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PROGRESS OF PLS 2-GeV LINAC*

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Abstract

Pohang Accelerator Laboratory (PAL) is constructing the 2-GeV Pohang Light Source (PLS). The 2-GeV electron linear accelerator will be used as a full energy injector to the storage ring. There are 42 accelerating columns in the 150-m long linac. The linac is powered by 11 klystrons of 80-MW maximum output power, which are driven by 200-MW modulators. Two 200-MW modulators connected to the klystrons are already under normal operation, and assembly work for the nine remaining modulators is in progress. In the tunnel, about half of the linac has been installed. The cooling system is completed along with the precision temperature controllers. The installation work will be completed by the end of 1993. We present the updated construction progress of the PLS 2-GeV linac.

I. INTRODUCTION

The PLS 2-GeV linear accelerator is a full energy injector to the storage ring (SR) which will serve as a low-emittance light source for various research: basic science, applied science, and industrial and medical applications [1]. There will be 11 klystrons and modulators, and 10 SLAC-type pulse compressors in the linac gallery. In the linac tunnel, which is 6-m below the gallery floor, there will be 42 accelerating columns, 6 quadrupole triplets, and various components to form the 150-m long linac.

The approximately 215-m long linac building is completed. The installation work started on July 1, 1992 is progressing smoothly. As of May 1, 1993, up to K6 module in the tunnel has been completed. This location is about 80-m from the e-gun. There are 22 accelerating columns and four quadrupole triplets up to this place. The completion of the installation is expected by the end of 1993. The commissioning of the 2-GeV linac will be carried out during the first half of 1994.

II. TECHNICAL DESCRIPTION

A. General Description

The nominal beam energy of the PLS linac is 2-GeV and the operating frequency is 2,856 MHz. The maximum repetition rate of the linac is 60 Hz. However, this repetition rate will be reduced to 10 Hz when the linac serves as an injector to the storage ring due to limitation on the SR injection system. The higher repetition rate will be useful for the testing of the machine or other purposes in the future.

The normalized emittance for the electron beam of the linac is 0.015 π MeV/c cm rad. It corresponds to 7.5 x 10^{-8} π m rad at 2 GeV. The energy spread of the electron beam is ±0.6% at FWHM. Major parameters are summarized in Table 1.

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B. Preinjector

The PLS 2-GeV linac is considered to consist of two parts: the preinjector and the main linac. The preinjector is the first 60 MeV section of the whole linac. It consists of a triode type e-gun, an S-band prebuncher and buncher, two accelerating columns, and various components. It is powered by a 25-MW klystron.

The preinjector was completed on February 28, 1992. At that time, 61.2 MeV electron beam was achieved [2]. Since then, it is being used to train PLS personnel.

Table 1: Major parameters of PLS 2-GeV linac.

Beam Energy	2 GeV
Accelerating Gradient	15.5 MV/m (min.)
Energy Spread	< 0.6 %
Machine Length	150 m
RF Frequency	2,856 MHz
Repetition Rate	60 Hz max.
E-gun	> 2 A, 2 nsec
Emittance	0.015 π MeV/c cm rad
Klystron Output Power	80 MW max.
Number of Klystrons	11 (=1+10)
Number of Pulse Compressor	10
Number of Accelerating Column	42
Number of Quadrupole Triplet	6
Number of Support & Girder	22
Beam Exit	at 80 MeV, 1 GeV, 2 GeV

C. Main Linac

The electron beams from the preinjector are accelerated to 2-GeV by 10 high-power klystrons and 10 SLAC-type pulse compressors [3]. Each klystron provides 80 MW maximum output power, and feeds RF power to four accelerating columns. Ten pulse compressors are employed to obtain a higher accelerating gradient. The accelerating gradient exceeds 15.5 MeV/m. To obtain the 2-GeV beam, the klystron output power is about 64 MW and the energy gain factor of the pulse compressor is 1.5. In this way, we can avoid operating the klystron at its maximum power level, and can, therefore, extend the lifetime of the klystron.

There are 40 accelerating columns in the main linac. The 3.072-m long accelerating column has a SLAC-type constant gradient structure with $2\pi/3$ operating mode. Its distinctive feature is the conflat flanges for easy installation. There are six quadrupole triplets altogether in the 2-GeV linac. These will be sufficient to focus and guide the electron beam even in event of a power failure in any one of the klystron, with the exception of the preinjector klystron, which provides the driving power to the rest of the klystrons.

III. INSTALLATION STATUS

A. Klystron and Modulator

The high power klystron used in the PLS linac is Toshiba's E3712 model [4]. The first two units were already delivered in June 1992 and installed in the klystron gallery as K2 and K3, respectively. The K4 klystron was delivered in March this year, and is now undergoing power testing in the klystron test lab which is annexed to the klystron gallery. The K5 unit is arrived at PLS in April 1993 and is waiting to be tested. Six more klystrons are being manufactured in Toshiba's Nasu factory, Japan, and all of them will be shipped to Pohang by this summer. A SLAC 5045 klystron was also delivered to PLS in September, 1992. This unit will be used as a reference klystron.

The matching modulator of 200-MW rated power is being manufactured in-house [5]. A prototype of the 150-MW modulator was completed in February, 1992. This unit now serves as a klystron test unit in the test lab. In the klystron gallery, ten modulator cabinets are placed in their final positions. The size of this modulator cabinet is 3.2 m (L) x 1.5 m (W) x 2.7 m (H). Two units are completed, and are under normal operation with matching klystrons. Most of heavy components such as transformers, choke coils, capacitors are already assembled in the remaining modulators. Subsystems such as thyratron assembly, SCR circuit, diode and transistor banks are being installed. Assembly work for remaining 8 modulators in the gallery will be finished by this summer.

The klystron and modulator for the preinjector will be replaced later this year with a higher power unit in order to drive 10 klystrons in the downstream.

B. Tunnel Components

Out of 44 accelerating columns ordered from the Institute of High Energy Physics (IHEP) in Beijing, China, 36 columns have been shipped to Korea. Eight sets of girders and supports have also arrived. Besides the preinjector, twenty accelerating columns have been already installed as of May 1, 1993, along with two beam current monitors, one beam profile monitor, and three quadrupole triplets. Therefore, approximately 80-m of the linac is completed. All waveguide components were delivered from IHEP. By using a standard girder with two accelerating columns on it, the whole waveguide network will be installed well before the accelerating column installation, which will save time and effort during the installation. All the centerline components will be installed by November this year.

C. Cooling System

The main cooling system was completed in April this year. This includes piping work, pump station, cooling towers, low conductivity water generation, and precision temperature control system. The PC-based temperature control system is under normal operation. The temperature of 45 ± 0.2°C is routinely achieved. The quartz crystal oscillator is used as a temperature sensor. The preinjector cooling is also connected to a new cooling system.

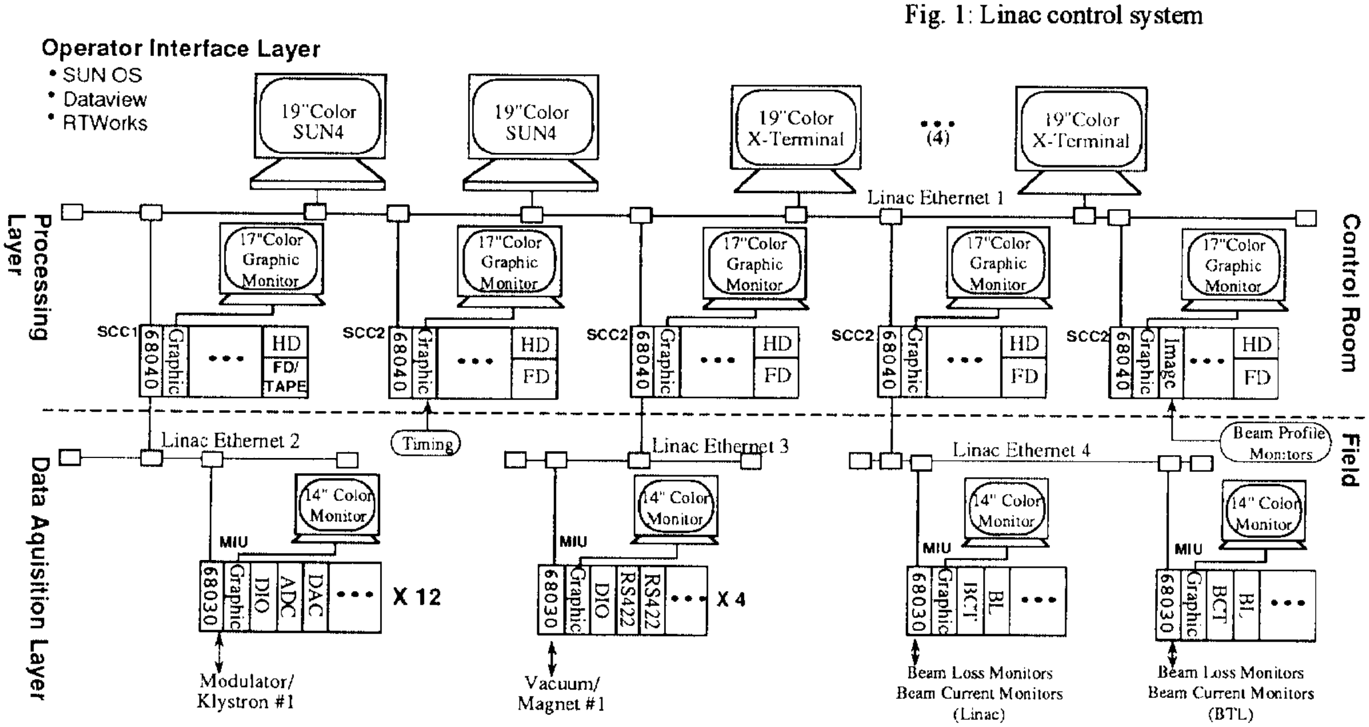
D. Microwave System

In order to drive 10 klystrons, the drive line is being installed from the first klystron. Two IPA (Isolator, Phase shifter, Attenuator) units are under test. The IPA unit will provide suitable input RF power and correct RF phase to the klystrons. The first pulse compressor was delivered and the cold test was completed. The result shows that the energy gain factor is 1.68. This unit can be detunable.

E. Control System

We made significant changes in the linac control system even though the basic structure is still VME based system. There are three layers in the control hierarchy as shown in Fig. 1. Three

Fig. 1: Linac control system



layers are connected with several Ethernets. Replacing a MIL-STD-1553B network by Ethernet is one of major changes.

The operator interface layer is composed of two SUN sparcstations and four X-terminals. Several graphic windows will be provided for the operators. In order to optimize the graphics and data acquisition in this layer, commercial S/W packages such as RTworks™ and Dataview™ are being used.

The data processing layer and the data acquisition layer are both VME based systems. The operating system is OS-9. The difference between the data processing layer and the data acquisition one is based on their functions. All CPU boards and many of I/O boards are commercial products.

The data acquisition layer is directly connected to the individual devices to be controlled or monitored. There are 11 units for the modulator control, and 3 units for the magnet power supply (MPS) control. One unit is assigned to control the pneumatic gate valves and several vacuum monitors. One unit is also dedicated to the beam current monitors and the beam loss monitors. Every CPU board in this layer is equipped with a 14" color graphic monitors, a keyboard, and a mouse. On-demand local computer control is available to all CPUs in this layer. This feature is extremely useful for local commissioning of an individual device, especially 200-MW modulators. All CPUs are located in the klystron gallery.

The data processing layer is divided into four different functions: modulator/klystron, MPS/vacuum, beam monitoring, and timing system. The run-time data collected by the data acquisition layer are stored in a RAM memory area temporarily and, later, in a hard disk permanently. This Motorola 68040 based CPU board has two independent Ethernet ports: one for data acquisition and one for operator interface layer. A 19" color monitor is attached to individual CPU board in this layer. All CPUs are located in the linac control room.

One special CPU is assigned to beam profile monitors which produce large image data. The beam profile image captured by a CCD camera is directly sent to this CPU board. After the image processing is completed, numeric data such as beam sizes are sent to the operator console through the Ethernet instead of image data itself. The isolation of image data can reduce the data traffic in the Ethernet significantly.

For fast signals such as modulator beam voltage, RF signals from pulse compressors, we will use digital sampling oscilloscopes connected to the CPU board via a GPIB port. Using oscilloscopes, we can reduce a lot of cumbersome hardware and software development works in handling fast signals.

The signal conditioning units will be used to isolate noises from the modulator. Isolation transformers and noise filters will also be used at the AC input terminal for all control cabinets.

F. Commissioning

The preinjector commissioning was completed by February, 1992. Last December, a combined system test for the preinjector and K2 module was performed. The main purpose of this test was the commissioning of first 200-MW modulator with matching 80-MW klystron. In this test, a 200-MeV beam was obtained. Even though many subsystems were operated by manual control, it showed that there were no significant flaws in the system integration for the 2-GeV linac.

IV. CONVENTIONAL FACILITIES

A. Linac Building

The linac building was completed in April this year. The machine tunnel includes three beam switch yards and beam dumps. The beam transport line (BTL) tunnel is also completed except the injection area in the storage ring. In the second floor, thirteen air handling units (AHUs) are installed. These units can be controlled remotely in the linac control room.

B. Cooling Station

The linac cooling station is located near 1-GeV beam switch yard. It includes the AHU pump system and the machine cooling system. All systems are completed and are under normal operation. The parameters for the precision temperature control system and normal cooling system are summarized in Table 2.

Table 2: Design parameters for linac cooling system

Description	Precision System	Normal System
Heat Load (max.)	250 kW	710 kW
Flow Rate	960 gpm	320 gpm
Pressure Drop	72 psi	93 psi
Temperature	45 ± 0.2 °C	35 °C
Conductivity	0.2~0.5 μS/cm	0.2~0.5 μS/cm
Cooling Tower	50 RT	220 RT

C. Linac Substation

The linac substation is located between the linac and the storage ring. Several transformers and switch gears are located in this building. Power lines for modulators and computers are separated in this station in order to avoid unnecessary interference. On November 30, 1992, the 154-kV main power station was completed. This power line is directly connected to the national power grid.

V. ACKNOWLEDGMENTS

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