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STATUS OF A COMPACT ELECTRON STORAGE RING JSR

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Abstract The JSR has begun operation. The electrons are accumulated with the beam current of 1.2mA at 135MeV. The acceleration and the storage at 300MeV are smoothly achieved. The life time of the stored beam is 12.5minutes at 135MeV and becomes longer by a factor of three at 300MeV. The computer control system works correctly and well-handles the whole equipment of JSR even though the computer is small (work-station).

1. INTRODUCTION

The design of the next generation 8GeV synchrotron radiation facility[1] in Japan is in progress, and our institute(JAERI) and RIKEN join forces in this project. The design study on the new facility is effectively facilitated by the technology accumulation through prior experiences of the construction and the operation of electron rings. A compact electron storage ring JSR[2] has been constructed in JAERI in order to study various kind of accelerator technologies, to examine the insertion devices and the beam monitors and to train young researchers. The design study of JSR was started in January, 1988 and the installation of all devices has been completed in March, 1989. Thereafter, the JSR's system was checked and the beam monitors and the vacuum pumps were added. We started the experiments of an electron beam injection for JSR in late May, and succeeded to inject electrons from a linac at an energy of around 150MeV, to accelerate, to decelerate and to accumulate at energies ~150MeV and 300MeV in JSR.

This paper describes experimental set-up of control system, beam monitors and presents initial operation results regarding the electron beam injection and storage. The performance of JSR magnets, vacuum system and RF system are shown in a previous paper[3].

2. CONTROL SYSTEM AND BEAM MONITORS

The plane view of JSR is shown in Figure 1. The JSR has a magnetic lattice of Double Focusing Achromat type (Chasman-Green type). The control system of JSR is

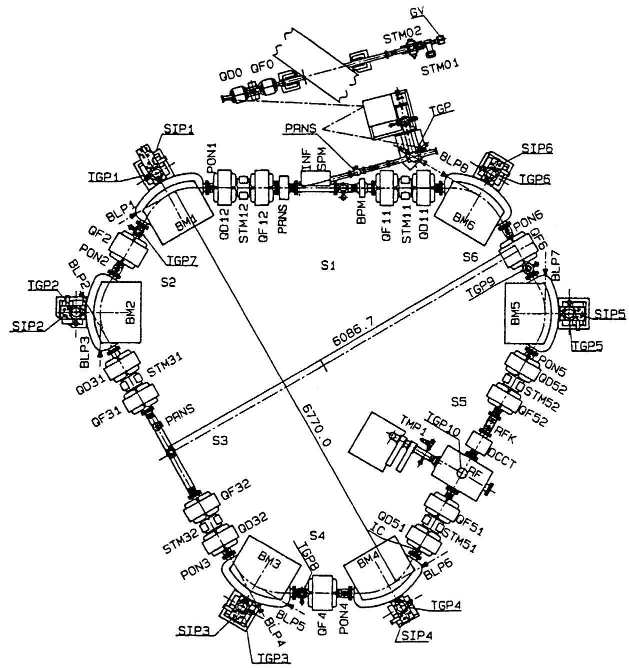

FIGURE 1 The plane view of JSR.
BM:Dipole magnet, QD:Quadrupole magnet(Defocus), QF:Quadrupole magnet(Focus), STM:Steering magnet, BPM:Kicker magent, PON:Pick-up electrodes, PRNS:Screen monitor, DCCT:D.C. current transformer, RFK:RF knock-out electrodes, IC:Ion clearing electrodes, TGP:Titanium getter pump, SIP:Sputter ion pump, GV:gate valve, S:Straight section.

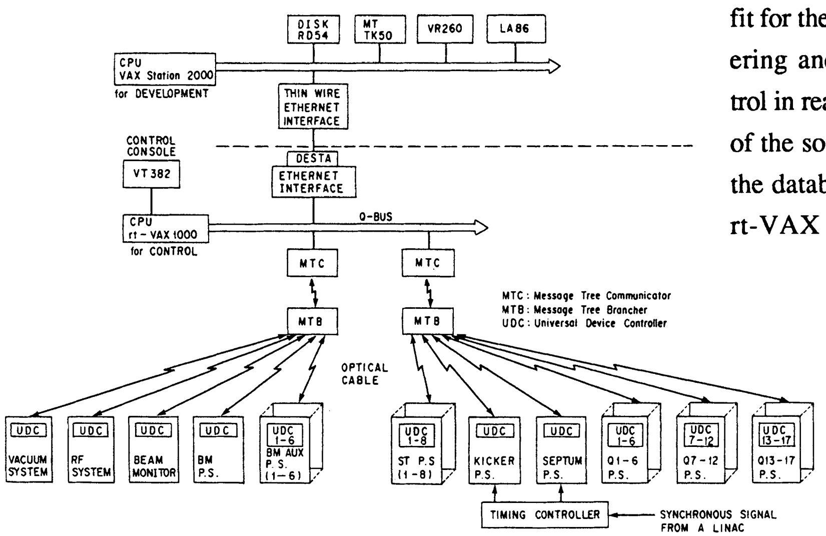

FIGURE 2 Control system for JSR.

shown in Figure 2. A VAX Station 2000 is used for the file management and the development of software and a rt-VAX 1000 is used to control and monitor each component of JSR. An operating system of the VAX Station 2000 is Micro VMS. This computer has a M/T and a disk in which all of the system program, the application software and the database are stored. The VAX Station 2000 is utilized for modification and addition of the sequence and the program and for setting the acceleration and the deceleration pattern data. The rt-VAX 1000 introduce the VAXELN system which fit for the data gathering and the control in real time. All of the software and the database on the rt-VAX 1000 are down-line loaded from the VAX Station 2000. The rt-VAX 1000 can read and write data in a disk of the VAX Station 2000 through the thin wire ethernet. The greater part of the control software describes C language. The rt-VAX 1000 monitors each component of JSR at intervals of 100msec. The rt-VAX 1000 is connected with intelligence device controllers (UDC) through the optical fibers. The UDC is an one-board computer with micro-controller 8344. The pattern data for the acceleration and the deceleration which is down-line loaded from the VAX Station 2000 is stored in the RAM on the UDC. The pattern data is swept out from the RAM to each component at the acceleration and the deceleration. The JSR has five modes of operation status; Power off, Stand-by, Injection ready, injection and Storage. The JSR has, furthermore, some transient modes which are Power on, Warm-up, Acceleration, Deceleration, Set-up and Abort as shown in Figure 3. All power supplies are usually turned on in the morning on Monday and tuned off on weekend. Dipole magnets and quadrupole magnets are warmed up in the morning with the waveform shown in Figure 4 before starting the experiment in order to reduce the field error due to hystere-

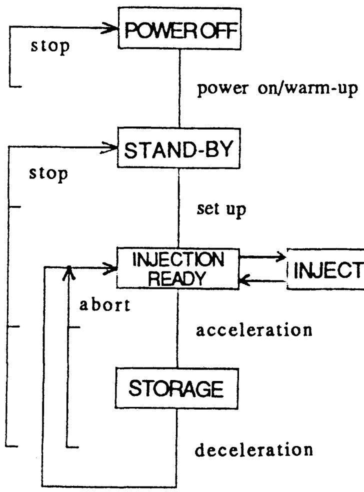

FIGURE 3 Operation modes of JSR.

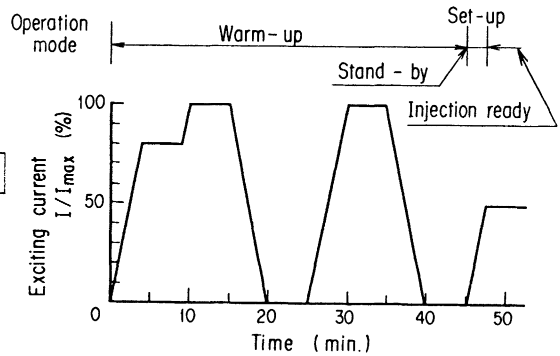

FIGURE 4 Warming-up pattern for the dipole magnet and the quadrupole magnet.

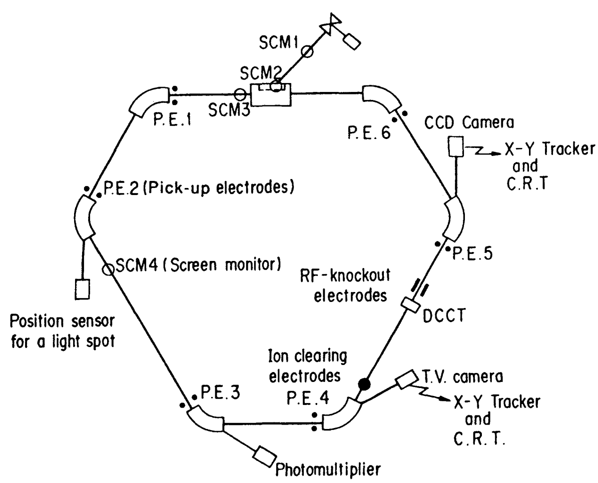

FIGURE 5 Arrangement of the JSR's monitors. SCM:Screen monitor, P.E.:Pick-up electrodes, DCCT:D.C. current transformer.

kicker magnet kicks the injected beam into the acceptance of JSR. The kicker magnet has an excitation pulse width of 0.6μsec. The electrons are able to be captured in the ring if they come into JSR between 300nsec and 550nsec after the beginning of kicker magnet excitation. The amount of the captured electrons depends on the kick angle of the kicker magnet and the closed orbit distortion of JSR as shown in Figure 7. The amount of the captured electrons has been calculated for two cases. The one is without the closed orbit distortion and the other is with the closed orbit distortion of 10mm at the inflector. The closed orbit distortion of 10mm is an extreme case, because the actual closed orbit distortion is expected to be ~4mm. The survival ratio of the stored electrons is also depend on the kick angle, and the most of stored electrons are lost in the case of the kick angle of more than 7mrad. Therefore, some amount of the injected electrons is expected to be accumulated in JSR when the kick angle is selected between 2 ~ 7mrad. The radiation damping time is 0.5sec at 150MeV, therefore the injection from the linac is repeated every 1sec. The damping time becomes longer at lower energy, so that injection can be changed to be repeated every 2sec for lower energy injection below 150MeV.

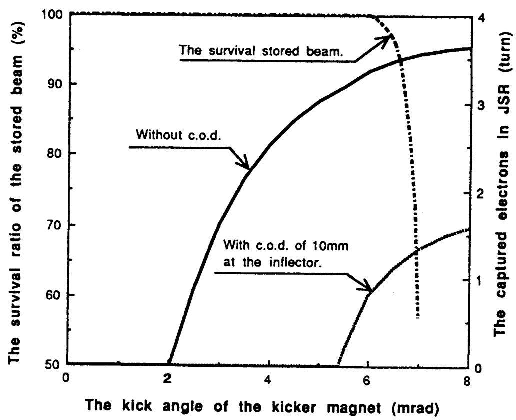

FIGURE 7 Calculation of the survival ratio of the stored beam and the amount of the captured injection electrons with the kicker magnet.

The magnets were adjusted for centering the electron beam on the screen monitors in a descending order. The efficiency of captured electrons becomes worse if the injected beam has an vertical angle of more than ±0.25mrad at entrance of the septum magnet. It is important to adjust the vertical gradient of the injected beam. Soon after the kicker magnet was excited, the electron beam was stored, as shown in Figure 8 which shows output data of a photomultiplier. The injection from the linac is repeated every 1sec. The output of

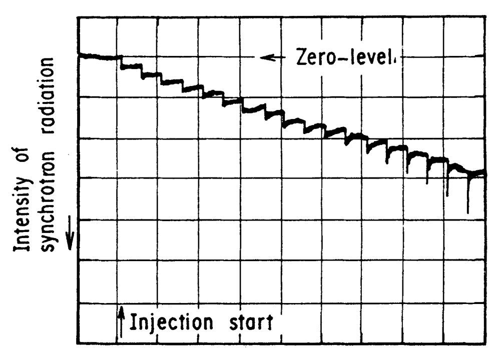

FIGURE 8 The output of the photomultiplier.

sis. The exciting current is slowly increased and decreased in order to reduce the eddy current effect in block type iron poles and yokes in the magnets.

The arrangement of JSR's beam monitors is shown in Figure 5. There are four screen monitors at a beam transport(SCM1), the entrance (SCM2) and the exit (SCM3) of the septum magnet and S3 section (SCM4). The SCM1,3,4 are movable, and the SCM2 is fixed. The SCM2 has the size of 39mm width and 30mm height with the hole of 8.33mm width and 8mm height. The screen monitor (SCM3) at the exit of the septum magnet can observe the injected beam from the linac and the single turned beam in JSR by changing the position of SCM3. Six position monitors are prepared at the entrance of each bending section. The beam current is monitored by one DCCT. The DCCT has three cores of Permalloy. The search coil of DCCT is modulated at 1kHz. A tune is measured by RF-knockout electrodes. The frequency of RF-knockout electrodes is able to be changed from 1MHz to 10MHz. The revolution frequency of JSR is 14.59MHz. One pair of electrodes is installed for the purpose of ion clearing. The maximum voltage of 500VDC is able to be applied each electrode. When one pair of the ion clearing electrodes can not remove the ion, some electrodes of position monitors are used for the ion clearing. Some synchrotron radiation monitors are set up at viewing windows of bending sections, such as T.V. camera(S-VHS movie), CCD camera, photomultiplier and position sensor for a light spot. The X-Y tracker, which analyzes data of CCD camera and T.V. camera, is prepared to indicate the beam position in real time. The position sensor of a light spot using PSD continuously detects 2 dimensional position. The photomultiplier has good time resolution ~1.3nsec, so that it is able to observe the form of an injected beam. The screen monitor, T.V. camera, CCD camera and photomultiplier are often used in the initial beam experiment.

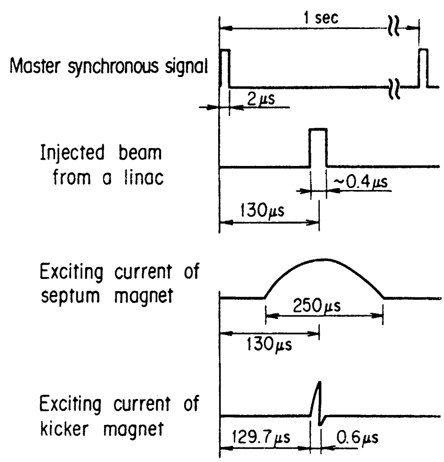

FIGURE 6 Timing chart of the beam injection.

3. ELECTRON BEAM INJECTION AND STORAGE

A septum magnet and a kicker magnet, which are located at the same straight section, are utilized for the injection of electrons into JSR. The timing chart of the beam injection is shown in Figure 6. The septum magnet deflects the injected beam from a linac by 15.172degrees. It is using the flattop (5μsec) of a sine wave excitation with 250μsec pulse width. The injected beam has an angle of 3mrad for normal orbit of the stored beam. The

DCCT is shown in Figure 9. The stored beam current is 1.2mA for this experiment and the beam life time is 12.5minutes, which is mainly determined by the collision with the residual gas in the vacuum chamber. The injection energy is 135MeV and the injection from the linac is repeated every 2sec. The energy of stored electrons is slowly increased up to 300MeV in 5minutes. The life time at 300MeV is longer by a factor of three than one at 135MeV. The deceleration from 300MeV to 150MeV is also carried out.

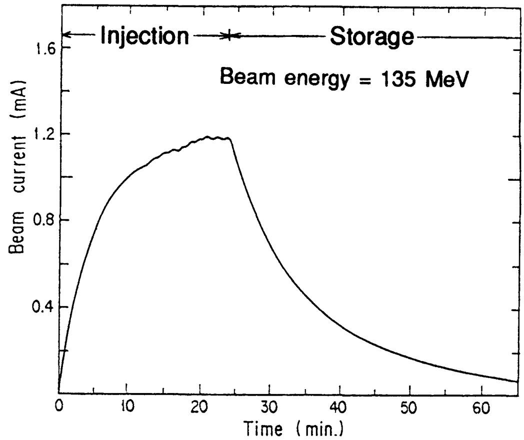

FIGURE 9 The output of DCCT.

4. CONCLUSION

The JSR satisfies fundamental function such as the injection, the storage at around 150MeV and 300MeV and the acceleration from 150MeV to 300MeV. The JSR has no major failure until now. The operation time is very short to scan the parameters to study the characteristics of JSR.

The experiment will be carried out to survey the operation conditions, to understand the properties of JSR and to improve the beam parameters. The study of the beam position control and the influence of insertion device installation is also planned to be carried out.

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