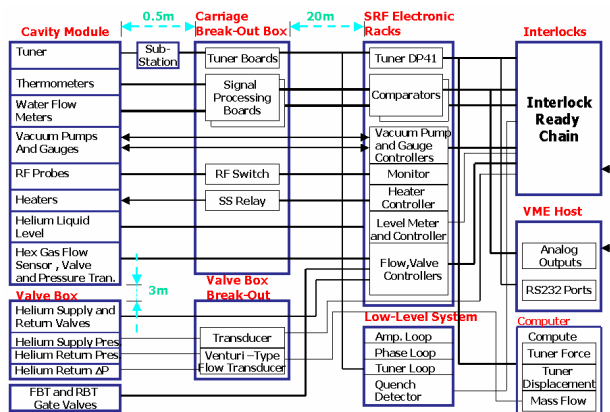


Figure 1 Overview of SRF electronics system

2.3 SRF electronic racks

The SRF electronic rack comprises display meters, comparator modules for the interlock ready chain, and controllers for the vacuum gauge and the heater. Meanwhile, the controllers inside provide different kinds of interfaces for diagnostic and feedback, including RS-232, analog output, and relay output.

2.4 Interlock ready chain

The interlock ready chain will turn off the RF system when an interlock signal is received. Interlocks include various alarm signals, such as tuner force and position, helium bath pressure, HEX gas flow rate, liquid helium level, cryostat insulation vacuum, cavity vacuum, tunnel safety, and so on.

2.5 Low-level system

The existing low level RF system, made by SLAC, comprises an interlock/protection system and three feedback loops. Shown in Fig.2 is its block diagram. The interlock/protection system consists of safety protection, transmitter interlock and an RF switch. The feedback loops are:

- 1) frequency loop, which drives the tuner to keep the cavity frequency by compensating both the beam loading and temperature/pressure effects,
- 2) amplitude loop, which stabilizes the cavity gap voltage by regulating the driving power of the transmitter, and
- 3) phase loop, which stabilizes the output power phase of the RF transmitter.

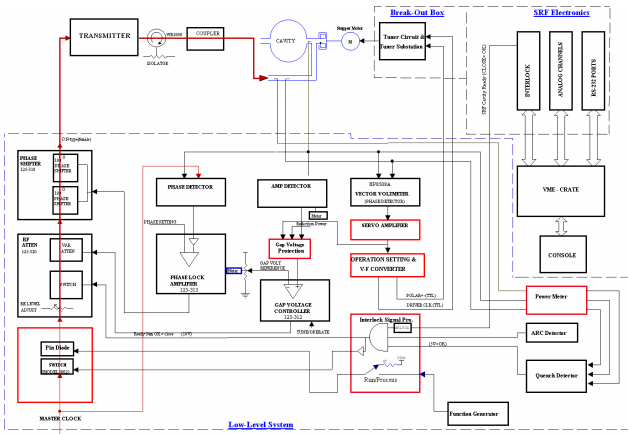


Figure 2 Block diagram of RF low-level system

This existing low-level RF system is being modified and expanded in order to be integrated with the SRF module. The modification is mainly on the tuner controller that converts tuning angle into motor steps and tuning direction. Moreover, a quench detector, a power meter with fast analog output, a gap voltage protection module, an interlock sum module, and an RF switch are going to be added to the low-level RF system.

The quench detector was developed at CESR to detect the quenching of superconducting. This circuit has been duplicated and tested at TLS. It functions well at off-line test. The power meter can be switched to display forward power, reflection power and transmitted power. It also provides fast analog output signals of the power detected. The RF switch is to turn off RF power as a second safeguard.

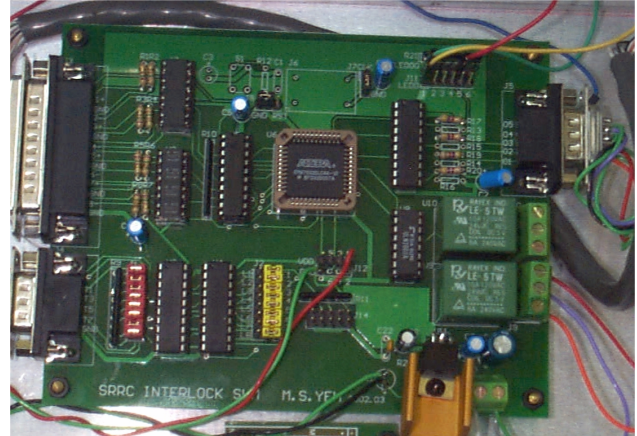


Figure 3 Interlock sum module

Shown in Fig. 3 is the interlock sum module designed and manufactured by ourselves. There are eight TTL signal inputs, eight dry contact signal inputs, four TTL signal outputs, and two dry contact signal outputs in this module. Whenever there is an interlock signal received by this module, a sum signal of the SRF interlock ready chain, the window arc detector interlock and the cryostat quench detector interlock will trigger the RF switch to turn off RF power.

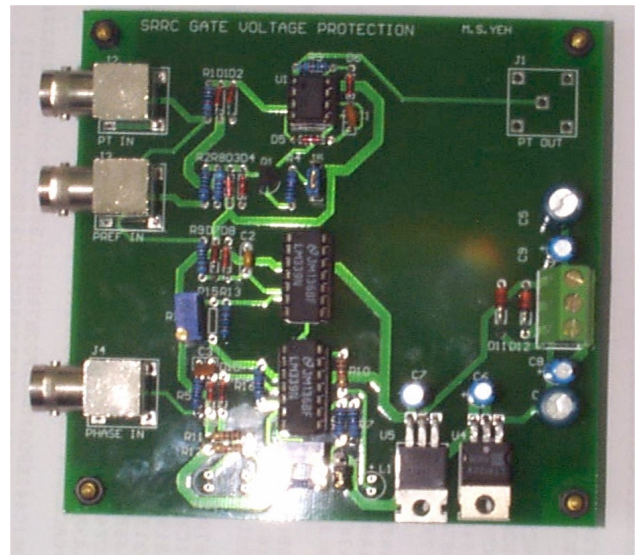


Figure 4 Gap voltage protection module

The gap voltage protection module designed and manufactured by ourselves is shown in Fig. 4. When the transmitted power is below the setting threshold or the tuning angle error is out of setting range, the output of

this module is the higher one of the transmitted power and reflection power. This output regulates the amplitude feedback loop and thus protects the cavity window.

These additional modules will soon be integrated with the low-level RF system. Then this modified low-level RF system will be tested at a test stand which has been established and a room-temperature DORIS cavity would be used to simulate the behavior of the SRF module.

3 CONCLUSION

The integration of SRF electronic system and the low-level RF system is one of the major tasks of the cavity upgrade project. Challenges are foreseen. Some key modules have been manufactured in our lab. The test results are pretty good. However, the goal is to operate the SRF module well in the coming year. Therefore a lots of efforts will be on mastering the routine operation, setting points and functional optimization of the feedback loops in the SRF electronic system. The integration and test of this electronic system with the RF test stand are thus very important.

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