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DATA ACQUISITION AND USER INTERFACE OF BEAM INSTRUMENTATION SYSTEM AT SRRC

Jenny Chen, C. J. Wang, C. H. Kuo, K. H. Hu, C. S. Chen, K. T. Hsu, SRRC, Hsinchu, Taiwan

Abstract

Data acquisition systems for the accelerator complex at SRRC are composed of various hardware and software components. Beam signals are processed by related processing electronics, and connect to control system by various type of interfaces in data acquisition front-ends. These front-ends include VME crates, personal computers and instrument bus adapters. Fast Ethernet connected all elements together with control consoles. The user interface is running on the control console. Real-time data capture, display and analysis are supported on the control console. Analysis tools based on Matlab scripts are adopted. Hardware and software implementation of the system is presented. User interface supports are also described.

1 INTRODUCTION

The control system of SRRC is essential to operate the light source efficiently. The console level is composed of control console and the control server. Field level computer composed of more than 30 VME crates and several PCs for special devices. Both level computer systems are connected by a dedicated control fast Ethernet. Beam instrumentation system is composed of various beam monitors and associated processing electronics. The most important beam parameters include beam current monitor and closed orbit, beam profile, etc. Various software tools are integrated with the system and provide an efficient means of operation.

2 OUTLINE OF THE CONTROL AND BEAM INSTRUMENTATION SYSTEM

2.1 SRRC Control System

The control system is a two-level hierarchy computer system [1]. Upper layer computers include two process computers and many workstations and PCs. Database management, archive and various application programs are executed on the process computers. The main purpose of the workstations is for use as operation consoles. Bottom layer computers are distributed VME crate controllers that are in charge of the control and data acquisition for accelerator equipment. Both computer layers are connected by a local area network. The software environment can be divided into four logical layers. They are device access layer, network access layer, database layer and applications from bottom to top. The database plays a role as data exchange center for applications and subsystems of accelerator system. Most of the data is updated into database at ten times per second.

2.2 Beam Instrumentation System

The beam instrumentation system is composed of various monitors and supporting electronics. The system supports precision intensity measurements and lifetime calculations. Orbit measurement, synchrotron radiation monitor and destructive monitor. All devices are controlled by VME based local controllers. The control console can access these devices through the user interface. The synchrotron radiation monitor is controlled by a PC and connected to control system via Ethernet. Beam diagnostic instrumentation systems provide the necessary electron beam parameters for commissioning, routine operations and beam physics studies.

2.3 User Interface

The Common Desktop Environment (CDE) is used for user interface development. It is an integrated graphical user interface for the SRRC control system, combining X Window System, OSF/Motif, and CDE technologies. Motif GUI Builder and Code Generator, UIM/X GUI builder is a used to generated various user interfaces. It enables software developers to interactively create, modify, test and generate code for the user interface portion of their applications. To satisfy various requirements, some applications are development in a LabVIEW based environment. For fast prototyping, users can customize user applications in the Malta environment. The control system supported various database access MEX files. User’s can access the database directly in Matlab. For the IEEE-488 based interface, a fast Ethernet based GPIB adapter was support. A GPIB/2 interface is also included to allow user access these instruments within Matlab.

3 SPECIFIC APPLICATIONS

3.1 BPM System

The BPM system consists of 57 BPMs equipped with switched electrode processing electronics. The data acquisition is done by a dedicated VME crate equipped with 128 16 bit ADC channels. The VME host sends raw data to the orbit feedback system via reflective memory. Averaged data are updated to the control database 10 times per second with a resolution of around one micron.

3.2 Orbit Display Utilities

To provide better orbit observation, a Motif based orbit display utility was developed. This utility provides basic orbit display and difference orbit display. Several display attributes can be selected by users, such as full scale range, persistent display mode enable/disable, average number, save, print, … etc. The update rate of the display is up to 10 Hz. This is very useful for routine operation and various machine studies.

3.3 Turn-by-Turn BPM System

To support various beam physics studies, several BPMs are equipped with log-ratio processors for turn-by-turn beam position measurement. A multi-channel VME form factor digitizer with 12-bit ADC acquires turn-by-turn beam position. A server program running on a VME crate manages the data acquisition of beam position. A client program running on control console and Motif based GUI are used for the user interface.

3.4 SmartLink System to Acquire Beamline Data

To acquire data from a remote site, a SmartLink based system was setup. The link used a private Ethernet as a field bus. The Ethernet is connected to a PMC Ethernet module installed on the VME host. The SmartLink data acquisition module is used to acquire data from the beamline monitor with high resolution, including photon flux (Io) monitor and photon BPM blades current. The update rate is about 2 times per second with 20-bit resolution. This slow update rate is the major disadvantage.

3.5 Synchrotron Radiation Monitor Interface

The synchrotron radiation monitor is used to measure beam profile. It consists of an optics and a high resolution CCD. To acquire profile information, a PC acquires the image from the CCD camera, analyses the profile and extracts profile parameters. The local display is also broadcast via facility-wide machine status CATV system. A server program running on PC serves the data request form control console. A client program running on the control console can access information of this PC by the help of LabVIEW program or Matlab MEX files running on the control console.

3.6 Gap Voltage Modulation Study Support

RF gap voltage modulation was adopted to relieve the effect of longitudinal coupled-bunch instability in routine operation of the storage ring at SRRC. Systematic measurements were done recently to investigate the mechanism why RF gap voltage modulation can do this. The experimental setup is shown in Figure 1. The gap voltage modulation frequency is about 50 kHz. The rolled off frequency of the LLRF gap voltage regulation loop is about 7 kHz. A function generator in VME form factor generates the modulation sinusoidal wave. This generator integrates with the control system to satisfy the requirement of routine operation. Frequency and amplitude can be adjusted on the control console. The modulation signal is injected after loop filter and added with a correction signal in the RF gap voltage regulation loop. HP4396A spectrum/network analyzer observes the beam spectrum form BPM sum signal.

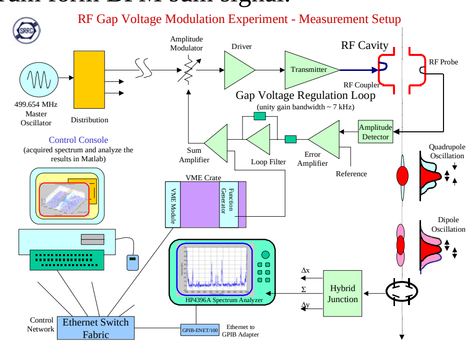


Figure 1. Experimental setup for RF gap voltage modulation study.

National Instruments GPIB/ENET-100 controller connects the spectrum analyzer to the control network. The control console supports database accesses MEX-file that allows Matlab to read and set the modulation parameters. GPIB MEX-file allows Matlab to read and write the GPIB devices via a GPIB/ENET-100 controller. The experimental data can be acquired directly into Matlab. The gap voltage modulation is effective because the modulation frequency is far beyond the unity gain cutoff frequency of the gap voltage regulation loop. Modulation amplitude is about 10 percent of total gap voltage in routine operation. The experiment's sequence is programmed by a simple Matlab script running on the control console that selects frequency scan range as well as modulation amplitude. The spectrum analyzer can select to measure upper or lower sideband either 1fs or 2 fs synchrotron oscillation frequency. Figure 2 shows the measured result and clear show that the instability is suppressed near 50 kHz.

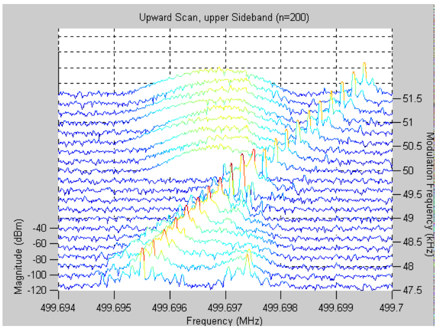


Figure 2. Typical scan spectrum of RF gap voltage modulation study.

3.7 Booster Tune Measurement and Correction System

The electron beam is accelerated form 50 MeV to 1.5 GeV at the booster synchrotron with 50 msec ramping time. Tune is an important index indicated the tracking performance of the White circuit based power supply system. Tune information was obtained by the tune measurement system; it provides the νx and νy during energy ramping. Tune variation in the energy ramping process are correlated to the tracking performance of three families White circuit. The optimized lattice can be obtained by the help of measured tune for the booster synchrotron to get a better working point for efficient operation. An application program was developed to automatically measure and correct the tune variation. The stored beam is excited by extraction kicker to perform damped betatron oscillation. Trigger timing and field strength of the kicker is set properly as the function of beam energy to ensure sufficient beam excitation and without killing the stored beam. Beam motion signals are picked up by stripline and processed by log-ratio BPM electronics [2]. A transient digitizer in the VME crate records the betatron oscillation of the stored beam. Server programs running on the VME crate coordinate the process of data acquisition. A client program running on control consoles is invoked by a Matlab script to perform data acquisition and analysis. Data analysis includes Fourier analysis, peak identification and visualization. The tune correction signal is generated and downloads to waveform a generator located in the VME crate. Figure 3 shows the system structure of the tune measurement and correction system [3]. The Matlab script is used to generate a correction waveform by the measured tune and measured sensitivity matrix between tune and quadrupole setting. Figure 4 shows the tune during ramping with and without correction. Tune variation during ramping can be reduced drastically by this feed-forward correction.

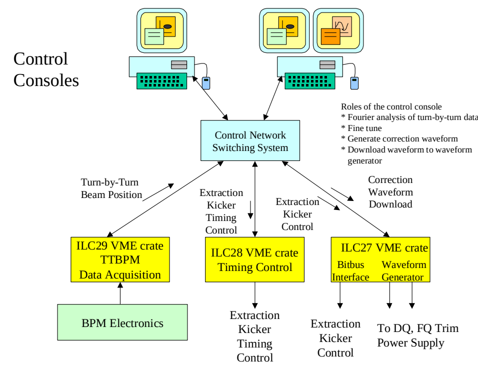
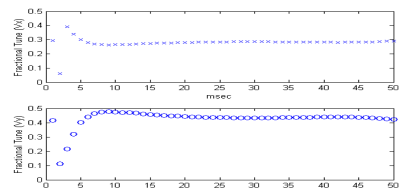
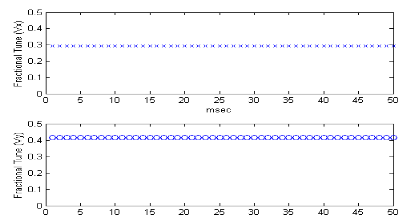


Figure 3. Tune acquisition and correction system.



(a)



(b)

Figure 4. Tune variation during energy ramping; (a) before correction, (b) after correction.

4 SUMMARY

Data acquisition and user interface of SRRC are summarized in this report. These systems are essential for the operation of accelerator system for machine tuning, various feedback, machine study, etc. The system is evolving continually with technology advanced.

REFERENCES

[1] Jenny Chen, et al., "Virtual Instrumentation Interface for SRRC Control System", PAC95, 2256 (1995) and reference therein.
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[3] C. S. Chen, et al., "Study of the White Circuit Tracking Performance in the Booster Synchrotron of SRRC", Proceeding of PAC2001, paper FPAH301.