CONTROL OF PLS 2-GeV LINAC*

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

Abstract

A graphic-based realtime control system is developed and used for the commissioning of the PLS 2-GeV linac. 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 supervising VME CPUs located in the control room. Operators can control and monitor devices simply by clicking a mouse on the control panels that are X-windows generated on a SUN workstation with the RTworks development software. Every data transaction is done through the ethernet. Fast signals such as RF signals and modulator beam voltages are captured by a digital oscilloscope and displayed in the control panel through the GPIB port. We report general performances of the control system for the PLS 2-GeV linac.

1. Introduction

The construction of the PLS 2-GeV linac is completed by the end of June 1994. The major role of the linac is to provide 2-GeV beams to a synchrotron radiation source named the Pohang Light Source (PLS). The linac is consisted of 11 klystrons and modulators in the gallery and 42 accelerating columns in the tunnel. There are also many magnet power supplies (MPS), vacuum monitors, and various beam diagnostic devices. The linac control system is required to remote control every equipment as fast as possible. Furthermore, the linac control system includes the 96-m long beam transport line (BTL) and beam analyzing stations (BAS). In order to accomplish this requirement, 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 [1]. Before starting the major work, we made the signal list and the design manual for the linac control system [2,3]. As of August 1994, we complete most of the control system, and it plays a major role during the linac operation.

2. Hierarchy of Linac Control System

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

* Work supported by Pohang Iron & Steel Co. and Ministry of Science and Technology, Korea

2.1 MK Stations

There are 11 MK stations to control 11 modulators and 10 IPAs (isolator, phase shifter, and attenuator). There is no IPA in the first MK station. Instead, the buncher and the prebuncher are controlled in this station via an RS422 port. There are eleven oscilloscopes in these stations. The RF signals and modulator high voltage signals can be seen on the main console via GPIB ports.

2.2 MV Stations

There are 100 power supplies for various magnets and solenoids in the linac and the BTL. These power supplies are placed in the three locations; 30 units in the preinjector, 24 units for the rest of the linac, and 46 units in the BTL power supply room. There are three MV 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 with an RS422 port and four magnet power supplies connected to the special interface. 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 MV station assigned to the vacuum system, vacuum pressures in the linac are currently displayed in the PC monitors. So, the vacuum related work is postponed until the remaining work of the control system is completed.

2.3 BM Stations

There are two BM stations; one for the linac and one for the BTL. Out of 14 beam profile monitors (BPRM), 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. There are also 42 beam loss monitors (BLM) in the linac and 15 units in the BTL and BAS.

The first BM station has one BPRM controller, and one camera controller for BPRMs. Currently, only BPRM controllers are used in the linac operation. Electronics for the BCMs and BLMs will be ready by the end of October.

2.4 Special Stations

There are two special stations located in the control room; the BPRM image process (IP) and the timing system (TM). Even though all the control action for the BPRM is done through two BM stations, the video images are sent directly to the IP station. In this way, we can avoid the massive data traffic in the ethernet. During the commissioning period, we measured the beam sizes using this station.

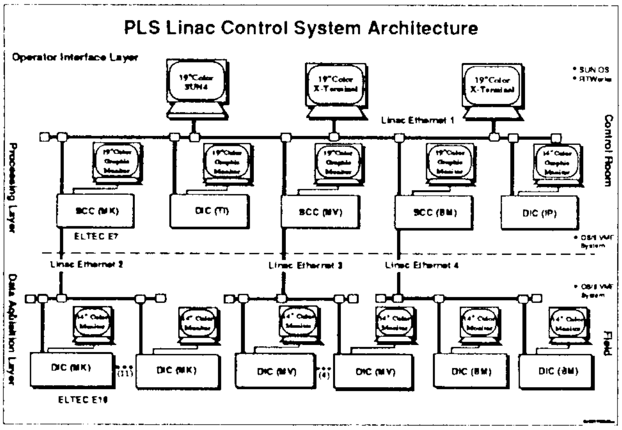

Fig. 1: Schematic diagram for the PLS linac control system

At present, the linac timing system is operated manually. The computer controlled timing station will be ready by the end of 1994. There will be one more station especially for the e-gun system. The e-gun related system will be renovated totally in the near future.

3. Hardware

3.1 Realtime Computers

For the data acquisition and process in real-time, we adopt the VME system. There are two kind of realtime computers; ELTEC E-16 for the data acquisition layer and E-7 for the data process layer. Both models run on the realtime operating system OS-9. The E-16 board includes a Motolora 68030 CPU, 4 MDRAM, an EGA compatible video port, and an ethernet port. The E-7 system has a Motolora 68040 CPU, 16 MDRAM, a workstation graphic board, and two ethernet ports. It is also equipped with a floppy disk, a 200-MB hard disk, and a streaming tape backup. There are 20 E-16 boards for various stations located along the klystron gallery. For the data process layer, three E-7 systems are required. There are also three more E-7 systems for the development works. However, these are the backup system for the data process layer in case of troubles.

3.2 UNIX Computers

There is only one SUN-4 workstation for the linac control system. Two X-terminals are linked to this SUN workstation. They are located on the main console desk in the control room. There is one 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 the OS-9 system.

There is one more SUN-4 workstation in the main control room for the physics-related work. The accelerator physicists and the operators can develop various codes such as XPORT [4] and will apply to the real operation later. At present, this system is not linked to the control system.

3.3 I/Os

Most of the I/O boards used in the VME system are commercially available. Table 1 shows a summary of these I/Os currently used in the linac control system.

Table 1: Summary of I/O boards

Name	Function	No*	Station
TSVME400	48 DI (isolated)	13	MK, BM
TSVME401	32 Relay-out	13	MK, BM
TSVME410	Multifunction	11	MK
TSVME500	4 x RS422	11	MV, Buncher
TSVME208	4 MDRAM	15	MK, MV, BM
AVME9470	80 I/O	10	MK (IPA)
AVME335	Image Processing	1	IP
E-16 GPIB	GPIB port	11	MK (Scope)

(* Number of used I/Os as of August 15, 1994)

3.4 Noise Isolation

Due to the 200-MW modulators, there are extremely strong electromagnetic interferences (EMI) in the linac building. Even though the ground line for the control system is separated from the ones for the modulators or power supplies, wrongful connections of cables sometimes produce highly induced voltages in the signal line for the control system. In order to avoid this trouble, we use a special noise isolation system in each control cabinet. 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 impulses on the 110 V AC line voltage to the undetectable range.

3.5 Signal Conditioning Units (SCU)

There are many SCUs to connect individual devices such as modulators and IPAs to I/O ports in the MK stations. In general, these units match the signal levels and/or types between devices and I/Os. 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 control computer systems. Some devices provide connectors mixed with analog/digital and in/out status. For such cases, special SCUs are served as effective cable connectors as well. All SCUs are made with standard NIM-type cases and crates for quick replacement and easy maintenance.

3.6 Control Room

There are two control rooms located near the center of the linac building. The main control room has a control console where one SUN workstation and two X-terminals for the operators are placed. There are also one TV monitor to display beam profiles captured by BPRMs and two for area surveillance. In the subcontrol room which is separated from the main control room by a large glass window, all data processing computers and

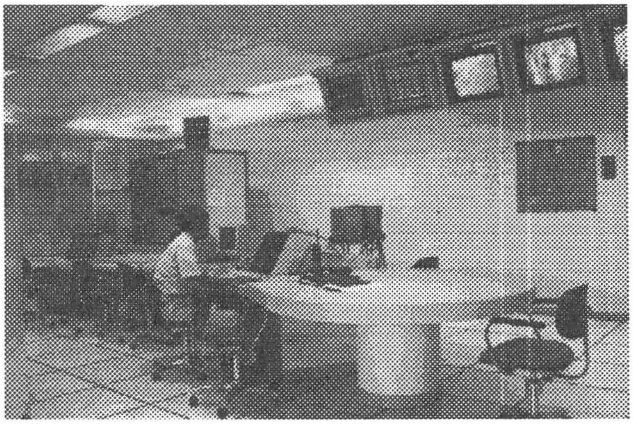

Fig. 2: View of the linac control room

a timing system are placed. The main control room is shown in Fig. 2.

4. Software

In parallel with the hardware structure, there are three layers in the S/W structure. Subsystems such as MK, MV, and BM are monitored and controlled by an individual task running on the appropriate layer.

4.1 Operator Interface

A commercial S/W package named RTworks is used to develop graphic-based operator interfaces. The RTworks is actually a powerful integrated development tool-kit for an optimum data handling between client/server systems. By using this, it is possible for one S/W engineer to develop all the required operator interfaces for the linac control in a year.

The data received in the RTdaq from realtime CPUs are sent to the RTserver by interprocessing 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 MPS, bunchers, IPAs, and modulators. 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. The BPRM control window is shown in Fig. 3 as an example.

4.2 Realtime S/W

There are two important features in the linac control S/W; the client/server routines to exchange data and commands between layers, and the separation of monitor/control tasks. When the operator selects a command from an appropriate window, it sends down to the designated device via control client/server routines in the realtime system. The data collected by a given command returns to the operator's window through a separate route.

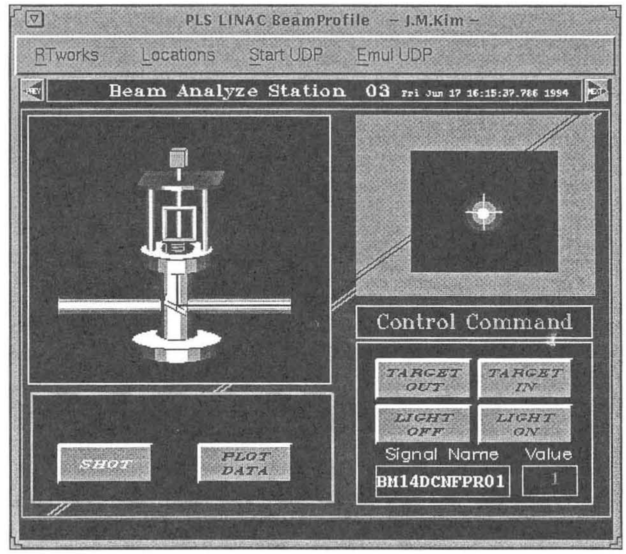

Fig. 3: BPRM control window

4.3 Current Status

As of August 1994, an operator can control most of subsystems including IPAs. These are used to perform the commissioning and routine operation to obtain 2-GeV beams [5]. Signals from beam current monitors and beam loss monitors will be displayed in the main control window later this year. The timing system will be incorporated to the main control system after completing optical communication circuits.

5. Acknowledgments

We are grateful to thank to J. H. Kim, S.C. Kim, J. M. Kim, and G. S. Lee for their valuable efforts in developing the linac control system. Most of all, we would like to dedicate this achievement to late Dr. Hogil Kim, who established the PLS project.

6. 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 and W. Namkung, "Signal List for 2-GeV Linac Control," MA/LN-93001, Pohang Accelerator Laboratory, 1993.

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

[4]. J. Jang, "Electron Beam Envelope Simulation and Comparison with Experiment in PLS Linac," Master Thesis, POSTECH, 1994.

[5]. W. Namkung, "PLS 2-GeV Linac," these proceedings.