DATA ACQUISITION AND MONITORING FOR TPS SRF MODULE HORIZONTAL TESTS

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Abstract

Three KEKB-type single-cell SRF modules were already shipped to NSRRC before the end of 2012. Horizontal test of the first KEKB-type SRF module had been finished in January of 2013. While the next two horizontal tests will be completed in May and August of this year. This article introduces the data acquisition and monitoring systems during the SRF horizontal test in NSRRC.

INTRODUCTION

A third-generation, high-brightness synchrotron light source, Taiwan Photon Source (TPS), is under construction at National Synchrotron Radiation Research Center (NSRRC), and is scheduled to be commissioned at the end of 2013. It consists of a 150-MeV electron linear accelerator, a booster ring and a 3-GeV storage ring.

The booster RF system includes a five-cell PETRA cavity at room temperature, a home-made analogue low-level RF system[1], and a crowbar-type transmitter that was upgraded to RF output power 100 kW. Two KEKB-type single-cell superconducting RF (SRF) modules will be installed in the storage ring. The RF source of the storage ring is provided by a 300 KW Thales klystron with a RF transmitter made by Thomson. To protect the SRF cavities from both contamination and performance degradation, two five-cell PETRA cavities at room temperature will serve for the machine commissioning. The routine operation of the two SRF modules is scheduled after the first quarter of 2014 [2].

Three KEKB-type SRF modules are already in NSRRC. Two SRF modules is used for storage ring routine operation, while the other one is spared. Horizontal tests for these SRF modules are scheduled to start in January 2013 and to finish in August of this year. During the horizontal test including the cavity cool down procedure, the SRF module status must be carefully monitored, such as the cavity temperature, cavity vacuum and LHe vessel pressure, etc. In this article, the data acquisition system including the data collection, archiving, retrieving and monitoring are introduced.

DATA ACQUISITION SYSTEM

The Hardware

Figure 1 shows the hardware structure of data acquisition rack. The data acquisition rack collects signals from SRF and LLRF systems on the junction box, J1, and spreads the signals out to digitizers from the J1 junction box. To avoid the impedance mismatch, signals buffers are addressed between junction box J1 and the digitizers.

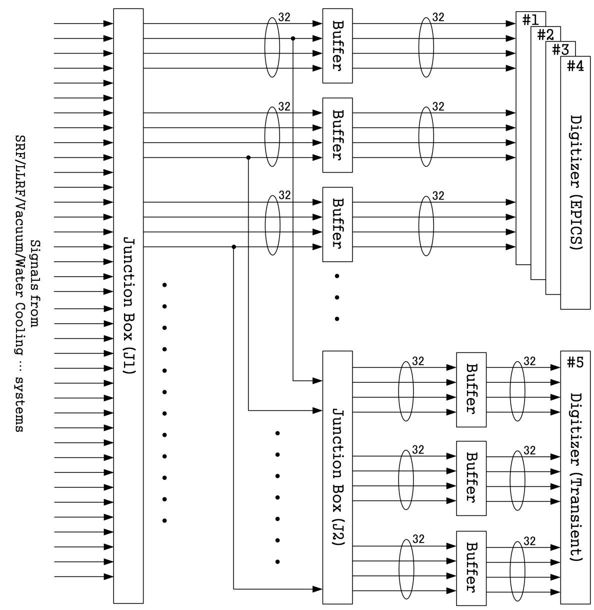

Figure 1: The hardware structure of data acquisition.

Few signals, such as arc and quench detectors and RF power signals, are needed to be sampled with a very high sampling rate. These signals are linked from J1 to another junction box J2 and then forwarded to another digitizer sampled with a faster rate, digitizer #5 in Fig. 1.

For the digitizers #1-#4, the sampling rate is set to be 1-KHz. Mean devices on the these digitizers will smooth out most of the noise and thus decrease the signal update rate to few Hz. These digitizers continuously sample the input signals. Embedded EPICS IOC broadcasts the signals to network. The fifth digitizer is a transient data recorder, which collects data few seconds before and after the positive or negative edge trigger signal. Sampling rate of this digitizer is 250KHz. The transient data recorder can be found in [3].

EPICS IOCs for Interlock and Cooldown Rate Monitoring Module

In addition to the embedded EPICS IOCs on digitizers, soft IOCs are developed to access controller for data monitoring.

Slow interlock control module uses a Fatek pro-

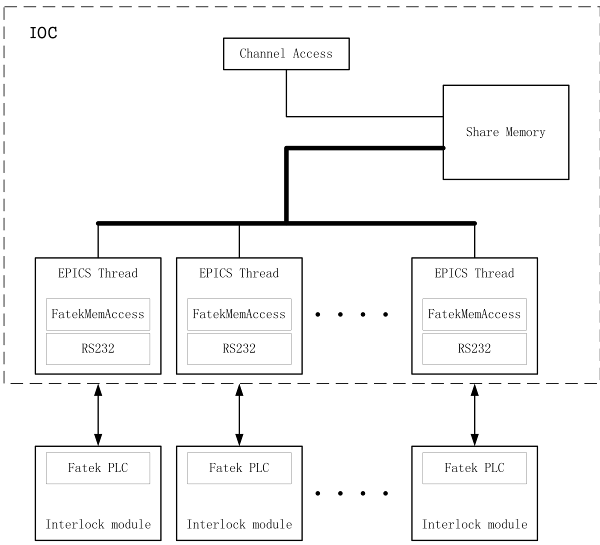

Figure 2: structure of interlock monitoring & temperature change rate monitering IOC.

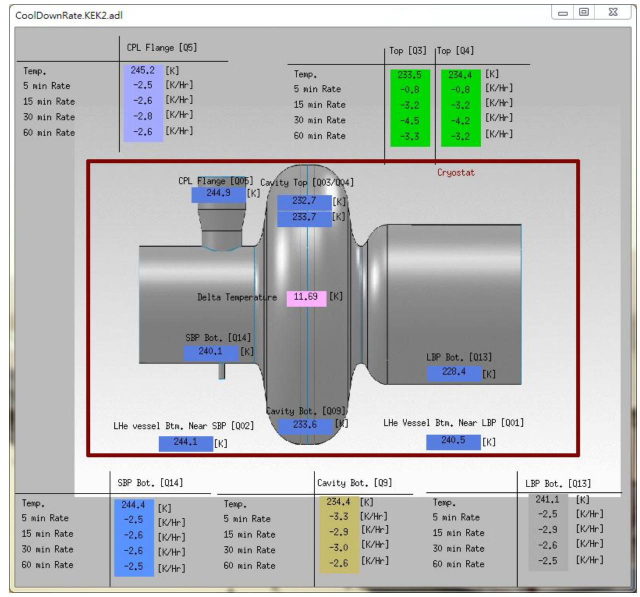

Figure 3: EPICS medm display of SRF temperature change rate monitoring module.

grammable logic controller (PLC) to combine a ready chain signal. Each slow interlock control module monitors 48 interlocks, and five slow interlock control modules are installed in a SRF system. Status of each slow interlock channel is forwarded to network by a EPICS soft IOC.

Figure 2 shows the diagram of EPICS soft IOC that read the interlock statuses from multiple slow interlock control modules. At initilization, the IOC creates a share memory area whose size is determined by the number of interlock modules. In addition, the IOC also creates several threads that directly access the Fatek PLC hardwares through the RS232 links. The threads periodically read the states of the interlock control module and map the statuses to the share memory. Channel access thus reads the interlock channel from this share memory.

SRF module cooling down procedure is risky. For the KEKB-type SRF module, the temperature change rate is suggested to be not more than 3 K/Hr decreasing during the cooling down procedure. To limit the temperature change rate, we developed a rate monitoring module. This module accepts six temperature input channels. A Fatek PLC estimates the temperature change rate, K/Hr, by the data of 5 minutes, 15 minutes, 30 minutes and 60 minutes. When the estimated temperature change rate is over or under specified values, this module generates an interlock signal to turn off the LHe supply valve and send an alarm text message to the on duty staffs. Temperature change rate information also propagates to the remote clients by EPICS soft IOC. The EPICS soft IOC structure of this module is similar to the one described in Fig. 2. Figure 3 shows a medm display screen snapshot of the temperature change rate monitoring module. Six temperature sensors and four temperature change rate estimations are shown on this display.

Services and Clients

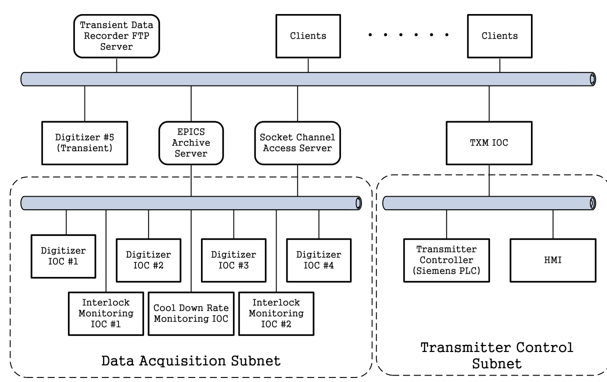

Figure 4: Network topology of the data acquisition system.

Figure 4 illustrates network topology of the SRF horizontal test area. There are three categories in the test area network, data acquisition local area network (LAN), transmitter control subnet and pubic area network. The public area network traffic is quite busy and sometimes might be not stable enough for data archiving. Therefore, most of the EPICS IOCs propagate the processing variable (PV) information on the data acquisition subnet, an independent private network.

EPICS archive server collects PV information from the IOCs in data acquisition network and the TXM IOC through public area network. A data retrieving service routine, which accepts requests from and transfers binary data to the clients, is also executing on this archive server.

Figure 5 shows the normal communication protocol between clients and the data retrieving service routine. Ser-

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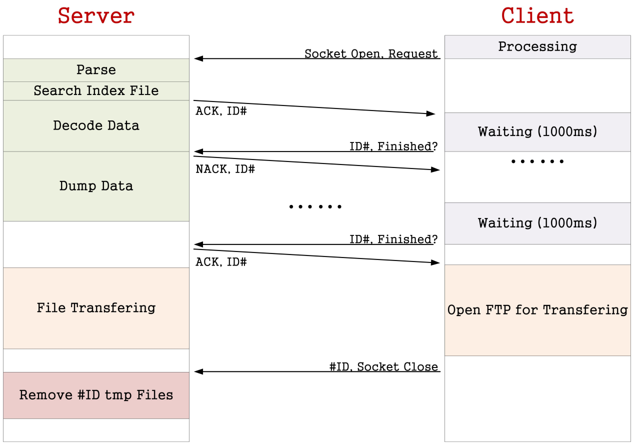

Figure 5: Archive data retrieving communication protocol.

vice routine listens to the request from the network. Once the service routine gets requests, it will extract the information from the database, dump the extracted information to a binary file and then forward a positive acknowledgment character to the client. Finally, file transfer protocol (FTP) connection will be created to transfer the binary file from server to the client. We also designed an archive viewer to retrieve the EPICS archive data for the clients. Figure 6 shows a archive viewer window snapshot for analyzing the first SRF module cooling down procedure. The second and third charts describe the temperatures of the two sensors at the cavity bottom, while the first chart shows one of the two temperature change rate during the cooling down period. The cooling down procedure was broken on 12th January, because the electrical system of NSRRC was under maintenance. The temperature change rate and the cavity bottom temperatures therefore goes positive and increasing.

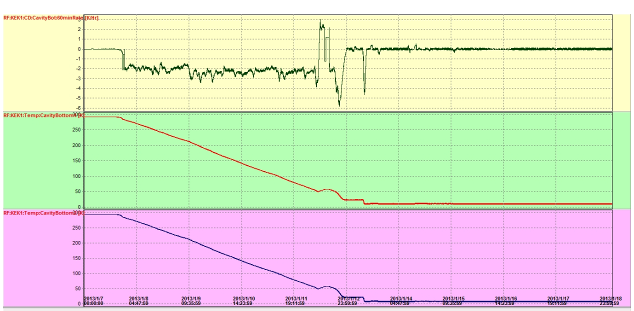

Figure 6: A snapshot of archive viewer.

EPICS channel access is very convenient to access PVs within a local area network. But it is not easy to access PVs across several subnets. Although, EPICS gateway can partially solve this issue. A socket channel access server is installed between the public area network and data acquisition network. Socket channel access server listens to the requests from public area network by TCP/IP protocol The service routine gets the requests from clients, translates the requests to regular EPICS channel access protocol. If no error exists in the requests, the service routine will receive correct PV information from EPICS channel access. Then, the socket channel access service routine will re-package the information and transfer back to the client. The client locates in another public area network, it also can access the PVs through this socket channel access server.

We develop a trend plot to collect data from the socket channel access. This trend plot software is similar to the EPICS Strip Tool [4]. It periodically collects data from EPICS IOC through the socket channel access and plot the data on screen. The on duty staffs can thus easily identify the direction of a signal during experiments. Figure 7 is a picture of trend plot data of coupler RF processing.

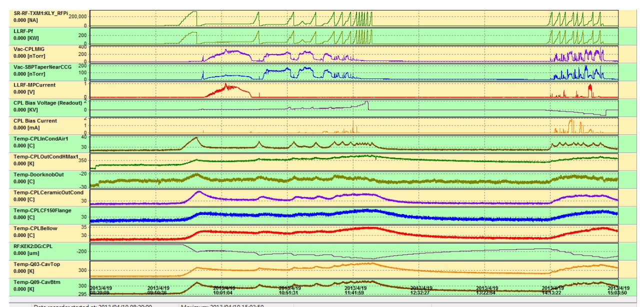

Figure 7: A picture of trend plot.

SUMMARY

This paper introduces the data acquisition system for TPS SRF horizontal tests. Several effective tools are also provided for analyses to discover the weakness of RF system. The hardware interlock and temperature change rate modules prevent the system from dangerous operations.

REFERENCES

[1] M.S. Yeh et al., "Low-level RF control system for the Taiwan Photon Souce", in *Proc. of International Particle Accelerator Conference 2011*, San Sebastian, Spain, 2011, pp. 463–465.

[2] Ch. Wang et al., "Design features and construction progress of 500-MHz RF systems for the taiwan photon source", in *Proc. of Particle Accelerator Conference*, New York, USA, 2011, pp. 2513–2515.

[3] Y.-H. Lin et al., "Diagnostic Systems for the TLS SRF System", in *Proc. of Particle Accelerator Conference 2009*, Vancouver, BC, Canada, 2009, pp. 4838–4840.

[4] APS, `http://www.aps.anl.gov/epics/index.php`