CONTROL SYSTEM FOR THE SUPERCONDUCTING RF CAVITY OF NSRRC

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Abstract

To double the stored beam current and to eliminate severe longitudinal instabilities of the 1.5 GeV storage ring of NSRRC, a broad and functional upgrade of machine in replacing the operational copper cavities with a single CESR-III superconducting RF (SRF) module is under way. Installation and commissioning of the SRF module is scheduled in 2004. The dedicated control system of the SRF module has been implemented and integrated into the NSRRC existed control system. Hardware, software components and various system-wide applications have been developed to facilitate the operation of SRF system. Details of the control system for SRF project will be summarized in this report.

INTRODUCTION

The control system for superconducting RF System is a VMEbus based system. A PowerPC VME host module that is running the LynxOS real-time operating system has been used as the system controller, and the dedicated software environment with friendly graphic user interface, which is included in the NSRRC control system, has been implemented for the purpose of daily routine operation and system-wide data acquisition. The control system coordinates the operation of the low-level system and the cryogenic data acquisition of the SRF system.

NSRRC SRF PROJECT SUMMARY

NSRRC have planed to replace the two operational Doris copper cavities by a single CESR-III superconducting RF module since 1999. The aim is to enhance the efficiency of this light source facility and enable it to be an ultra high intensity photon factory that is operated at the maximum beam current. The upgrade project of the 1.5 GeV storage ring of NSRRC is expected to double the stored beam current and to eliminate severe longitudinal instabilities of the beam. Installation and commissioning of the SRF module is scheduled in 2004.

SRF CONTROL SYSTEM

Infrastructure

We used to have two Motorola MVME-147 single board computer module based VMEbus systems, which were running the PSOS$^+$ real-time operating system, for monitoring and controlling the old Doris copper cavity RF subsystems. In order to facilitate the simplicity and efficiency in operating of the new SRF subsystem, we have decided to replace two ageing systems with a PowerPC single board computer module based VMEbus system, and it runs the popular Unix-like LynxOS real-time operating system. Control interfaces of the system consist of analog input/output, digital input/output, and RS232 serial bus connections. All essentially monitored, controlled signals of SRF and cryogenic subsystems are well incorporated and engineered into the new VMEbus system to fulfill requirements of the commission stage. For future modification or expansion of the existed system, we have already reserved enough rooms for control interfaces revamping. The whole control environment is shown in Figure 1.

The beam trip event recorder system is useful to record transient diagnostic signal information from the subsystems of the storage ring. The most significant part of this system is the VME transient recorder module. It consists of eight input channels with 12 bits resolution digitizer that the fastest converting rate is 10 MHz and the recording FIFO length is up to 128k samples per channel. The faster and longer sampled signal information is always of grate advantage to data acquisition and analysis fields, especially in recording the turn-by-turn data of the storage ring and those transient, diagnostic signals generated from the RF system as well. Owing to the necessity of locating and analyzing the source of beam trip event, we have incorporated this support into SRF control system.

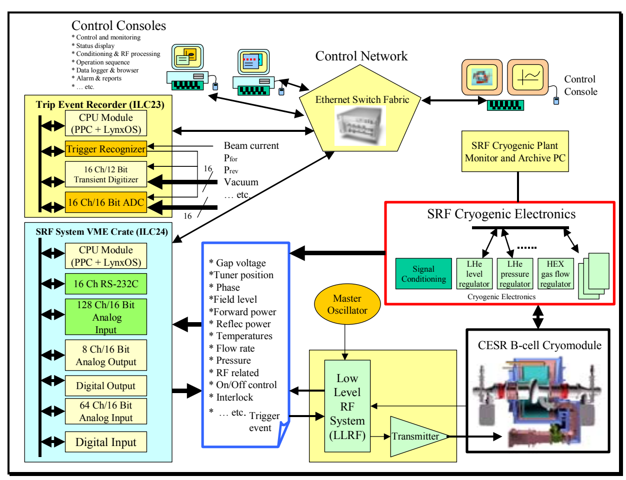

Figure 1: The NSRRC superconducting control environment.

Software Environment

Since we have changed the real-time operating system to LynxOS, all the system and application programming libraries have to be rewritten. Therefore, we have spent significant amount of time on software migrating and debugging. The general layout of NSRRC control system is depicted in Figure 2. The intelligent local controllers (ILC) are responsible for data acquisition and working magnitudes setting of all subsystems, hence the SRF and cryogenic VMEbus based control system is a dedicated ILC within the whole control system. The Ethernet network between database server workstation and ILCs has been innovated to the current stage that is a hybrid network of 10 Mb/s, 100 Mb/s and Gigab/s. Global upgrade to 100 Mb/s and Gigab/s Ethernet will be carried out in the near future.

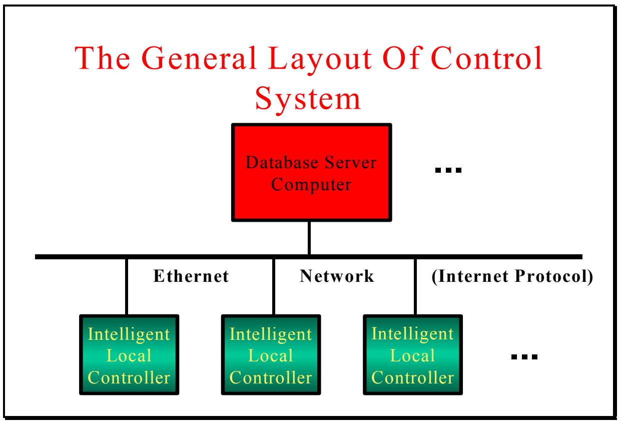

Figure 2: The general layout of NSRRC control system.

The software configuration of SRF VMEbus based ILC is depicted in Figure 3. As one turns on the power of this crate, the booting firmware will request and load the operating system from a dedicated server then it mounts the predefined network file system and executes the application software that creates the desired control environment.

All applications running on the ILC are generated by the Root task, which is a unique process to each ILC, basing on actual hardware installations and dedicating requirements of each individual ILC. In the figure, those tasks that reside on the lower level are child tasks spawn by the process on the higher level as those solid lines indicate. The Root task is the kernel part of whole applications on the ILC, which creates the share memory region and specifies the existing system configuration of each node. The Network task is responsible for all query and monitoring events from the Ethernet, especially in exchanging online information between running applications and developer's computer system. The I/O control task checks each interface board, local bus or device installed on the node. It also dynamically spawns data acquisition and setting subtasks for local bus or smart device, if they existed. Moreover, it scans each input interface on every 100 ms interval for refreshing the control database. The Setting task bases on the agreed key, between control database and local node, of a signal to change its working magnitude by creating a Unix process thread to accomplish the mission. The Upload task receives 100 ms control database uploading event from the database server then triggers the scanning procedure to acquire the freshest input data of the node and sends them back to the server. The Local Bus/Device Reading/Setting tasks monitor and control extended commercial buses or specific devices if they are connected on the node. Some occasions, there are quite a few buses or devices connected on a specific node, therefore the system performance and programming techniques have to be carefully tuned and considered.

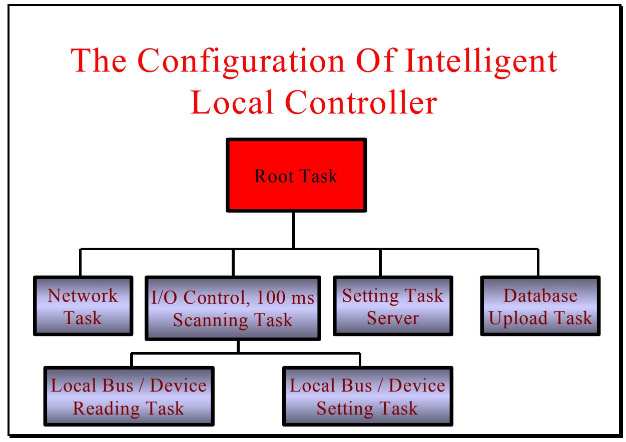

Figure 3: The software configuration of SRF VMEbus based control system.

User Interface

The user interface of the SRF control system has two friendly graphic pages on the display screen of the control console. One is for the SRF low-level system routine operation that includes system status and control parameters of the low-level system as shown in figure 4. The operator and machine physicist can fine tune and control the low level electronics of the SRF system through this page.

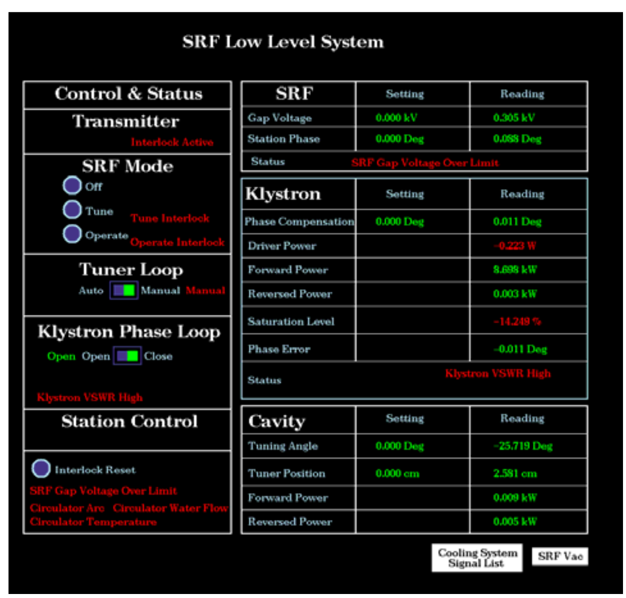

Figure 4: The control page of the SRF low-level system.

The other page, as shown in figure 5, displays all the important parameters of cryogenic system, such as the vacuum pressure, current existing levels of liquid helium and liquid nitrogen, temperatures of the cryostat related parts etc. The purpose of this page is focusing on monitoring the global status and functional integrity of the cryogenic system.

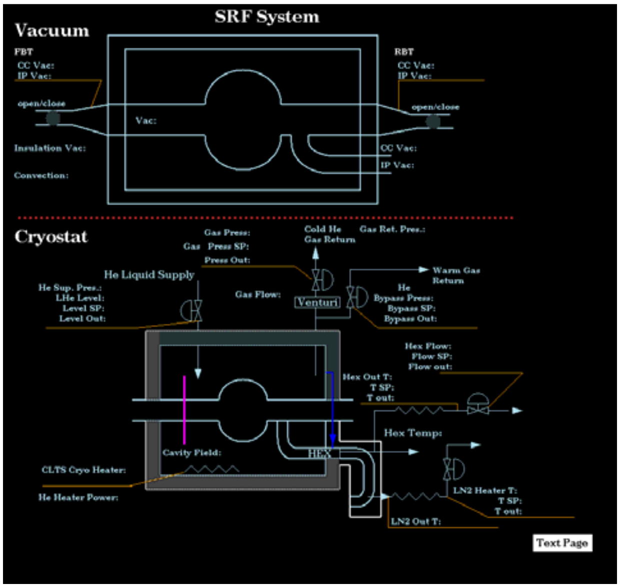

Figure 5: The monitoring page of the SRF cryogenic system.

SUMMARY

Owing to the upgrade project of superconducting RF cavity, we have the chance to carefully examine and rebuild our intelligent local controller for RF subsystem. During revamping period, we have replaced the ageing system and application softwares, also utilized most up to date hardware products for the controller. Since these efforts have been put on the controller, we believe that innovations implemented on SRF intelligent local controller will last for years.

So far, the NSRRC SRF control system only monitors the status of cryogenic system that makes it to be a stand-alone facility. From the control point of view, it is awkward and inconvenient for integrated operation of the SRF system. Therefore, an intelligent communication method should be considered and investigated.

Generally speaking, the SRF control system has been already completed, and waits for the installation and commission stage in 2004. By that time, we believe that there is still lots of unexpected problems happened and needed to be overcome. Last but not least, I would like to appreciate those colleagues of Instrumentation and Control Group of NSRRC who have participated in this upgrade project.

REFERENCES

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