ISBN: 978-3-95450-254-7 ISSN: 2226-0358 doi:10.18429/JACoW-ICALEPCS1991-S03SRD10

Present Status of Control System at the SRRC

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ABSTRACT

The modern control technique was used to design and set up a control system for the synchrotron radiation facilities at the synchrotron radiation research center (SRRC). This control system will be finally to operate the dedicated machine to provide the 1.3 GeV synchrotron radiation light. The control system will control and monitor the components of storage ring, beam transport and injector system. The concept of the philosophy is to design a unique, simple structure and object-oriented graphic display control system. The SRRC control system has the major features such as two level architecture, high speed local area network with high level protocol, high speed microprocessor based VME crate, object-oriented high performance control console and graphic display. The computer hardware system was set up and tested. The software in top level computers which include database server, network server, upload program, data access program, alarm checking and display, as well as graphics user interface (GUI) program were developed and tested. The operational system and device driver on the field level controller were implemented. The overall performance of the SRRC control system were tested and evaluation. The preliminary results showed that SRRC control system is simple, flexible, expandable and upgradable open system to control and monitor devices on the small scale synchrotron radiation facility.

I. INTRODUCTION

The 1.3 GeV synchrotron radiation facility is going to construct at SRRC to provide a low emittance and high brilliance light source. The dedicated synchrotron light source will include three subsystems that are a turn key 1.3 GeV electron full energy injector, beam transport line and storage ring. The 1.3 GeV full energy electron injector was constructed to Scanditronix AB at Sweden and installed at SRRC site. The injector is going to commission within 2 or 3 months. The beam transport line has been designed and its major component was also fabricated partially. The storage ring with triple bend achromat lattice [1] has been designed and the most components were constructed and passed its qualification of the specification.

The control system at SRRC provides a unique control and monitoring three subsystems which include the injector, the beam transport line and the storage ring facilities. The 1.3 GeV energy electron injector is composed of a 50 MeV linear accelerator and 1.3 Gev booster synchrotron accelerator. The control system of booster synchrotron can be run in a turn-key system and/or to be integrated into SRRC control desk to form an unique control system. The design concept is to standardize the same computer architecture, digital communication network with some protocols and some database structure as well as some console computer. The control system of the electron injector can play as a stand-alone subsystem to test and commissioning machine as well as machine study for booster synchrotron.

The control system of SRRC is cost-effectively designed by using recent developed computer technology [2,3] and modern control technique [4-9]. Two level hierarchical computers, process and console computer as a top level and multiple intelligent local controllers (ILC) as a low level, was configured. One process computer and several console computers at top level provide the database management and maintenance, devices control and monitoring, data logging and archiving, machine modeling, object-oriented graphical display. The lower level computers are multiple VME crate based system which handle device related data acquisition and control as well as local interlocking functions. It simplifies the architecture of control system at SRRC. The upper and lower level computers are connected by ethernet using high level protocol.

The process computer will handle the static and dynamic data base. It also offers to carry out the calculation of the electron orbit and simulation of the machine physics parameter. It is a high speed computing, multi-task and muti-user virtual memory system (VMS), and high through input/output (I/O) capability. The console computers will play a similar job as a process computer except maintenance of the database. The console computer plays an important role to operate and monitor the synchrotron radiation facility using man-machine interface that is developed based on the concept of the object-oriented graphic display. This is the most recent development on the third generation of the synchrotron radiation facility [7-9].

The ILC is a field level (or called device level) controller which performs the local data collection, local interlocking and closed loop control for the components and/or the equipment of the various system. It is also very important for the real time feedback control system.

II. COMPUTER HARDWARE SYSTEM

Two level hierarchical computer configuration has been designed and installed partially at this moment. The hardware configuration of the control system at SRRC is shown in figure 1. The top level computers are composed by one process computer and several console computers. The VAX 6000 model 610 supermini computer is chosen as a process computer. The VAXstation 3100 model 76 is selected as a console computer. The big semiconductor and mass storage capacity as well as high speed I/O peripheral devices are also considered and configurated.

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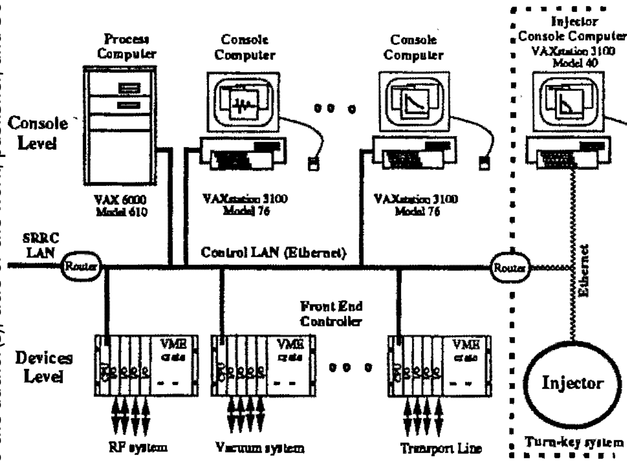

Figure 1. Hardware configuration of the control system at SRRC

The process computer creates and maintains the database and manage them at current development. The central database has been used at SRRC control system due to the on-time schedule to commission the machine. It will be modified as a distributed data base in near future. The update data rate from ILCs is set 10 Hz due to broadcasting mode or under request mode. These data can be received by any top level computers. The top computers can also set the parameters of the device and read the signal back and display it graphically. The process computer is running in VMS operating system but the console computer can run in VMS or Ultrix operating system. The ethernet using TCP/IP protocol is used to link all top computers and multi-ILCs.

The console computers are composed of VAXstation 3100 model 76, model 40 and DECstation 5000 model 200 that is run Ultrix operating system. The workstation will provide the console control and monitor the machine parameter and/or device signal through user graphic interface software. It provides the real time data trend or graphic display friendly.

The ILC is an VME crate system which includes Motorola MVME-147 central processing unit (CPU) board and variety of I/O cards. The CPU board consists of 68030 microprocessor , 68882 floating point processor, 4 Mbyte on-board memory and ethernet interface. The field devices are connected into ILCs through parallel analog or digital input/output or IEEE-488 bus standard or serial communication interface. The major tasks of the ILCs will handle the data setting, data acquisition interlocking, and close-loop control and monitoring function of the equipments or devices. Twelve set ILCs will handle the magnet power supply, RF system, vacuum system, beam diagnostic, and general purpose measurement instruments, ... etc. The user from the workstation can set and read back the parameters of the device easily.

III. COMPUTER SOFTWARE SYSTEM

Based on the VMS operational system and utility package, the software of the control system at SRRC has been designed and basic program of this software was coded and tested. The block diagram of software structure is shown in figure 2. The software structure is divided into several logical layers that is device access, network access, database management, graphics user interface and applications. The goal to modularize the software into layers is to reduce the developing time.

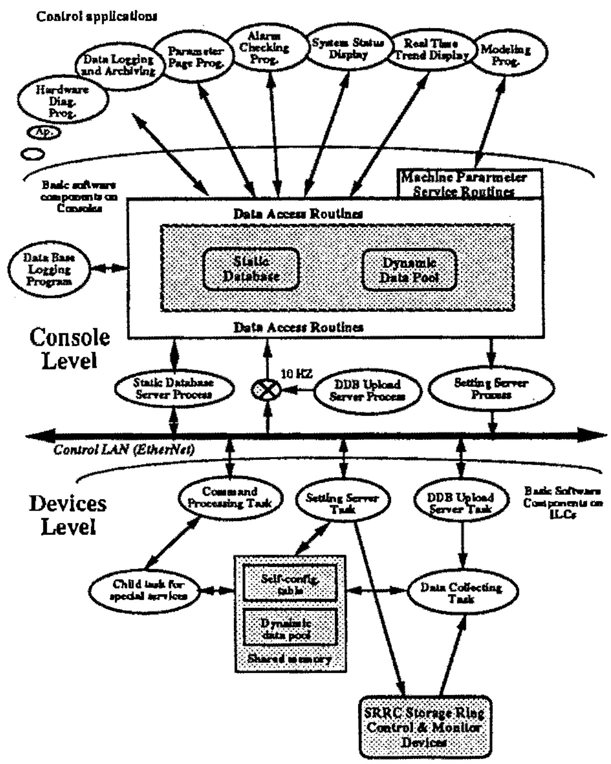

Figure 2. Block diagram of software system

The device access process are run on the ILCs. The pSOS+ real time kernel provides the ILC with support for task scheduling, memory allocation, even handling and message queuing. The pNA+ network support package provides socket network interface. The control tasks and various I/O tasks are developed and tested on the ILC. The device dependent software drivers are implemented partially. The magnet current regulator, RF low-level electronic controller and vacuum gauge controller were implemented and tested successfully. The speed of the dynamic data uploading to the top level computers is about 10 Hz. Downloading the database from the process computer into the ILCs to form a local distributed is initialized and underway.

The network access software is in charge of the information exchange between the top and the low-level computers. The protocol of the IEEE-802.3 is used to communicate with the turn-key injector system. The high level protocol TCP/IP is using at this moment. The reason to use IEEE-802.3 and TCP/IP protocols due to the beginning of the vendor contract to made an agreement for IEEE-802.3. That time the TCP/IP is not popular enough for VAX computer and 68000 series computer vendors. However, it would be changed into TCP/IP after the commission of the electron injector to form a unique local area network.

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The database access is developed on the console level computers. The console level computers are VAX/VMS system (or can be an Ultrix system for the console computer). The software is coded in C language. The function of the process computer and operational console computer (or called workstation) is slightly different. The process computer keeps the system-wide static database and maintains it. The upload sequence is also requested by the process computer. At system start-up, each workstation requests and receives a copy of the static database from process computer. Each console computer then has all the database information necessary to process dynamic database frames received from the ILCs.

The workstation are mainly to provide user to operate the machine. The upload sequence is requested by the process computer, the ILCs multi-cast the dynamic data sequentially. All of the console level computer received dynamic data and updated into database at the same time.

The central database on the console level computer is used as buffer between the low level tasks at the ILCs and the console level applications. The application programs of the user can access the equipment parameters directly from their own database rather than from the ILCs. The application programs are device transparent. The development programs on the top level computers can be run concurrently.

The basic control and monitoring program has been developed at current stage. These programs are urgently need for machine commissioning. Those programs include the data logging, archiving, alarm checking and display routine etc., were coded and tested successfully. The machine model calculation can be run on process computer and/or individual workstation. The graphics user interface software was developed based on X Windows and Motif in VAXstation 3100 model 76. The block diagram of the relationship to develop the graphics user interface is shown in figure 3. The graphic edit program is to edit the display pattern of the machine components and build up the linkage relationship between the component and the static database. Those pattern file is stored with ASCII format in the hard disk. The control program is to read these ASCII file and make a connection between the component pattern and dynamic database. This program is also to execute the task of the data reading, setting and display from the DDB server. All subprogram is written in modularize software package. This human interface software will provide the operation of the synchrotron radiation facility more friendly.

IV. SUMMARY

The control system for the dedicated synchrotron radiation light at SRRC has been designed and the computer hardware and software was implemented partially since last year. Two level hierarchical computer control system has been configurated and the high speed local area network that use ethernet and high level protocol such as TCP/IP have been implemented and linked. The data upload rate is to maintain about 10 Hz without increase of traffic load at network. The over-all performance of the process computer and multiple ILCs as well as digital communication network has been

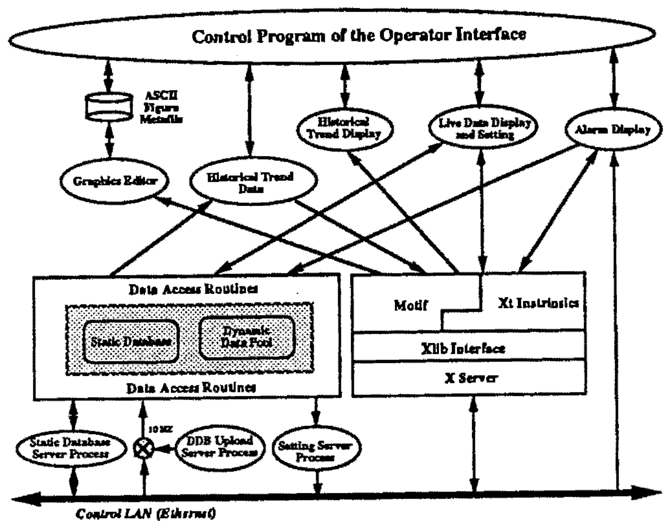

Figure 3. Block diagram of the operator interface

tested and evaluated. The results show the 10 Hz update from the ILCs is not big issue to control and monitor the devices for synchrotron radiation facility at SRRC.

The object-oriented development tool of the graphic display and data trend display were developed and tested. The user can set and read back the signal from the field level devices within 10 Hz. The flexible change of the time interval for the data display at specified signal is allowable to change from 1 sec up to 60 sec. The GUI software can be developed from the developed basic edit program to code and modify it. This software will provide the user to operate the machine were easily and friendly. Finally, the two level computer architecture, multiple ILCs that are linked by ethernet local area network using TCP/IP, object-oriented graphic display software will be a nice control system for synchrotron radiation facility.

V. ACKNOWLEDGEMENTS

One of the authors (G. J. Jan) would like to express his appreciation to R. W. Goodwin and Mike Shea of FNAL, W. D. Klotz at ESRF and Tomotaro Katsura at KEK-PF for many useful suggestions. We also would like to acknowledge David Rice at CESR to discuss the technical consideration from the operational point of view. We would like to thank Shin-ichi Kurokawa at KEK-Tristan to give a lot of technical information and experience.

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