KSR AS A PULSE STRETCHER

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Abstract

A pulse stretcher mode of the electron storage ring, KSR, is presented. Such a scheme as includes the extraction system in the same straight section as the injection line is adopted in order to enable coexistence of the stretcher mode with the insertion device. This scheme also has a merit that it can use the same beam dump as the output beam from the electron linac.

1 INTRODUCTION

KSR is an electron storage ring with the maximum energy, circumference and radius of curvature of 300 MeV, 25.6 m and 0.835 m, respectively. It was initially designed as a synchrotron radiation light source [1],[2]. Responding to the recent needs for electron beam of the energy region around 100 MeV with high duty factor, its possibility as an electron stretcher ring has also been studied. The 100 MeV electron beam accelerated by the s-band (2857 MHz) disc-load linac with the maximum duty factor of 2x10^{-5} is 3-turn injected and extracted from the ring in ~100 msec by the third-order resonance extraction utilizing transverse RF electric field synchronized with betatron oscillation. Here the repetition rate of 10 Hz is assumed both for the linac and the stretcher ring, KSR. With this stretcher mode enabling duty factor of more than 90 %, the average electron intensity is expected to be improved from 1.2x10^{9} per second to 1.5x10^{12} per second inspite of the reduction of the peak intensity from 6x10^{15} per second to 1.7x10^{12} per second [3]. The scheme studied so far, however, had been assuming only tentative use of such stretcher mode before the final use of KSR as a synchrotron light source and the stretcher mode was not compatible with the insertion device. A new arrangement of the extraction system to compromise the insertion device and the stretcher mode is presented in the next section. Then the slow extraction scheme is presented together with the brief design of the extraction equipment. Finally the present status of the KSR is briefly given.

2 LAYOUT FOR KSR STRETCHER MODE

The slow beam extraction channel for KSR stretcher mode is to be installed in the same long straight section as the injection line as shown in Fig.1. The electrostatic septum is to be set 1.809 m downstream from the exit of the quadrupole magnet(QF) just after the RF cavity and the electrode for RF-knockout. The septum magnet is set 0.7 m downstream from the electrostatic septum so as to keep the septum thickness as large as 14 mm with technically reasonable electric field of 60 kV/cm. As the resonance exciter, a single sextupole magnet(SXR) is located after the quadrupole doublet just downstream of the inflector. The contribution of the sextupole magnets for chromaticity correction (SXA and SXB) to the resonance will be cancelled out when the horizontal betatron tune is exactly equal to 7/3 [3]. For real extraction process, the horizontal betatron tune should not coincide with this value in order to form finite size separatrix. The contribution, however, is expected to be small and can be neglected at the lowest order approximation.

3 SLOW EXTRACTION SCHEME

The output beam from the electron linac will be injected by 3-turn injection into the transverse phase space with use of the perturbator (PB) and the beam emittance thus

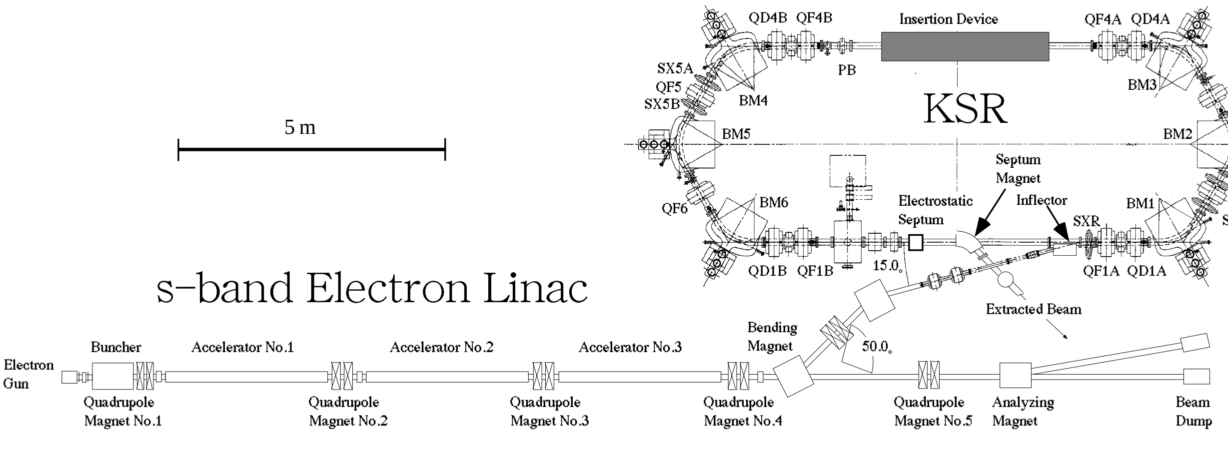

Fig. 1 Layout of the s-band Electron Linac and the Stretcher, KSR

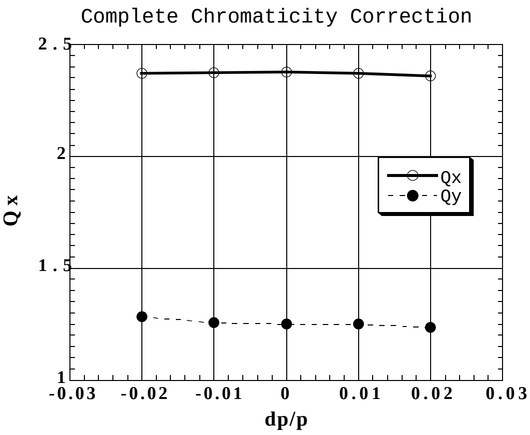

Fig. 2(a) Complete Chromaticity Correction.

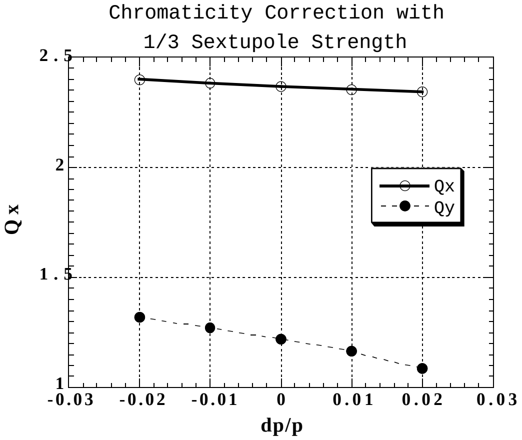

Fig. 2(b) Chromaticity corrected with sextupole magnets with 1/3 strength.

injected is estimated to be 250 πmm•mrad [3]. So we want to extract the beam by expanding the horizontal betatron oscillation amplitude with use of RF knock-out method [4].

3.1 Chromaticity Correction

Complete chromaticity correction so far proposed as shown in Fig. 2(a) assumes usage of rather strong sextupole strength (B”*l* /Bρ) of -36.0 and 36.5 1/m^2 for SXA and SXB, respectively, where the chromaticities (defined as ΔQ/(Δp/p)) in horizontal and vertical directions are calculated to be 0.027 and 0.007, respectively. With this chromaticity correction, it has been found that the extraction beam can almost align at the entrance of the Electrostatic Septum (called as ESS hereafter) when the slow extraction with RF knockout is applied. This situation holds for relatively small momentum spread with the size of a few % as shown in Fig. 3(a). Due to large nonlinearity caused by strong sextupole fields, the situation changes largely for the beam with much larger momentum difference. In addition to this, the extracted beam has the same momentum spread as large as that of the circulating beam.

The sextupole strengths of 1/3 of the above values realize the betatron tunes given Fig. 2(b). Under such chromaticity correction, electron beams with lower momenta than 2% are considered to be stable because their horizontal tunes are much different from the third integer resonance, 7/3. Even for the momentum of 2%, the beam with the amplitude of 0.033 m is also found to be stable as shown in Fig. 3(b) by solid circles. By application of transverse RF electric field which resonates with horizontal betatron oscillation with tune value 2.3406 (corresponding to fractional momentum difference of 2 %), the amplitude of betatron oscillation will increase. The electron with the larger amplitude (0.04 m) will be extracted as shown in Fig. 3(b) by open circles. The merit of this scheme is that the momentum spread of the extracted electron is expected to be smaller because only higher momentum electron around 2% will be extracted. This scheme, however, needs additional beam acceleration scheme described below. More quantitative calculation is needed to give precise value of the momentum spread of the extracted beam.

3.2 Induction Accelerator for Momentum Shift

In order to extract all the circulating beam with the

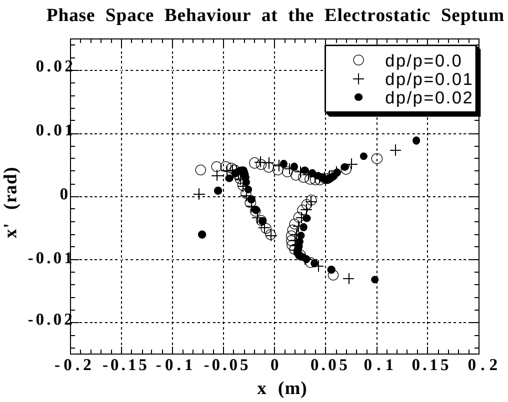

Fig. 3(a) Phase Space Plot of the Extracted Beams with Different Momenta at the Entrance of ESS.

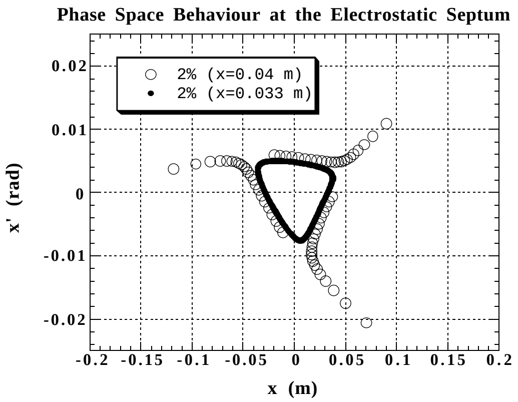

Fig.3 Phase Space Plot of the Electron Beam at the Entrance of the Electrostatic Septum.

scheme described above, the circulating beam should be accelerated in the time interval of 100 msec. For this purpose, we are now thinking about the possibility of utilizing an induction accelerator as used at TSR for laser cooling [5]. We want to accelerate 100 MeV electron as large as 4% in 0.1 second. As the revolution frequency of the electron is 11.67 MHz, necessary acceleration voltage per turn is 3.4 V and flux interval of 0.34 Vs is needed, which seems in the reach of the present technology [5].

3.3 Electrostatic Septum (ESS)

In order to kick out the beam expanded to some amplitude (~0.057 m) and realize the necessary coil space for the succeeding septum magnet, an electrostatic septum with the septum thickness and length of 0.2 mm and 0.3 m, respectively is to be used. The electric field of 60 kV/cm will be applied and the deflection angle of 18 mrad is added to 100 MeV electron. The gap of the ESS is designed to be variable between 10 and 15 mm.

3.4 Septum Magnet (SM)

For the septum magnet located 0.7 m downstream from the end of the ESS, the thickness of 14 mm will be available as septum thickness. With this condition, the magnetic field of 5 kG is attainable although the current density in the septum coil is estimated to be as high as 58 A/mm^2. The septum magnet will be set in the air and the vacuum chamber is installed inside of its gap. From the previous experience at TARN II, the current density up to 78 A/mm^2 has been realized even in the vacuum chamber [6]. For the case of 100 MeV electron, the radius of curvature is 700 mm and the septum magnet will have the curved aperture. It will deflect the extracted electrons as large as 46° with the length of 0.5 m. In Fig. 4, the trajectory of the extracted beam is shown.

4 PRESENT STATUS OF KSR

The precise alignment of the magnets of KSR has already been completed in 1995 and cabling of power line and control systems and piping for cooling waters have been finished in 1996. The installation of the vacuum chambers into the magnet sections have also been finished last year. An arc section has been already evacuated and was found to be free from major leak(see Fig. 5).

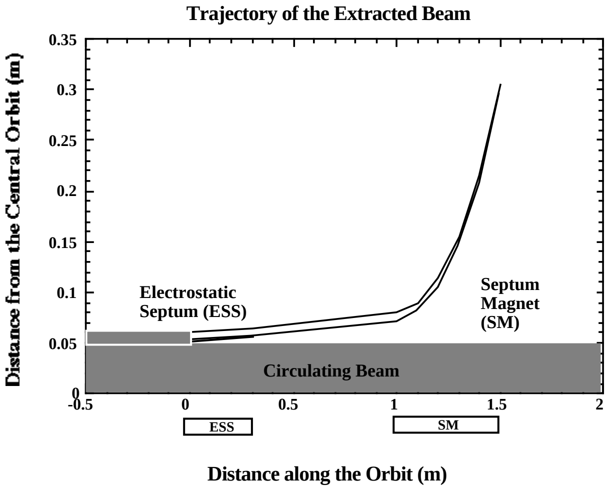

Fig. 4 Trajectory of the Extracted Beam.

Fig. 5 Overall View of KSR.

Within this fiscal year, beam injection into the ring is expected. The construction of the beam injection line and vacuum chambers in the long straight sections are now proceeding. In parallel to this, the construction of the equipment for slow beam extraction has been started so as to use the KSR as an pulse stretcher for the electron-beam radiation-physics.

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