COMMISSIONING OF THE SYNCHROTRON LIGHT SOURCE AT LSU

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Abstract

Maxwell Laboratories, Inc., has completed a synchrotron light source for Louisiana State University (LSU). This turnkey project, the first light source to be built commercially in the United States, is located at the Center for Advanced Microstructures and Devices (CAMD) in Baton Rouge. The light source consists of a 1.2 GeV, 400 mA electron storage ring and a 200 MeV linac injector. Installation of the source commenced immediately upon the completion of the CAMD building in May of 1991, and commissioning began in the autumn. Progress on the commissioning is discussed.

1. INTRODUCTION

The Brobeck Division of Maxwell Laboratories, Inc., has completed a synchrotron light source for Louisiana State University. This turnkey project, the first light source to be built commercially in the United States, is located at the Center for Advanced Microstructures and Devices [1,2,3] in Baton Rouge. The purpose of this facility is to provide intense beams of x-rays for research, especially research in x-ray lithography. Therefore, the light source design was driven by the following performance goals: warm magnet technology; synchrotron radiation with a critical wavelength of 9.5 angstroms; electron beam current capability of 400mA; large access to synchrotron radiation; low beam emittance; four long straight sections (3.0 meters each); cost-optimized injection (short filling times, multiple filling modes); and efficient and reliable operation.

2. SYSTEM PARAMETERS

The major system parameters of the synchrotron light source at CAMD are given in Table 1. A linac provides high-current injection at 0.2 GeV into the storage ring. Both multibunch and single-bunch injection are provided, for maximum operational flexibility. Operation of the storage ring at 1.2 GeV provides synchrotron radiation with a critical wavelength of 9.5 angstroms from the storage ring bend magnets, and increasing the electron beam energy to 1.4 GeV decreases the critical wavelength to 6 angstroms. The natural horizonal emittance of the electron beam is 2 x 10^{-7} pi-m-rad at 1.2 GeV. Only a brief description of the synchrotron light source will be presented here, since a more detailed description has been published previously [4].

Table 1
Storage Ring Parameters

Injection Energy	0.2 GeV
Nominal Operating Energy	1.2 GeV
Peak Operating Energy	1.4 GeV
Beam Current at 1.2 GeV	400 mA
Beam Current at 1.4 GeV	200 mA
Circumference	55.2 m
Number of Superperiods	4
Length of Long Straight Sections	3 m (each)
Radiofrequency	499.65 MHz
Horizontal Betatron Tune	3.26
Vertical Betatron Tune	1.168
Momentum Compaction Factor	0.03323
Natural Emittance at 1.2 GeV	2 x 10^{-7} pi-m-rad
Damping Times at 0.2 GeV	
Horizontal	1.5 s
Vertical	1.5 s
Longitudinal	0.8 s
Damping Times at 1.2 GeV	
Horizontal	7.1 ms
Vertical	7.1 ms
Longitudinal	3.5 ms

3. DESCRIPTION OF MAGNET LATTICE

Figure 1 is a plan view of a quadrant of the storage ring. The separated-function magnet lattice design has four-fold symmetry: the lattice consists of four achromatic arcs separated by four long straight

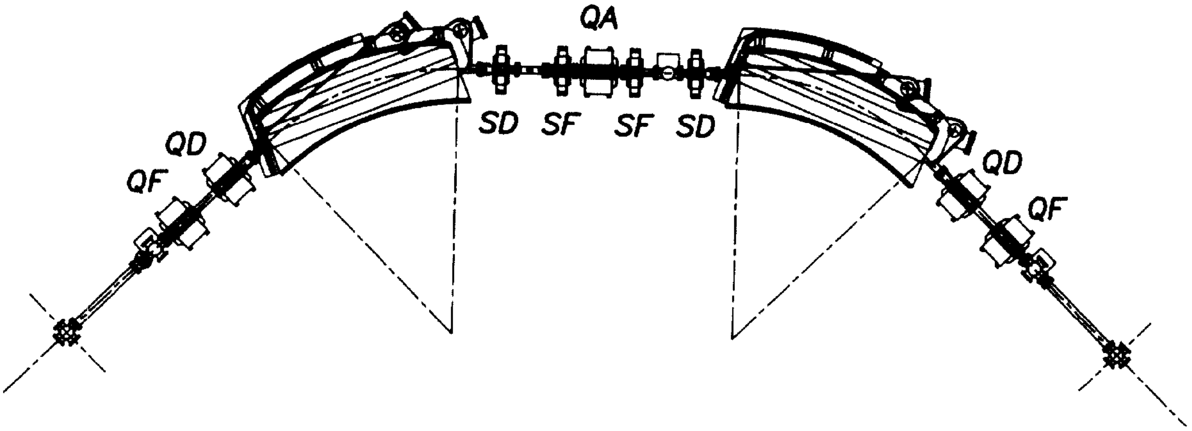

Figure 1. Plan View of Storage Ring Quadrant

sections. Each arc contains two bend magnets. In this Chasman-Green lattice, the momentum dispersion function and the horizontal beta function have small values in the bend magnets, thereby minimizing the natural horizontal emittance of the electron beam.

4. INSTALLATION AND COMMISSIONING

Installation of the light source began immediately after the CAMD building was completed in early May, 1991. A preliminary survey of the site was completed in May, in preparation for the installation of the linac, the magnets, and the electrical equipment in June and July. The vacuum system was installed in August, and subsystem integration followed. In late October, the first attempt to inject beam into the storage ring was met with success: the beam circulated around the ring for four turns. Achieving this most important milestone showed that all the major systems of the light source were functional. See Table 2 for the project schedule.

One of the two klystrons which provide RF power to the 200 MeV linac failed immediately after beam was circulated in late October, 1991. Therefore, subsequent commissioning activities of the light source has been restricted to a linac energy of 108 MeV. Nevertheless, significant progress has been made, as will be discussed below. With the reinstallation of the repaired klystron, scheduled for late March, 1992, progress in commissioning will improve.

Table 2.
Overall Project Schedule

1988	LSU Invitation for Proposals (fixed price contract)
	Purchase Contract signed with Maxwell Laboratories, Inc.
1989	Completion of Conceptual Design Report
1990	Detailed design, procurement, and manufacture
	Construction start of building
May, 1991	Completion of subsystem fabrication
	Construction completion of building
	Delivery to site, begin assembly
October, 1991	First beam injected into ring
	Begin commissioning
March, 1992	First energy ramping of stored beam
June, 1992	Scheduled completion of commissioning

4.1 Beam Lifetime

The electron beam has been captured in the ring and stored at 108 MeV with a long beam lifetime. Figure 2 shows the beam current as a function of time. After the transient beam losses, which occur immediately after injection, the beam has a lifetime of over 5 minutes. The initial stored current is about 5 mA, averaged over a 20-ns macrobunch. The vacuum pressure in the ring is in the neighborhood of 2×10^{-10} Torr after bakeout.

4.2 Beam Acceleration (Energy Ramping)

A major milestone was achieved when the stored beam was accelerated for the first time on March 12, 1992. See Figure 3. The solid curve shows the energy setting of storage ring bend magnets, given in terms of the beam energy (vertical scale). The beam survived about about 5.6 seconds (as measured with the DC current transformer), so it reached a final energy of about 160 MeV, starting from an energy of about 108 MeV. The three horizontal dashed lines show that the ratios of quadrupole currents to the bend magnet current are constant throughout the energy ramp. These current ratios are arbitrarily normalized in this plot.

The computer control system is playing a central role in providing convenient operation of the light source, in addition to coordinating all the magnet currents during beam acceleration. Closed orbit measurements are made using signals from the beam position monitors.

4.3 Future Plans

When the repaired klystron is reinstalled, it will be possible to inject beam at the design energy of 200 MeV. This will facilitate acceleration of the beam to 1.2 GeV full energy. Subsequently, the cleaning of the vacuum system by photodesorption will permit acceleration of high-current beam.

5. CONCLUSIONS

Considerable progress has been made in the commissioning of the synchrotron light source built by Maxwell Laboratories, Inc., for Louisiana State University. The beam has been captured and stored in the storage ring, it has been accelerated, and the closed orbit has been measured. We anticipate even more rapid progress when the repaired klystron is reinstalled.

6. REFERENCES

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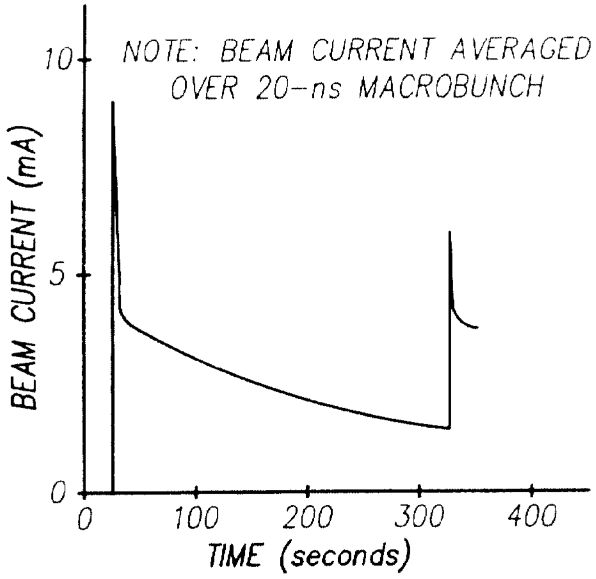

Figure 2. Beam Lifetime at 108 MeV

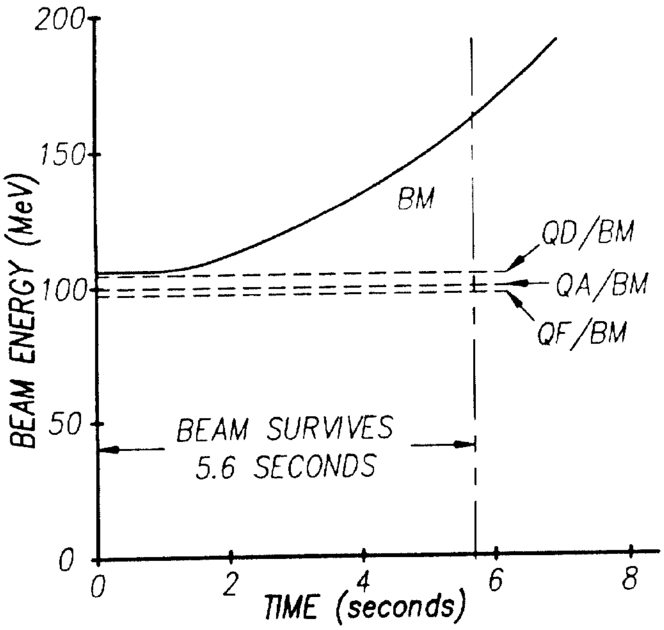

Figure 3. Accelerating the Stored Beam