PLS Linac Instrument and Control System*

C. Ryu, S.S. Chang, J.H. Kim, M.S. Kim, D.K. Liu†, S. Won, W. Namkung
Pohang Accelerator Laboratory/POSTECH
Pohang, Korea 790-600

Abstract

A plan for the instrument and control system of the PLS (Pohang Light Source) 2 GeV linear accelerator is described. Major beam diagnostic instruments consist of 2 *ns* beam current monitors, beam profile monitors, and beam loss monitors. The control system will adopt the VME bus. For the timing system, the basic timing pulses will be obtained from the storage ring's RF master oscillator and distributed to the gun pulser and klystrons through the time delay electronic modules.

1. Introduction

The PLS 2 GeV linac is a full energy injector for the PLS storage ring. This injector linac consists of a gun, 42 accelerating column, and 11 klystrons, with 10 energy doublers. The total length is about 150 m. In this PLS linac, electron beam will be accelerated to 2 GeV with the beam current of 200 mA in normal operation and of 500 mA in maximum. Beam pulse length will be 2 ns with the repetition rate of 10 Hz for the injection. The initial purpose of the PLS linac is to provide the storage ring with a 2 GeV electron beam. Later on, however, the linac will be used for other physics experiments, which will be carried out at facilities located at the beam analyzing stations.

Based on the above requirements, we plan to monitor the following beam characteristics as the essential physical quantities for the operation of the linac : beam current, beam position, beam emittance, beam profile, beam energy spread, beam bunch length, and beam loss location. For this purpose, we will employ the beam current monior, beam profile monitor, beam loss monitor, and beam bunch monitor.

For the control system, we plan to adopt a distributed control system based on VME bus. And for the timing system, we plan to take a scheme of distributing the timing pulse of the storage ring's R.F. master oscillator to the gun grid pulser and to high voltage modulators and klystrons.

*This project is suppoted by POSCO and MOST, KOREA.
†Permanent address : IHEP, Academia Sinica, PRC.

2. Beam Current Monitor

For accurate measurement of a 2 nanosecond short pulse beam current, 10 sets of beam current monitors(BCM) will be installed. These curresnt monitors are wall current type ones with cylindrical resistors surrounded by toroidal ferrite cores in metal shields. This type of monitor has a very fast response with excellent signal to noise ratio. Seven of them will be on the linac and three will be in the beam analyzing stations. During the operation, BCM's will be the most effective monitors. The operator can optimize the beam intensity by adjusting the RF phases, the quadrupole triplets, and the steering magnets based on the readings of these monitors. Fig.1 shows the schematic layout of the beam current monitors as well as other beam diagnostic instruments.

3. Beam Profile Monitor

In the commissioning period and in later operation, direct observation of the beam spot size and position is expected to provide very useful information. For this purpose, beam profile monitors using a fluorescent target are used. These monitors can be used to measure the beam energy, energy spread and emittance. Utilizing recent advances in image processing technology, video signals taken by a camera will be digitally processed. Digitally processed beam information will be much more accurate and useful than that observed by eye on a TV monitor. There will be a total of 9 profile monitors in the PLS 2 GeV linac. Three of them will be located on the linac, three of them will be in the transport line to measure the beam emittance, and three will be in the beam analyzing stations.

4. Beam Loss Monitor

The beam loss monitor is a long ion chamber which will be installed along the 2 GeV linac. It is a coaxial cable with a length of 6-8 m. When the electron beam hits the accelerating column, radiation will be emitted. The strength of the signal from the ion chamber is proportional

0-7803-0135-8/91$01.00 ©IEEE

The considerations applied to this architecture are as follows:

- PLS linac control system can get greater benefits when it utilizes off-the-shelf items and already existing software. VME modules are getting very popular in the Factory Automation market. For this reason, they are adopted as control modules for the stroage ring. Using the common modules between the ring and the linac will reduce the overall development cost, and, later, maintenance efforts.

- As VME becomes more popular on the commercial market, more third vendors will produce compatible items, forming a more powerful development environment.

Based on the VME system, the architecture of the 2 GeV linac control system is configured as shown in Fig. 2.

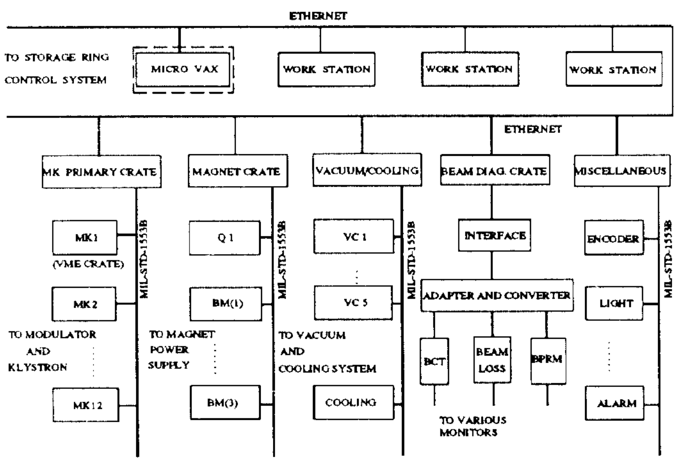

Fig.2 Control Architecture of 2 GeV Linac.

9. Timing system

A basic requirement of the timing system is that beams should fill up a single RF bucket of the storage ring in any pattern. For this purpose, the linac beam pulse needs to be synchronized with the storage ring's 500 MHz RF frequency. Thus timing signals are taken from the storage ring's RF master oscillator. The time interval between the RF buckets is 2 *ns*, and this 2 *ns* will be used as a basic time unit in the linac timing system. Thus, these precise 2 *ns* pulses synchronous with the ring RF oscillation will be distributed to the gun, klystron and other devices on a pulse to pulse basis at up to 60 *Hz*.

Functions of the timing system will consist of pretriggering, acceleration and standby modes of operations.

For the triggering of klystrons, timing signals are generated by time delay modules. These triggers are sent to the MK and delayed by a programmable counter.

A schematic diagram of the timing system is shown in Fig. 3.

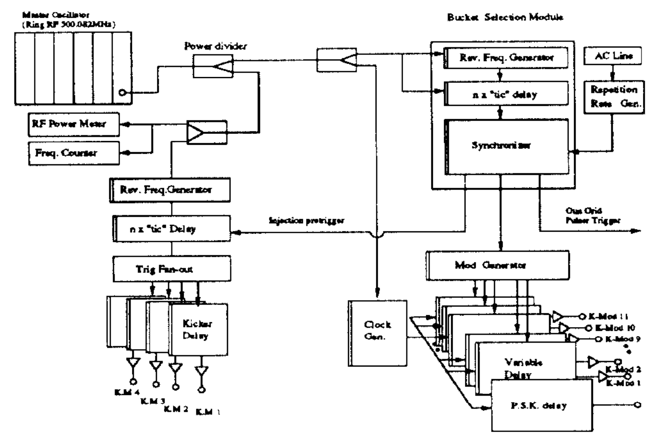

Fig.3 Schematic Diagram of the Timing System

References

[1] PLS Project, "Pohang Light Source Conceptual Design Report," POSTECH, 1990.

[2] R. B. Neal eds., "Stanford two mile accelerator," Benjamin, 1967.

[3] P. M. Lapostolle and A. L. Septier, eds. "Linear Accelerator," North Holland Amsterdam, 1970.

[4] E. Plouviez, "The automatic phasing system for the LEP Injector Linacs (LIL)," LAL/RT/84/03, April, 1984.

[5] BEPC, "Summary of the preliminary design of Beijing 2.2/2.8 GeV electron positron collider," BEPC design group, Dec., 1982.

[6] G. Stange, IEEE Trans. on Nucl. Sci., Vol. NS-26, No.3, June, 1979.

[7] M. C. Ross, "Beam diagnostics and control for SLC," 1987, PAC.

[8] T. Urano and K. Nakahara, "Trigger control system of the PF linac," NIM, A247, 226, 1986.

to the radiation. From this information, it is possible to identify the place where the beam is lost.

5. Bunch monitor

The bunch monitor consists of two RF cavities, one resonant at 2856 MHz and the other one at 14280 MHz. It is mounted on the beam line 10 m down from the gun. When a beam pulse passes through the bunch monitor, the monitor picks up signals whose frequencies are resonant with the cavities. The difference in power output between the two detected signals is

$$P_m = \frac{1}{2} R_m I_0 (1 - \frac{1}{2} m^2 \theta^2)$$

where $m = 5$ is a harmonic number, R is the shunt impedance of the cavity, I_0 is the fundamental component of the current, and θ is the phase width of the bunch stretch in radian. The smaller the θ is, the stronger is the output power P_m.

In principle, it is possible to use the bunch monitor to measure the absolute beam length, but there is some difficulty in reality. So the bunch monitor will be used as a qualitative measurement of the bunch length.

The cavities of the bunch monitor will have small apertures (9 mm in diameter), so it should be mounted on a special support to ensure that the beam passes through the cavities precisely.

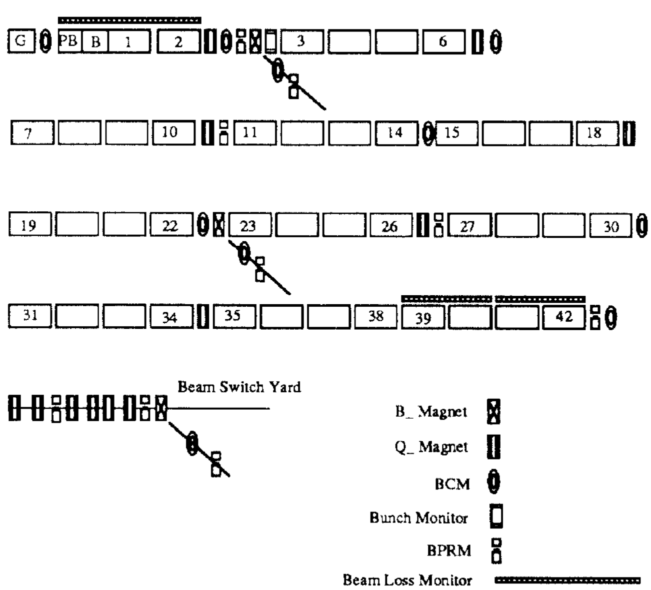

Fig.1 Beam Diagnostic Instrument Distribution in the Linac

For the same reason the bunch monitor will be located after the accelerating column number 6. At this position, the beam energy will be high enough to ensure the required small beam size.

6. Phase Amplitude Detector

The phase of the RF wave in the drive system will be measured for a comparison with the signal on the reference line. For this purpose, phase amplitude detectors(PAD) will be used. A PAD unit consists of a local phase shifter, nulling detector and amplitude monitor. The data obtained in the PAD unit will be sent to the MK control station and to the operator in the control room through a data link.

7. Modulator Klystron Support Unit

A klystron, modulator, and Energy Doubler(ED) cavities will be monitored and controlled by using a modulator klystron support unit(MKSU). The monitoring and control values taken care by an MKSU are; the amplitude and phase of the RF drive to the klystron, the ED cavity tuner position, current supply to the klystron electromagnets, the trigger pulse to the modulator, and status and fault information. The MKSU also provides hardware and software interlocks for the modulator and klystron.

8. Control System Architecture

The design philosophy of the PLS linac control system is to fulfil the requirements of linac by utilizing recent achievments in computer technology with minimum cost. Due to the rapid progress in VLSI technology, powerful intelligent controllers are readily available these days, and it has become possible to construct a powerful distributed control system at a reasonable cost.

In the PLS linac control system, a combination of front end intelligence controllers based on VME single board computers, microcomputers, and minicomputers are planned. A minicomputer (VAX 3100 size) will be used as a data acquisition computer and as a host computer. 32 bit workstations will be used as consoles and development stations. Thus, the system structure consists of computers, workstations, various intelligent controllers, networks and dedicated interfaces.

Between the linac and the storage ring control system, and between the linac host computer and the primary local VME intelligent crates, the Ethernet network standard (IEEE802.3) will be used. Between the primary VME crates and the secondary VME crates, MIL-STD-1553B will be used. The secondary VME crates will directly control the instruments, and their primitive database will be maintained in the primary VME crates.