CONTROL SYSTEM OF PLS 2-GeV LINAC*

I. S. Ko and W. Namkung
Pohang Accelerator Laboratory, POSTECH
Pohang 790-784, Korea

The graphic-based realtime control system is developed and used for the normal operation of the PLS 2-GeV linac. Control and monitoring signals from local devices, such as magnet power supplies and modulators, are connected to the VME CPUs located in the field via special signal conditioning units. Data collected by these field CPUs are summarized and stored in the supervising VME CPUs located in the control room. Operators can control such devices simply by pointing and clicking with a mouse on the control panels which are X-windows loaded on a SUN workstation environment. Status and data to be monitored are displayed in terms of digital values and graphical presentations on individual status windows which are categorized functionally. Those windows are generated with the commercially available development software named RTworks. Every data transaction is done through a specified ethernet. There are four separate ethernets for effective data transactions. Fast signals, such as RF signals and modulator beam voltages, are captured by digital oscilloscopes and displayed in the control panel through the GPIB port. This paper presents main features and the general performance of the computer control system for the PLS 2-GeV linac.

I. INTRODUCTION

The Pohang Accelerator Laboratory (PAL) has recently completed the 2-GeV synchrotron radiation source named the Pohang Light Source (PLS). The PLS will serve as a low-emittance light source for various research such as basic science, applied science, and industrial and medical applications [1]. There is a 2-GeV linear accelerator as a full energy injector to the storage ring. This linac is consisted of 11 klystrons and modulators in the ground floor and 42 accelerating columns in the tunnel which is placed 6-m below the ground level. There are also many magnet power supplies (MPS), vacuum monitors, and various beam diagnostic devices. Furthermore, the linac control system includes the 96-m long beam transport line (BTL) and beam analyzing stations (BAS). These systems have various MPSs and diagnostic instruments. In order to accomplish fast and reliable control of the linac and BTL, the control system is divided into several subsystems, and these are linked to form a hierarchical structure.

The structure of the control system was finalized by January 1993, and actual S/W development started in May 1993 [2]. Before starting the major work, we made the signal list and the design manual for the linac control system [3,4]. At present, we complete the linac control system, and it plays a major role during the linac operation. It is obvious that the linac control system is continuously being upgraded based on operational experiences and diagnostic equipment added.

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II. CONTROL SYSTEM STRUCTURE

Our aim for the linac control system is to provide a reliable, fast-acting, distributed real-time system. The basic structure of the linac is shown in Fig. 1. There are three layers in the control hierarchy; device interface, data process, and operator interface layers. There are also three subsystems divided into their own functional characteristics; modulators and klystrons (MK), magnet power supplies and vacuum system (MG), and beam diagnostics (BM) subsystems. These are linked with four independent ethernets.

III. DEVICE INTERFACE LAYER

This layer is connected to the individual devices to be controlled and monitored. Each unit is consisted of an ELTEC E-16 CPU board, a 14" color graphic monitor, a draw-type keyboard, and appropriate I/O boards. The E-16 board includes a Motorola 68030 CPU, 4 MDRAM, an EGA compatible video port, and an ethernet port. The unit is operated under the realtime operating system OS-9. This computer is called the device interface computer (DIC). There are 11 units for the modulator and microwave system control, three units for magnet power supply control, two units for various diagnostic instruments. On-demand local computer control is available to all DICs. This feature is extremely useful for tests and the local commissioning of individual devices. All DICs are located in the klystron gallery.

A. MK Control

There are eleven MK stations placed next to the assigned modulator in the gallery. They control 11 modulators, 10 IPAs (isolator, phase shifter, and attenuator), and other equipment located adjacent to the MK station. In the first MK station, there is no IPA. Instead, the prebuncher and the buncher are controlled in this station. There are four RS422 ports to connect four step motor controllers to control the phase and the attenuation of the buncher and the prebuncher, respectively.

There is one 4-channel digital oscilloscope mounted on each MK station. The fast signals such as RF forward/reflect signals, an output signal of the pulse compressor, and modulator high-voltage signals can be seen by these oscilloscopes. The same data can be seen on the oscilloscope window in the main console via an GPIB port installed in the CPU board. There will be a 16x4 multiplexer to switch various signals to one of four input channel of the oscilloscope. These oscilloscopes are particularly useful to the maintenance crew to confirm the machine status by glancing the display panel.

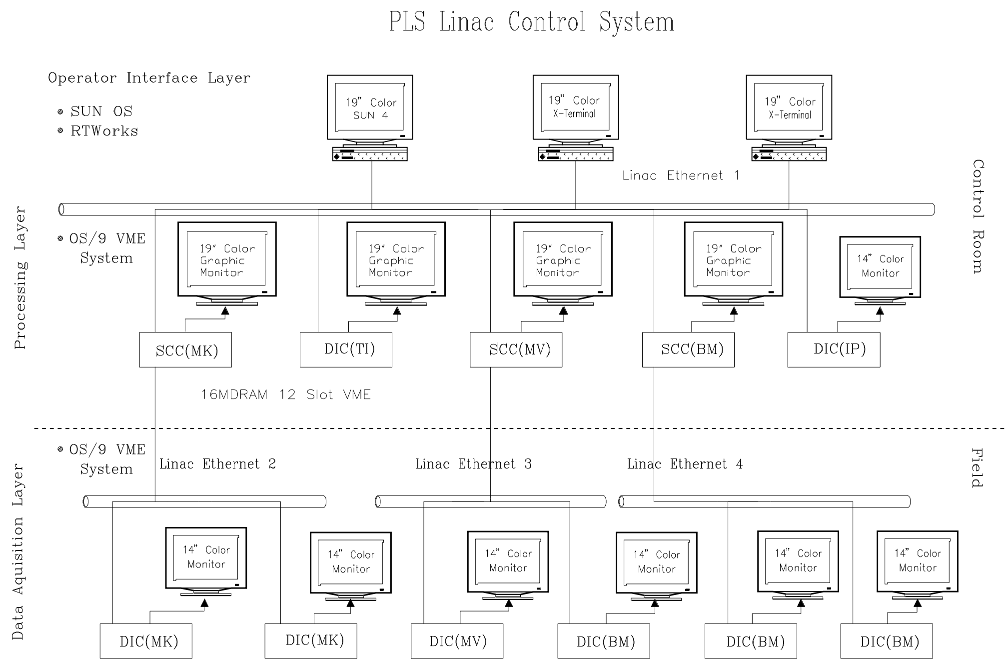

Figure 1: Schematic diagram for the PLS linac control system

B. MG Control

There are 100 power supplies for various magnets and solenoids in the linac and the BTL. These power supplies are grouped in three locations: 30 units for the preinjector placed near M1, 24 units for the rest of the linac placed near M8, and 46 units for the BTL placed in the BTL power supply room. Thus, there are 3 MG stations for the MPS control.

Each unit of six power supplies for dipole magnets in the BTL has an RS422 communication port that is connected to the VME CPU. However, the remaining power supplies are connected to the VME CPUs via special interfaces. In each MPS cabinet, there are one special interface unit with an RS422 port and four MPSs connected to the special interface unit through analog I/O channels. In this way, we can reduce the number of RS422 ports in the VME side and the cabling work drastically.

Even though there is one MG station assigned to the vacuum system, all the vacuum gauges are currently connected to IBM type PCs, and the vacuum pressures in the linac are displayed in the PC monitors. So, the vacuum related work is postponed to the future.

C. Beam Monitoring System

Various beam diagnostic instruments are used in the linac and the BTL for reliable machine operations.

There are 14 beam profile monitors (BPRM). This consists of a pneumatic actuator, a florescent screen, 4-way chamber and a viewing port, and a CCD camera. The BPRM is actually a destructive monitor, so we use them only to see the profile and rough location of the beam during the beam steering. The CCD camera control such as focusing and zoom in/out is done manually. Out of 14 BPRMs, 4 units are located in the linac, three (currently two installed) units for the BAS, and 7 units in the BTL.

There are 13 beam current monitors (BCM): 7 in the linac, one for the BAS, and 5 for the BTL. The BCM consists of a ceramic vacuum chamber and a toroidal ferrite core to pick up the signal. At present, we use an analog oscilloscope to observe 2-ns pulses from the BCM. However, we have completed the signal peak holder to catch the BCM signals and to send them to the DIC. The circuitry is made on the VME board. It will be installed during the maintenance period in this summer.

There are also 57 beam loss monitors (BLM): 42 units in the linac and 15 units in the BTL and the BAS. The BLM is simply an ionization chamber to measure the ionization current due to the secondary emission. The signal integrator circuits have been completed after the commissioning period. It is installed in the NIM standard case. These units will be tested after completing data acquisition S/W.

In order to remove off-momentum particles, slit monitors are installed. One slit is placed just after the first bending magnet of the BTL. Another slit is placed in front of the 2-GeV BAS. The slit controller has an RS422 communication port connected to the VME CPU.

There are two BM stations: one for the linac placed near M7 and one for the BTL at the end of the linac gallery. The first BM station has one BPRM controller, one CCD camera controller, a VME CPU with BCM fast sample holders, and BLM signal integrators. Second BM station has one BPRM cable connection box, two slit controllers, a VME CPU with BCM fast sample holders, and BLM signal integrators. At present, all BPRMs are controlled from the first BM station.

IV. DATA PROCESS LAYER

A. Main System

In this layer, there are three CPUs called supervisory control computers (SCC). They are assigned to supervise MK stations, MG stations, and BM stations, respectively.

Each unit consists of an ELTEC E-7 board, a 19" monitor on the sub-control console, and a floppy and a hard disk for data storage. This Motorola 68040 based CPU board has two ethernet ports: one for data acquisitions and one for the operator interface layer. These units are installed in one cabinet. The cabinet is placed in the center of sub-control room which is next to the main control room only separated by large glass windows.

There is one more unit which is assigned to beam profile monitors. The beam profile image captured by a CCD camera is directly sent to the frame grabber (AVAL AVME-335). Image processing is done by the E-16 board. The beam profile is then displayed with x- and y-profiles directly from the AVAL-335 board. The refresh speed per 300x200 sized frame is about one-half second. A graphic monitor connected to the E-16 board is used to display beam profiles with the Gaussian fitting. It shows actual numeric numbers of beam sizes and deviations from the central trajectory. The graphic monitor is located on the main control console. This kind of configuration reduces massive traffics of image data drastically in the ethernet.

B. Backup System

There are three identical SCCs next to the main system as a backup system. Normally, these units are served as develop-ment stations without disturbing the main control system.

V. OPERATOR INTERFACE LAYER

A. Main Console

The operator interface computer (OIC) is actually a SUN-4 sparcstation with two X-terminals. The operating system is UNIX and the commercial S/W package named RTworks is intensively used to optimize graphics and data handling between the UNIX system and the OS-9 system. There are several windows for an operator to control and monitor individual components. Each window has a value display area and a control sub-window. All the control action can be made by selecting a specified area with a mouse or items from the pull-down menu. Two X-terminals and a SUN monitor are located in the main control console which is designed ergonomically. In front of the main console, there are two 19" CRTs and three color TV monitors hanging from the ceiling. One CRT displays current vacuum pressures and another one shows temperatures of cooling water circulating on accelerating columns in the tunnel. When the linac is not operating, three TV monitors are used to display several areas in the tunnel and the gallery. During the linac operation, these monitors are used to display information such as the beam lifetime and the beam current in the storage ring. They are broadcasted via cable TV channels from the storage ring control room.

B. Backup Console

There is a backup console in the sub-control room. Normally, this is used as a development station with backup SCCs. Since the main control room and the sub-control room are separated with large glass windows, the operators in the sub-control console can see the information displayed in the CRTs and TV monitors in the main control room.

VI. NETWORKS

There are four independent ethernets in the linac control system. Originally, the connection between the DICs and the SCCs was designed to use the MIL-STD-1553B protocol. However, it was replaced with three ethernets because of high cost and relatively slow data transaction rates. In addition to the ethernet between the OIC and the SCCs, there are three ethernets to MK, MG, and BM stations connecting to matching SCCs, respectively. This kind of configurations provides us highly flexible ways in writing schedule routines of the data process in the VME system.

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