Status of PLS Linac Control System*

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

Abstract

The PLS electron linac is the injector for the Pohang Light Source (PLS) storage ring. The control system for the 2-GeV linac consists of three layers. In the bottom layer, the individual devices such as 11 modulators and 54 magnet power supplies are connected to VME-based 68030 CPUs under OS-9 real-time operating system via special signal conditioning units to avoid severe electromagnetic interferences. In the middle, VME-based 68040 CPUs are clustered as specific functions such as modulators, diagnostics, power supplies, etc. The top layer is the operator-machine interface running on UNIX workstations. Its function is based on the pull-down menu and mouse-driven parameter settings. This operator interface is developed by using RTworks. To observe fast signals such as klystron RF output and modulator beam voltage, commercial digital sampling oscilloscopes are used. These signals can be observed in the main control console via GPIB ports. Three layers are connected through four different Ethernets. In this paper, we report the recent achievements for the PLS linac control system.

1. INTRODUCTION

The PLS 2-GeV linac is a full energy injector to the PLS storage ring. There are 11 klystrons and modulators placed over about 150-m long klystron gallery. Magnet power supplies, vacuum monitors, and various beam diagnostic devices are also located in the gallery. The linac control system is required to remotely control all of these equipment as fast as it can allow. To accomplish this requirement, the control subsystems are placed over the gallery and the these are linked to form a hierarchical structure. The structure of current control system was fixed by January 1993, and actual S/W development started May 1993 [1]. Before the major work started, we made the design manual for the PLS linac control system [2]. This manual provided various informations to S/W and H/W designers. Here we introduce the detail achievement of individual subsystem.

2. HARDWARE

Our aim for the PLS 2-GeV linac control system is to provide a reliable, fast-acting, distributed real-time system. The basic architecture of the PLS linac control system is shown in Fig. 1. There are three layers in the control hierarchy; operator interface layer, data process layer, and data acquisition layer. There are also three subsystems divided into their own functional characteristics; modulators and microwave system, magnet power supplies and vacuum system, and beam diagnostics. These subsystems are linked with several ethernets.

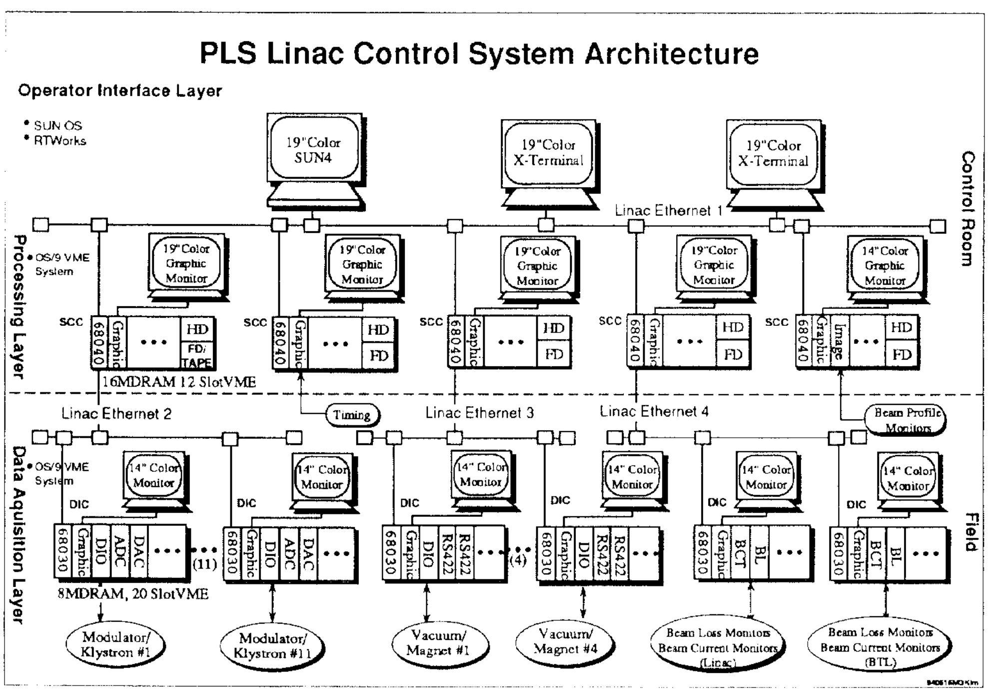

Fig. 1: Schematic diagram for PLS linac control system.

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A. Device Interface Unit (DIU)

This layer is directly connected to the individual devices to be controlled or monitored. Each DIU is consisted of an ELTEC E-16 CPU board, a 14" color graphic monitor, a draw-type keyboard, and several I/O boards. The E-16 board includes a Motorola 68030 CPU, 4 MDRAM, an EGA compatible video port, and an ethernet port. The operating system is OS-9 with the MGR graphic development tool. There are eleven units for the modulator and microwave control systems, three units for the magnet power supply control, one unit for pneumatic gate valves and several vacuum monitors. There are also one unit for beam current monitors and beam loss monitors. On-demand local computer control is available to all DIUs. This feature is extremely useful for the local commissioning and testing of an individual device, especially 200-MW modulators. All DIUs are located in the klystron gallery.

B. Supervisory Control Computer (SCC)

The role of SCCs is categorized by three major functions; modulators and microwave system (MK), MPS/vacuum system (MV), and beam diagnostics (BM). There are three units assigned to their own functions. Each unit consists of an ELTEC E-7 board, a 19" monitor located on the sub-control console, and a floppy and a hard disk for data storage. This Motorola 68040 based CPU board has two independent ethernet ports: one for data acquisition and one for operator interface layers. These units are located inside the sub-control room which is next to the main control room only separated by large glass windows. There are also three more such units in the same room. Even though the major role of these units is to develop the system softwares without disturbing the main control system, they can provide backups for the main SCCs in cases of trouble.

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 CPU board. The beam profile is displayed with x- and y-profiles directly from the AVAL-335 board. The refresh speed per 300x200 sized frame is about half second. A graphic monitor connected to the E-16 board is used to display beam profiles with the Gaussian fitting. It shows the 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 the data traffics in the ethernet drastically.

C. Operator Interface Computer (OIC)

The OICs are actually one SUN-4 sparcstation and two X-terminals linked to this SUN workstation. They are located on the main console. There is one more duplicated system in the subcontrol room. This is the backup system which is normally used for the development work. The operating system is UNIX and the RTworks is intensively used to optimize graphics and data handling between the UNIX system and OS-9 system.

D. Noise Isolation

Due to the 200-MW modulators, there are extremely strong electromagnetic interference (EMI) in the linac building. Even though the ground line for the control system is separated from the one for the modulators or power supplies, wrongful connections of cables sometimes produce highly induced voltages in the signal line for the control system. To avoid this trouble, we are using a special noise isolation system. It consists of one noise isolation transformer (-70 dB for 10 kHz ~ 30 MHz) and one impulse noise filter (-30 dB for 0.6 ~ 30 MHz) in the AC input line. This combination reduces 2 kV peak, 1 μs impulse on the 110 V AC line voltage to the undetectable range. All of the control cabinet are equipped with this system.

E. Signal Conditioning Unit (SCU)

There are many SCUs to connect individual devices such as modulators and IPAs to I/O ports in the DIUs. In general, these units match the signal levels and/or types between devices and DIUs. Optocouplers are used in the I/O circuits of every SCUs in order to isolate noisy signals electrically and, thus, to avoid any damage to the DIUs. Some I/O ports in the DIUs are mixed with analog and digital signals with mixed input/output status. For such units, certain SCUs are served as effective cable connectors. All SCU are made with standard NIM-type cases and crates for quick replacement and easy maintenance.

3. SOFTWARE

Like the hardware structure, there are three layers in the software structure. Each subsystems such as MPS, MK, and BM are monitored and controlled by individual tasks running on the appropriate layer as shown in Fig. 2. At present, about two third

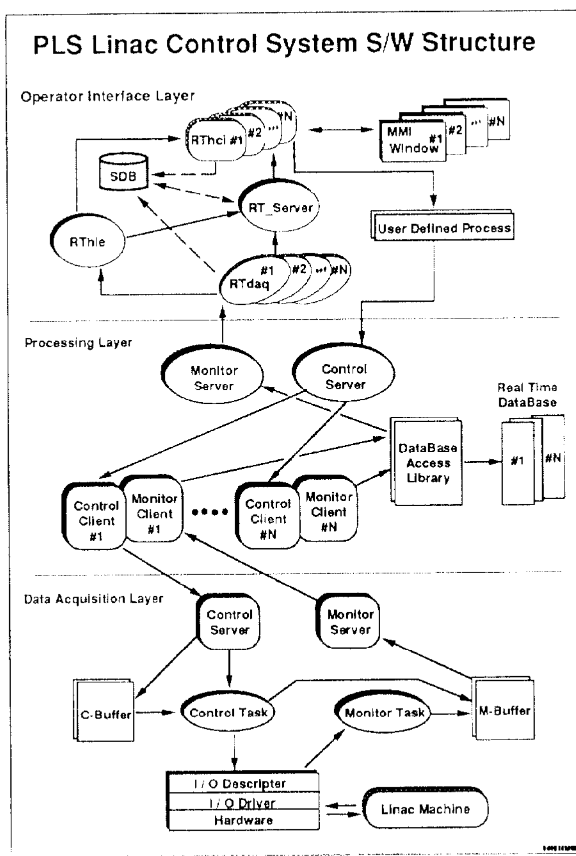

Fig. 2: Software structure of PLS linac control.

of code development work has been completed. All S/W work is done by three PLS staff for about one year.

A. Data Acquisition Layer

Major roles of the data acquisition task in DICs are as following; to store monitored data from individual devices to the designated buffer (m_buffer) regularly, and to send updated data to the SCC upon request. For the control command from the SCC, the corresponding control task sends data or messages to control individual device in realtime through proper I/O ports. Other important roles of the data acquisition task are to monitor any malfunction of connected devices and to provide emergency cures if possible, and to report the status to the SCC.

B. Data Processing Layer

The major role of the data process task is to collect the updated data from attached DICs and to store them in the realtime database. These data are sent to the RTdaq running on the OIC upon requests made by the operator. Also a corresponding task sends control commands to the proper DIC in realtime. All the required application softwares are running in realtime in this layer including client/server routines for the ethernet communications.

Every data related to the linac are stored in the RAM area temporarily and the hard/floppy disk for permanent records.

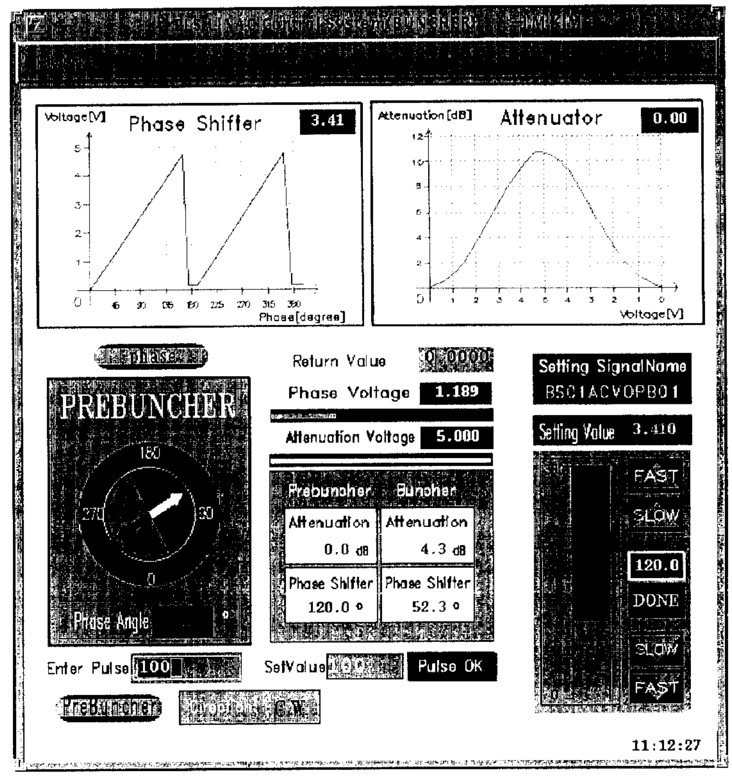

Fig. 3: Buncher control window.

C. Operator Interface Layer

A commercial software package named RTworks is used to develop graphic-base operator interfaces. RTworks is actually a powerful integrated development toolkit for an optimum data handling between client/sever systems. It also includes a graphic user interface named DataView. By using this toolkit, it is possible for one S/W engineer to develop all required operator interfaces for the PLS linac control within a year.

Actually, the data received in the RTdaq from the SCCs are sent to the RTserver by interprocess communications, and they are displayed in the monitoring windows by the RThci routine. A command selected by a mouse action drawn by an operator is sent to the SCC through user defined processes.

There are several windows for operators to control and monitor individual system such as magnet power supplies, prebunchers and bunchers, beam profile monitor control, IPA (isolator, phase shifter, attenuator) control, and modulator control. Each window has a value display area and a control subwindow. All the control action can be made by selecting areas with a mouse or select items from pull-down menus. It means that the keyboard work is not required for normal operations. Fig. 3 shows a window to control the buncher/prebuncher system.

D. Current Status

As of June 1994, several subsystems can be controllable from the main console. They are the MPS control, the buncher/prebuncher control, the beam profile monitor control, and the modulator monitoring. These are used to perform the commissioning to achieve 2-GeV beam [3]. S/W parts for the IPA control, the oscilloscope control, and the timing control are ready and waiting for matching SCUs installed. Vacuum pressures and cooling temperatures are currently displayed by PCs, so these data will be added to VME system by late this year. At present, we are concentrating our efforts to develop the control system for the beam transport line, so the SR commissioning will be able to start September this year.

4. ACKNOWLEDGMENTS

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5. REFERENCES

[1]. W. Namkung, et. al., "Progress of PLS 2-GeV Linac," Proc. of 1993 Particle Accelerator Conference, Washington, D.C., U.S.A., May 1993, pp. 581-583.

[2]. I. Ko, et. al., "Design Manual for PLS Linac Control System," MA/LN-93002, Pohang Accelerator Laboratory, 1993.

[3]. W. Namkung, et. al., "Commissioning of PLS 2-GeV Electron Linac," these proceedings.