THE STATUS OF PLS LINAC*

W. Namkung, I. Ko, M. Cho, J. Bak, C. Ryu, S. Won, and B. Kim
Pohang Accelerator Laboratory, POSTECH
P. O. Box 125, Pohang, Korea 790-600

Abstract

Pohang Accelerator Laboratory (PAL) constructs the 2-GeV Pohang Light Source (PLS). A 2-GeV electron linear accelerator is used as the full energy injector to the storage ring. The 150-m long linac consists of 42 accelerating columns. The 3.07-m long accelerating column is a $2\pi/3$ mode, constant gradient structure with conflat flanges. The linac is powered by 11 klystrons of 80-MW maximum output-power, which are driven by 200-MW modulators. A prototype of the modulator is manufactured and tested. There are also 10 pulse compressors to increase the accelerating gradient. The first 60 MeV module is now under normal operation. Installation of the rest of the linac starts from July 1, 1992. We present the updated design parameters and the construction status of the PLS 2-GeV linear accelerator.

1 INTRODUCTION

The PLS 2-GeV linear accelerator is a full-energy injector to the storage ring which will be served as a light source of various researches [1]. The 150-m long linac consists of 11 klystrons and modulators, 42 accelerating columns, 10 SLAC-type pulse compressors, and various components. It is placed at the underground tunnel located 6 meters below the klystron gallery floor.

About 200-m long linac tunnel and beam switch yards including beam dumps are completed. The structure and outside panel of the gallery building is also completed. The first section of 2-GeV linac, called the preinjector, has been completed, and it is under normal operation [2].

The installation of main linac is already started from July 1, 1992 and its completion is expected by the end of 1993. The commissioning of 2-GeV linac will be carried out during the first half of 1994.

2 BEAM TRANSPORT

The nominal beam energy of the linac is 2 GeV and the operating frequency is 2,856 MHz. The maximum repetition rate of the linac is 60 Hz. However, when the linac is served as an injector of the storage ring, the repetition rate will be 10 Hz due to the limitation on the injection system of the storage ring. The higher repetition rate will be useful for the machine test 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 7.5×10^{-8} π m rad at 2 GeV. The energy spread of the electron beam is $\pm 0.6\%$ at FWHM. Major parameters are summarized in Table 1.

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

Beam Energy	2 GeV
Energy Spread	0.6 %
Machine Length	150 m
RF Frequency	2,856 MHz
Max. Repetition Rate	60 Hz
E-gun Current	> 2 A
E-gun Pulse	2 ns
Emittance	0.015 π MeV/c·cm rad
Klystron Output Power	80 MW max.
Number of Klystron	11 (=1+10)
Number of Pulse Compressor	10
Number of Accel. Column	42
Length of Accel. Column	3.072 m
Number of Quad. Triplet	6
Number of Support & Girder	22

As a consequence of the project, the PLS 2-GeV linac is separated to 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, S-band prebuncher and buncher, two accelerating columns, and various components.

The 60 MeV electron beam from the preinjector is accelerated to 2 GeV by 10 high-power klystrons and 10 pulse compressors. The klystron provides 80 MW maximum output power, and each klystron feeds four accelerating columns. Ten pulse compressors are employed to obtain higher accelerating gradient. When the klystron power is 64 MW and the energy gain factor of the pulse compressor is 1.5, the achievable beam energy is more than 2 GeV.

The 3.07-m long accelerating column is the SLAC-type constant gradient structure and the operating mode is $2\pi/3$. The filling time is 0.83 μs. A maximum cumulative phase excursion of 2.5° will be allowed for each accelerating column.

In order to have higher beam break-up threshold, some accelerating columns have four supplementary holes with 9 mm (S9 type) or 11 mm (S11 type) diameter around the center aperture of the disk. Only the cavities from

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

no. 2 to no. 6 have such holes. Out of total 42 accelerating columns, there are twelve S9 type columns, another twelve S11 type columns, and 16 plain (or S0 type) ones. Besides the first two columns as a part of the preinjector, these columns are repeatedly arranged in such a way that four S0s are followed by four S9 and four S11s. This arrangement will help to reduce the resonant condition of the HEM_{11} mode in the region where this mode has a phase velocity equal to light velocity.

There are six quadrupole triplets in the linac to focus and guide the electron beam. Four of them including QT1 in the preinjector have 44-mm aperture. The two quadruple triplets located at the high energy end is required strong field gradient, so these triplets have an aperture of 32 mm. The effective length of quadrupoles are 10 cm for the outer magnets and 20 cm for the center one.

There are three bending magnets at 60 MeV, 1 GeV, and 2 GeV location, respectively. These magnets are designed to analyze beam properties such as beam energy, momentum spread, and emittance. There are three beam exit ports besides the beam transport line to the storage ring. No. 1 port is located at the first beam switch yard (BAS1) just after the preinjector, and provides the 60 MeV beam. It also provides a space to accommodate the positron beam generation which is a future option. The BAS2 provides the 1 GeV beam which will be useful for a compact storage ring. Third BAS is located at the end of the 2 GeV linac. A high energy electron beam will have ample applications in the future.

3 TECHNICAL DESCRIPTION

3.1 Klystron and Modulator

The 80-MW maximum output klystron required to make 2 GeV beam will be Toshiba E3712 model. Its specification is summarized in Table 2. The first two units are already delivered to PLS after completing factory acceptance tests in May and June, 1992. A SLAC 5045 klystron will also be delivered to PLS in Summer 1992. This unit will be used as a reference klystron.

Table 2: Specifications of the klystron.

Output Power	80 MW
Pulse Width	4.4 μs
Repetition Rate	60 Hz (max.)
Gain	52 – 53 dB
Maximum Drive Power	500 W
Beam Voltage	400 kV
Beam Current	500 A
Perveance	2 $\mu Perv$
Maximum Magnetic Field	1.2 kG

The matching modulator of 200-MW rated power are being manufactured in-house. A prototype of the 150 MW modulator is assembled and the preliminary test is completed on February 28, 1992 [3]. The test shows satisfactory performances up to 110 MW with a water load and many temporary components. Full power operation of this prototype modulator will be performed after installing the SLAC 5045 klystron. In the mean time, various modifications of circuits and the cabinet for 200-MW modulator are undertaking. The specification of the 200-MW modulator is shown in Table 3.

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

Table 3: Specification of the modulator.

Peak Power	200 MW
Output Pulse Voltage	23.3 kV
Pulse Transformer Ratio	1:17
Repetition Rate	60 Hz (max.)
Pulse Length	4.4 μs
Pulse Risetime	0.8 – 1.0 μs
Pulse Falltime	1.5 – 2.0 μs
Pulse Height Deviation	$\pm$0.5 %
PFN Impedance	2.8 Ω
Thyratron Current	9.5 kA
Anode Voltage	47 kV

3.2 Centerline Components

A total of 44 accelerating columns are already ordered to the Institute of High Energy Physics (IHEP), Beijing, China. The first 12 units (all S0 type) are delivered at PLS in June, 1992. After the straightness check and prealignment, the columns are ready to be installed.

Two quadrupole triplets will be available along with various waveguide and cooling components in August, 1992. The steering coils are being manufactured in house. The girders are made with extruded aluminum tubes which are about 7-m long. Four sets of girders and supporters are ready to be installed. These will hold eight accelerating columns in this year.

All required vacuum components are either ready to be used or under procurement. Twelve high power loads are under vacuum conditioning prior to be installed.

3.3 Cooling System

The cooling system for the preinjector is completed and the PC- based cooling control system is under normal operation. The temperature of 45 $\pm$ 0.2°C is routinely achieved. The quartz crystal oscillator is used as a temperature sensor.

As a part of the installation started from July 1, 1992, the cooling pipe installation inside the tunnel is completed on July 23, 1992. The total length is about 600 m.

3.4 Alignment System

The linac alignment is based on a laser alignment system. This system is adopted for better alignment accuracy and systematic checking for the periodic realignment of the linac.

The Fresnel zone plates (FZP) are used for the laser alignment system. One FZP mounted on an actuator is placed at the upstream end of each girder pipe. The laser source is located at the downstream of the linac and the image processing device is placed behind the e-gun. The focal length of each FZP is determined by the location of the target. The girder pipe is evacuated to 10^{-2} Torr to minimize the environmental effects such as air refraction.

The prototype of FZP with a focal length of 7.23 m is fabricated by photoetching method. The FZP material is Sandvik 38 and the frame is SUS 304. The thickness of the FZP is 38 μ and the minimum opening is 80 μ. The prototype of the FZP actuator is also fabricated and the durability test is finished.

3.5 Control System

The PLS control system adopts the VME system on SUN Sparcstations. This system will provide a highly distributed control system for the linac and the storage ring.

The computer control system of the preinjector is, however, based on an Intel 310 computer and BITBUS network. Along with two IBM PC compatibles as the man-machine interface, the preinjector control system is in normal operation. The modification of this Intel system to the VME system is being taken place.

3.6 Magnet Power Supply

All 29 magnet power supplies in the preinjector are now remote-controllable via either original Intel control system or RS422 communication channel by IBM PC or SUN control system. This is achieved by developing a RS422 controller and slight modification of output ports in the power supply. Each controller can handle up to four power supplies. This unit will be used to control the rest of magnets in the linac and the beam transport line (BTL).

3.7 Preinjector

The preinjector is powered by a 25 MW klystron. Its installation has been started on July 27, 1991, and the first commissioning is completed on December 7, 1991 when the 61.2 MeV electron beam is obtained. The preinjector is under normal operation after the completion of the second commissioning, which is emphasized on computer control system, on February 28, 1992. The preinjector is also used to train PLS personnel for their experiences on machine operation.

The preinjector program is one of the institutional collaboration programs between Pohang Accelerator Laboratory, Korea and the Institute of High Energy Physics (IHEP), Beijing, China.

4 CONVENTIONAL FACILITY

4.1 Linac Building

Since the ground breaking ceremony which was held on April 1, 1991, a lot of progress is made in the construction of the linac building. About 200-m long tunnel structure and the beam switch yards, which is located 6-m below the ground level, are completed. About 40 m long horizontal section of the BTL tunnel is completed and finishing work is undergoing. The vertical section of the BTL tunnel will be constructed as a part of the storage ring building.

Whole steel structure and outer panel of the gallery building are also completed. First half of the gallery is ready to accommodate more modulator cabinets. The air handling units located on the second floor are being installed. The whole linac building will be completed by Spring next year.

4.2 Cooling Station

The linac cooling station is located just outside the linac building near the 1 GeV outlet. The ground work of the station building is completed, and the pumps and other equipment are being installed. This station will be completed by October 1992. The cooling station will be operated by computer control system at the end of this year.

4.3 Linac Substation

The linac substation is located between the linac and the storage ring building. Its foundation is completed and the electricity will be available at the end of this year. The 154 kV main power station will be ready by November, 1992.

5 REFERENCES

[1] PLS Project, Design Report (Revised Edition) of Pohang Light Source, Pohang Accelerator Laboratory, Pohang, Korea, 1992.

[2] W. Namkung et al., "Installation and Commissioning of PLS preinjector Linac", paper submitted to EPAC92 conference.

[3] S. Nam et al., "Prototype Pulse Modulator for High-Power Klystron in PLS Linac", paper submitted to 20th Power Modulator Symposium, June 23-25, 1992.