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Construction of 100 MeV Electron Linac in Kyoto University

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Abstract

An electron linear accelerator and a compact storage ring have been constructed at Kyoto University. The beam energy of the storage ring is 300 MeV and will be utilized as a synchrotron radiation source. The output beam energy of the linac is 100 MeV and the designed beam current is 100 mA at the pulse width of 1 μsec. The construction of the linac had been finished and the test is under going. The electron beam of 300 mA is extracted from the electron gun and the peak RF power of 20 MW is successfully fed to the accelerating structures at the pulse width of 2 μsec.

1. INTRODUCTION

A compact electron storage ring (Kaken Storage Ring, KSR) and the linear accelerator are now under construction at the Institute for Chemical Research, Kyoto University [1]. The layout of the accelerators is shown in Fig. 1. The KSR has a race track shape and the maximum beam energy is 300 MeV. It will be used as the synchrotron radiation source from the dipole magnet and the insertion device. The critical wave length of the synchrotron radiation is 17 nm. It will be also used for the research of the free electron laser.

The beam energy of the electron linear accelerator is 100 MeV. Table 1 shows the main beam parameters. For the linac constriction, some components of the JAERI linac were transported from the Japan Atomic Energy Research Institute (JAERI) to the Kyoto University [2]. The linac is used for the beam injection to the KSR and some beam experiments. The beam parameters are determined by the condition of the beam injection to the KSR and the restriction of the size of the building. Photo 1 shows the view

Table 1 Beam parameters of the linear accelerator.

Energy	100 MeV
Beam Current	100 mA
Pulse Width	1 μsec
Maximum Repetition	20 Hz

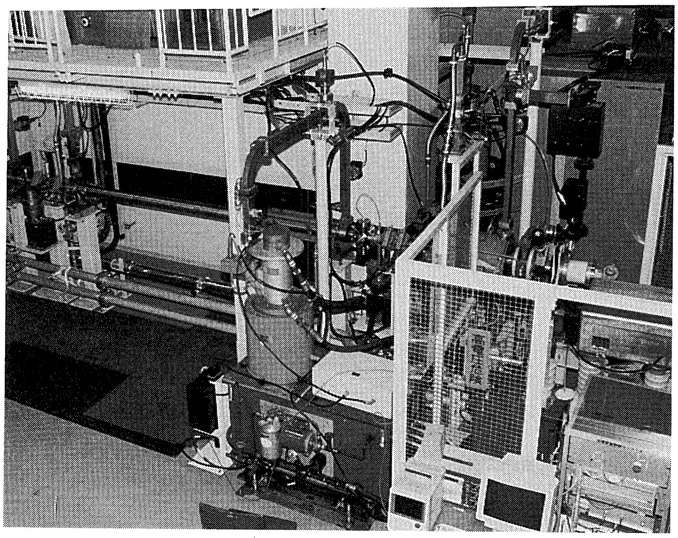

Photo 1 View of the front part of the accelerator. The electron gun, the buncher, and the first accelerating structure from the right to left.

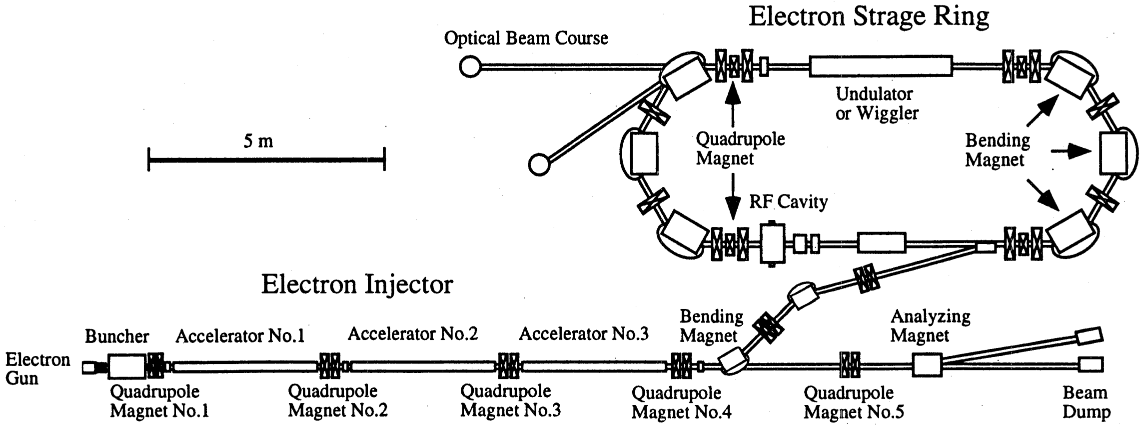

Figure 1. Layout of the electron linac and the KSR.

of the front part of the accelerator.

2. ACCELERATOR

The electron gun has the Pierce electrode and the cathode assembly is the Y-796 (Eimac). The maximum extraction voltage is -100 kV. The pulse width of the grid pulser is variable from 10 nsec to 1 µsec. The beam current of 300 mA has been achieved at the pulse width of 1 µsec.

The pre-buncher is a single reentrant cavity. It is designed to bunch the beam within the phase spread of 60 degree. The buncher is a disc-loaded and 3 step constant gradient structure. It has 21 cells and the total length is 777 mm. The designed phase spread is within 3 degree at the beam current of 100 mA when the input power is 12 MW.

There are three main accelerating structures. The main characteristics of the accelerating structure are listed in table 2. The maximum electric field is 45 MV per an accelerating structure without beam loading at the input power of 20 MW.

The doublet of the quadrupole magnets is used as a focusing element between the accelerating structures. The calculated beam radius along the beam axis is shown in Fig. 2. It is assumed that the normalized emittance is 100 π·mm·mrad. The calculated beam radius is kept within 6.5 mm along the beam axis. The steering coils are placed at the entrance of the first and the third accelerating structures.

3. RF SYSTEM

The block diagram of the RF system is shown in Fig. 3. The master RF oscillator is a synthesized signal generator (HP-8664A). The booster klystron (TH-2436, Thomson) has a gain of 40 dB and the output power is 10 kW. The pulse width is 3.5 µsec. The output power is divided by the 4-way RF divider and supplied to the four main klystrons. RF attenuators and phase shifters are inserted between them.

The main klystron is ITT-8568. The maximum output power is 21 MW. Figure 4 shows the input RF power of the buncher and the three accelerating structures. The peak RF power is 12 MW at the buncher and 20 MW at the accelerating structure. The RF frequency is 2857 MHz and the repetition is 7 Hz. The RF pulses are picked up by the directional couplers and detected by the RF diodes.

The modulator is composed of the high voltage power supply, the pulse forming network (PFN) and the pulse transformer. The stabilized power supply for the modulator is

Table 2 Main specification of the injector.

Electron Gun (Pierce type)	
Cathode Assembly	Y-796 (Eimac)
Extraction Voltage	-100 kV DC
Accelerating Structure	
Mode	2/3π, Const. Gradient
Number of Cell	85
Bore Radius	11.74 - 13.4 mm
Length	3 m
Operating Frequency	2857 MHz
Maximum Electric Field	15 MV/m at 20 MW
Klystron (ITT-8568)	
Cathode Voltage	250 kV, 250 A
Output RF Power	21 MW
Gain	53 dB

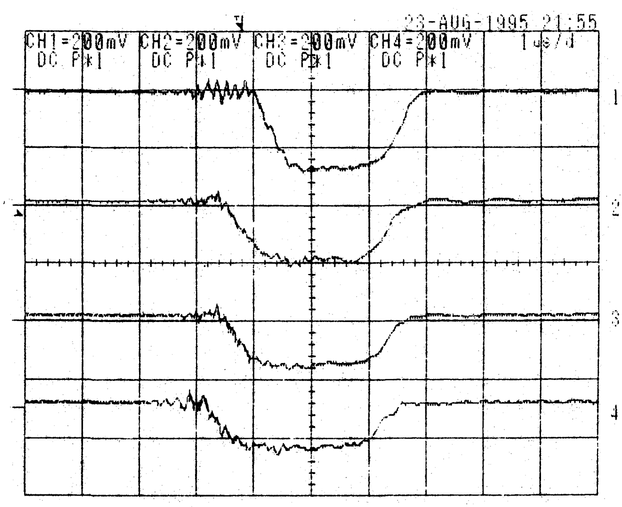

Figure 4 Input RF pulse to the buncher and the three accelerating structures. The peak power is 12 MW and 20 MW, respectively. The repetition is 7 Hz.

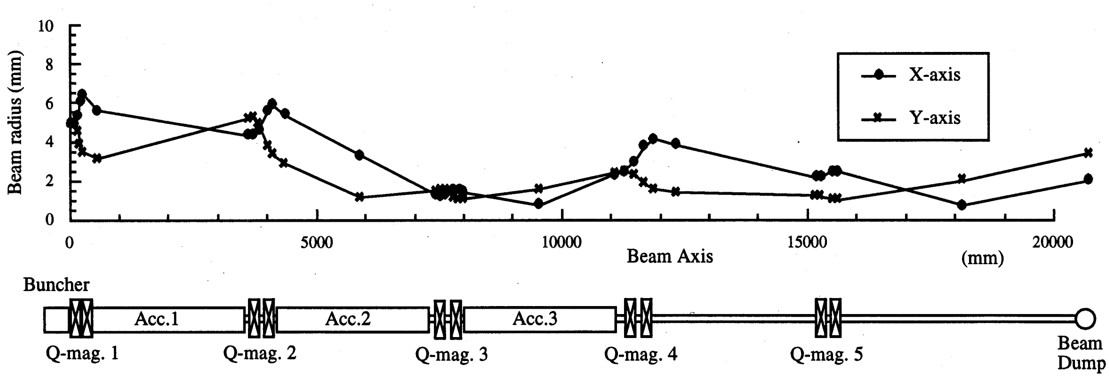

Figure 2 Calculated beam radius along the beam axis. The normalized emittance is assumed to be 100 π·mm·mrad.

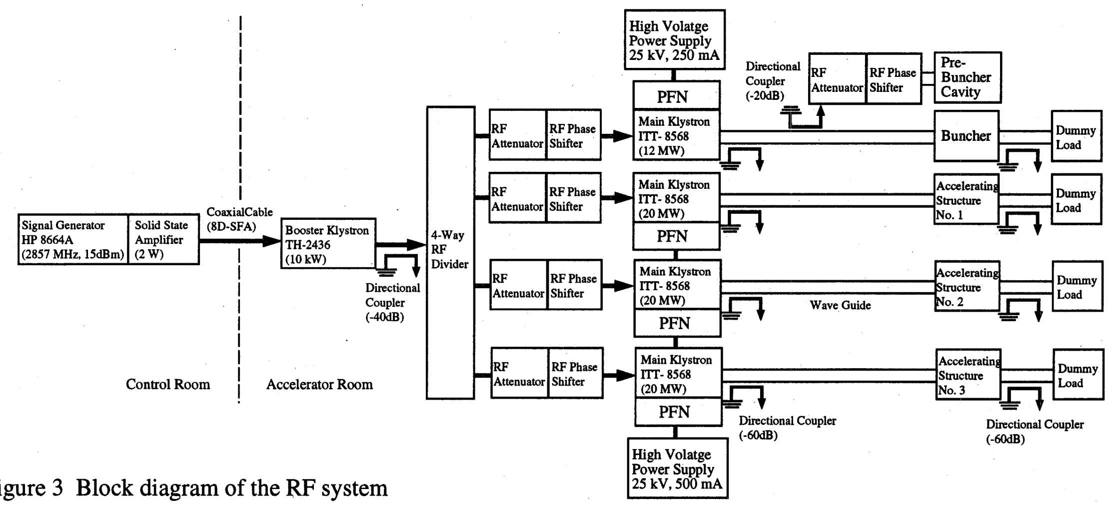

Figure 3 Block diagram of the RF system

adopted to keep the electron beam energy constant. The maximum voltage is 25 kV and the current is 500 mA. The voltage stability is less than 10^{-3}. It feeds the electric power to the three PFNs for the accelerators at the repetition of 20 Hz.

4. BEAM MONITOR

The current monitor is installed between the accelerating structures. The monitor is the ferrite core with the coil. The current sensitivity is 1 mV/mA.

The beam profile monitors will be installed at the close to the current monitors. The material of the beam screen is an alumina ceramic in which a little chromium oxide is homogeneously doped (Desmarquest, AF995R). The beam profile monitor is also used for the emittance measurements combined with the upstream quadrupole magnets

5. CONTROL SYSTEM

The block diagram of the device control system is shown in Fig. 5. The controller units have the GP-IB interface and connected by the optical fiber each other. The fiber cable isolates each devices and reduces the noise. The master controller is a personal computer IBM-PC/AT with ISA GP-IB card (AT-GPIB, National Instrument). The control software works on the Microsoft Windows system. A user can operate by the mouse or a touch panel.

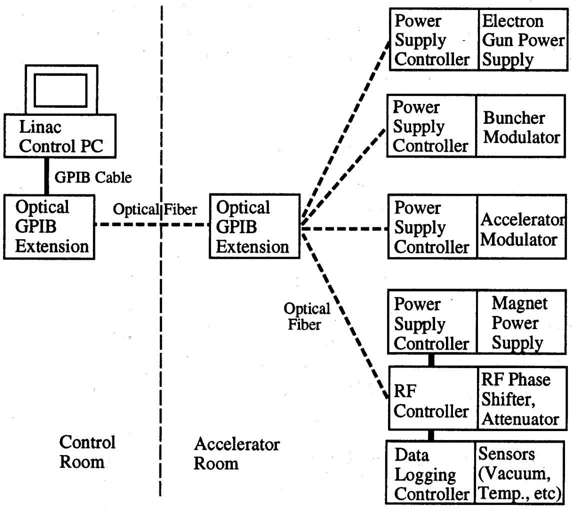

Figure 5 Block diagram of the control system.

6. SUMMARY

The construction of the 100 MeV electron linac had been finished and the tests of the main components such as the klystrons and the electron gun were carried out. We succeeded to feed the 20 MW into the accelerating structure at the repetition of 7 Hz. The conditioning work is now in progress. The beam acceleration test of 100 MeV is scheduled in autumn 1995.

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