THE LINAC FOR THE NATIONAL SYNCHROTRON LIGHT SOURCE*

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Summary

The nominally 100-MeV electron linear accelerator to be used as an injector for the booster synchrotron of the National Synchrotron Light Source is described. The machine utilizes a combination of Varian and SLAC accelerating guides[1,2] and is interfaced by means of a microprocessor-based Intel Multibus® system, to the Data General central control computer. Provision for emittance and momentum measurement is provided in the transport line between the linac and the booster synchrotron.

Introduction

The National Synchrotron Light Source, now under construction at Brookhaven National Laboratory, (Fig. 1) will consist of two electron storage rings to provide intense sources of synchrotron light in the vacuum-ultraviolet and soft x-ray wavelengths. The electrons will be injected from a linac at about 100 MeV into a slow-cycling booster ring for acceleration to 750 MeV. A 750-MeV storage ring will be used to generate light in the ultraviolet and visible regions between 10 Å and 10^4 Å. A larger storage ring will accelerate electrons from 750 MeV to about 2.5 GeV for generation of x-rays at wavelengths between 0.2 Å and 10 Å.

Both storage rings will require multiple cycles of linac or booster injection in order to accumulate sufficient stored beam current.

The linac system is shown in schematic form in Fig. 2. It consists of a pulsed 100 kv electron gun and 3 iris-loaded cavities operating at 2856 MHz. One klystron will power the first cavity at 12 megawatts and a second klystron will provide a total of 20 KW to cavities 2 and 3 via a power splitter. The linac parameters are shown in Table 1.

The electron gun, buncher section and first cavity were formerly used as an injector at the Cornell University 10-GeV electron synchrotron. Cavities 2 and 3 were used at EVA, Amsterdam and are of SLAC design. The klystron, modulator, and waveguide systems were from BNL rf beam separator systems. All of the original hardware was manufactured in the early 1960's.

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TABLE 1.

e^- LINEAR ACCELERATOR INJECTOR

Accelerator type	S band, 2π/3 mode
Frequency (at 39°C)	2855.7 MHz
Pulse repetition rate	1 pps
Number of accelerating sections	3
Rf power source	2 klystrons (21 MW/unit)
Nominal output beam parameters:	
Energy	100 MeV
Momentum spread, $\Delta p/p$	$\pm$ 0.2%
Emittance	2 x 10^{-5} m-rad
Design beam current	20 mA
Beam modulation frequency	52.88 MHz
Chopped beam modulation frequency	10.576 MHz

The assembly of the linac has been in two distinct phases:

(1) Assembly and testing of the original components.

(2) Redesign and modification of equipment for the new facility.

The cavities were installed in a temporary shielded enclosure and powered by existing circuitry to evaluate the major components and spares. This also allowed early testing of prototype beam diagnostic equipment. Figure 3 is a schematic showing the equipment layout in the test area.

The second phase is well underway and consists of the following:

(1) Repackaging the existing Varian gun/modulator into two separate units. The repackaged gun is shown in Fig. 4.

(2) Rebuilding the modulator portion (see Fig. 5) to reduce electromagnetic noise and provide stable pulsing at low repetition rates under the control of a microprocessor system.

(3) Building or rebuilding all focusing and correction magnet systems for solid-state digital control.

(4) Rf modulator rebuilding to eliminate many vacuum tube circuits and to reduce pulsing noise.

(5) Redesign of low level rf and timing distribution system.

(6) Development of beam diagnostic equipment.

(7) Development of hardware and software for automatic operation from a central computer using many small microprocessor systems

The linac will be operated at one pps with a 20-mA, 1 μsec pulse. Because the average power is very low and the interpulse period is long, all of the gun and rf modulator circuits will be modified to resistive charging. The linac beam will be modulated via beam deflector plates in the gun-to-linac transport system, at the single bunch revolution frequency of the booster synchrotron, (10.576 MHz), in order to improve the rf capture in the booster. The linac is only required to operate for short periods of time during injection and may be dormant for many hours at a time. This will place severe demands on the stability of the system in order to avoid a warm-up and adjustment period for each injection sequence.

Controls

A microprocessor control system using Intel Multibus® hardware performs all of the local control and monitor functions as well as closing several critical servo-loops. It also allows all machine parameters that affect the beam performance to be digitally stored at the local device and free the central computer from doing real-time corrections.

A separate microprocessor will be used for: each klystron system, the gun modulator, the vacuum system, timing, beam diagnostics, and magnet systems. Each is connected by a high-speed serial asynchronous link to the central computer system.[3]

Beam Diagnostics

Beam diagnostic equipment consists of devices for measuring beam current, position and energy. All three types of measurements are digitized and may be used to servo the beam to a given condition. This requires noise-free and drift-free monitors.

These measurements are carried out in the transport system between the linac and the booster synchrotron. This line may be divided into three separate functional regions. The first section serves to transport the beam to the first dipole bending magnet. It contains a quadrupole focusing triplet; secondary emission monitors are located in this line for emittance measurement. Next, there is a momentum recombining system which is comprised of two dipole bending magnets and a center quadrupole next to which is placed a movable and variable slit for momentum selection (at the point of maximum dispersion). Tape-wound toroidal current transformers before and after the slit monitor the fractional transmission through it. The third section of line contains 5 quadrupoles for matching the linac beam to the booster. A viewing screen is provided for a final visual check of the profile before injection into the booster. Electron beam current is measured between linac tanks and at various places along the transport system by tape-wound toroidal beam current transformers.

REFERENCES

1. J. Haimson, "Electron Bunching in Travelling Wave Linear Accelerators." Nucl. Inst. Methods, 39, No. 1-13, 1966.

2. R.B. Neal, editor, "The Stanford Two-Mile Accelerator." W.A. Benjamin, Inc., publishers, 1968.

3. K. Batchelor, B. Culwick, G. Goldstick, J. Sheehan and J. Smith, "Distributed Control System for the National Synchrotron Light Source." IEEE Trans. in Nucl. Sci., NS-26, No. 3, p.3387, June 1979.

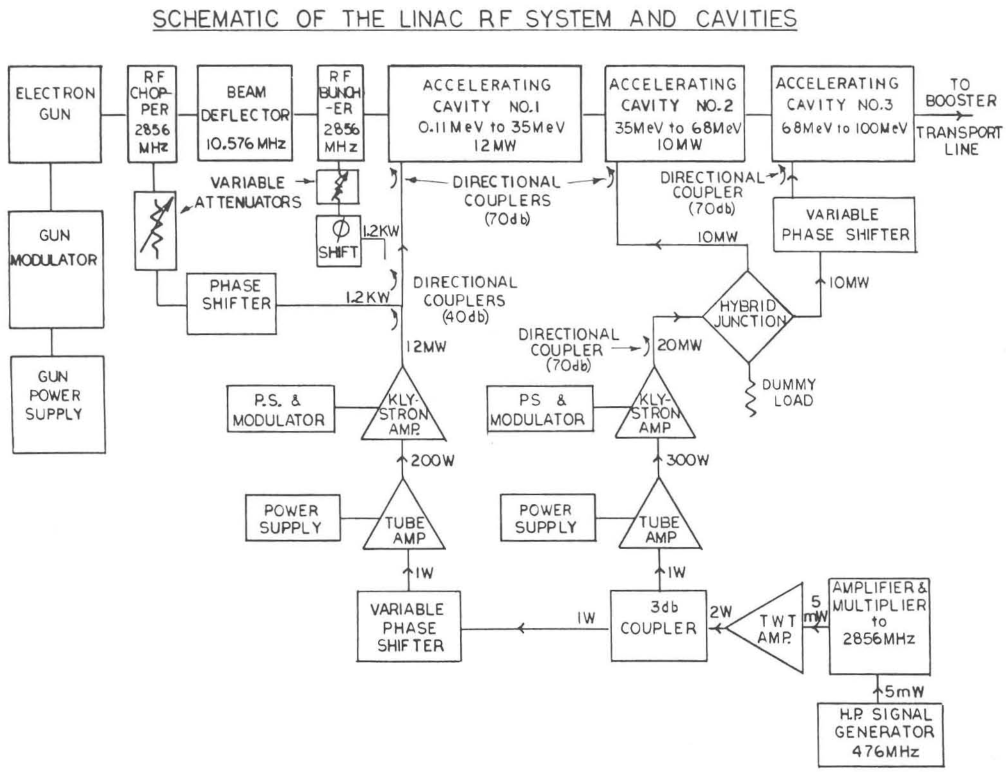

Fig. 1 National Synchrotron Light Source site layout

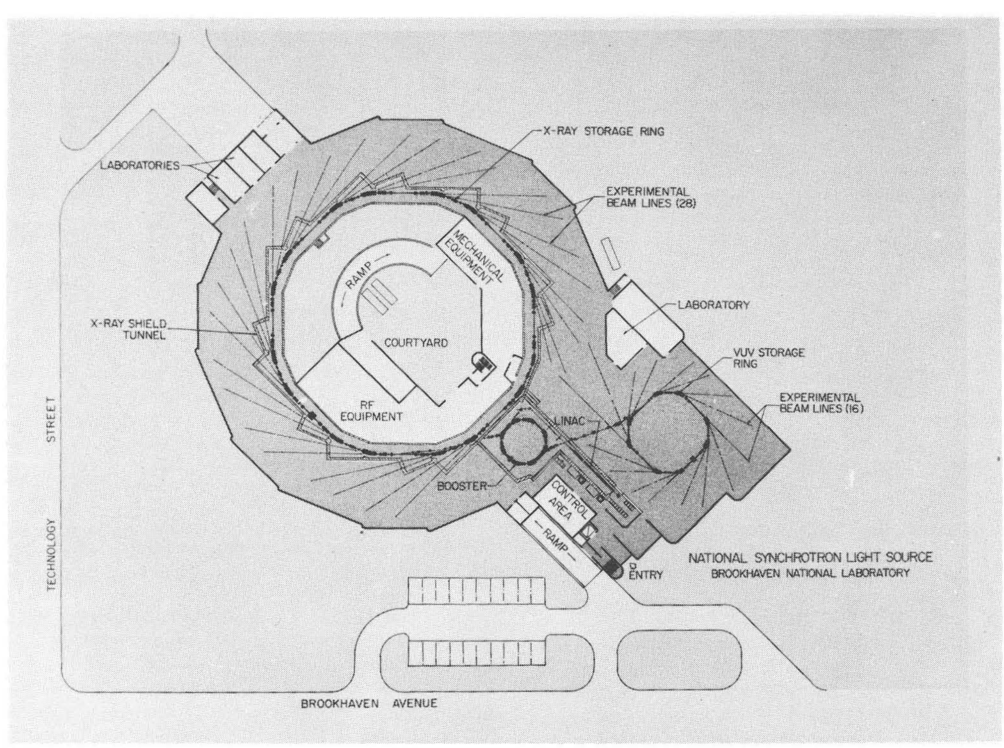

Fig. 2 Schematic of the linac rf system and cavities

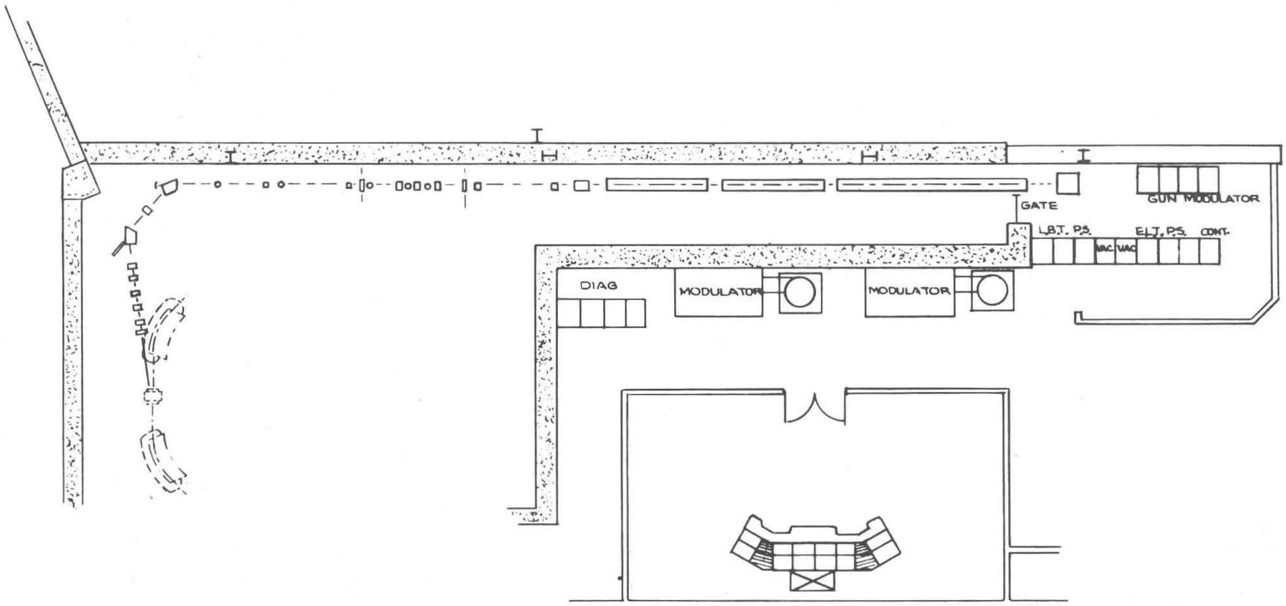

Fig. 3 Linac equipment layout

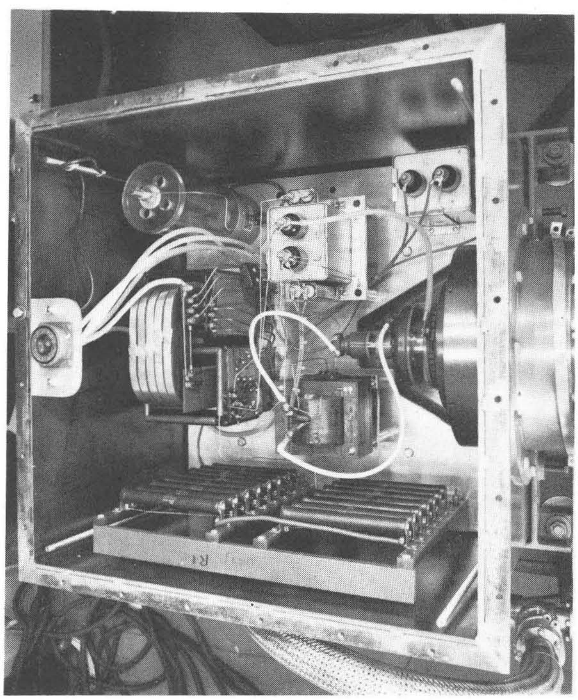

Fig. 4 Repackaged electron gun

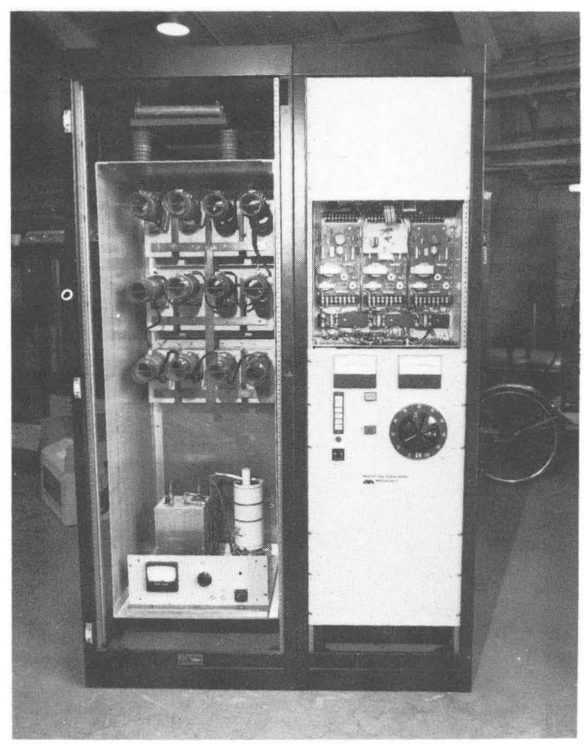

Fig. 5 Rebuilt gun modulator