Beam Diagnostics

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1. Introduction

The BPM (Beam Position Monitor) system including the signal processing circuits was completed during 1996, and so were the data taking activities for the calibration of all the BPMs. The installation of the current monitors and a tune monitor at one of the straight sections of the storage ring was also completed. Screen monitors were installed at the SSBT (Beam Transport line from the Synchrotron to the Storage ring) for beam injection adjustment.

2. BPM

In order to cover the entire storage ring, the signal processing circuits are available in 24 sets. Since the storage ring consists of 48 unit cells, one set of the circuits covering 2 unit cells has 12 front end modules since 6 sets of the BPM electrodes are attached to each unit cell.

As reported last year[1], one set of these circuits has two modes: the COD mode and the SP mode. Two unit cells are covered by one COD mode detection module and 4 sets of SP mode detection modules. Each module has a 12-to-one selection switch to be able to select one of the 12 BPMs in two unit cells.

In general the detection circuits have some degree of non-linearity. Since this non-linearity affects the beam position measurement error, it must be corrected. In order to correct the non-linearity, we measured all detection modules of the circuits, both the COD and SP modules. Input signals were supplied by a synthesized signal generator to the front end modules of the circuit. The input power was monitored by a power meter and the output voltage was measured by a module specially manufactured for the analog to digital conversion of the BPM signal processing circuits. The relationship between the input power and the output voltage was fitted by a polynomial after the former was linearized from dBm to an amplitude voltage. In order for the circuit to cover the wide range of the stored beam current, each circuit has step attenuators that are remotely controllable. The input-output relationship was measured at many settings of the step attenuators, since the different level of the power passes the components in the circuits depending upon the difference in the setting of the attenuators, and since its linearity may depend on the level of the passing power. The non- linearity of the circuits are specified to be within 3% for the COD mode modules and 10% for the SP mode modules, which corresponds to the position measurement ambiguity of 0.5mm for the COD mode and 1.5mm for the SP mode. The goal of the correction is the order of 10µm for the COD mode and 100µm for the SP mode. After the correction of the non-linearity, the position measurement error was estimated to be 20µm in the central region of the BPM and 50µm for outer region for the COD mode, while it was estimated to be 100µm in the central region and 200µm for the outer region for the SP mode, where the central region means the 2mm $\times$ 2mm region from the BPM center. After the characterization of the linearity and other kinds of measurements, these circuits were installed in the maintenance passage just next to the storage ring tunnel. The cables from the BPM electrodes were directly extended to the front end modules of the circuits. The low pass filters, bandpass filters, and switches are installed in the front end modules to select the necessary Fourier components of the signal and to prevent too much power from entering the switches. The cable attenuation imbalance between the electrodes and the front end modules generates an offset to the measured beam position. The imbalance was measured with that feeds the signal from the inside of the tunnel through the cable. The data for linearity corrections and the imbalance corrections are stored in the database, which will be used for the position calculation by measured electrical signals on actual operation.

3. Current Monitors and Tune Monitor

The beam current monitors and tune monitor had been installed at one of the straight section of the storage ring. In addition to those monitoring devices, the radiation absorbers to prevent the unnecessary exposure to the synchrotron radiation, and several vacuum pumping systems were installed in the same straight section. Figure 1 shows the overall arrangement of the components in the straight section.

Two types of current monitors, a DCCT (Direct Current Current Transformer) and a bunch charged monitor, were installed. A DCCT of the parametric current transformer type was installed for monitoring the stored beam current with the resolution of 5μA. The bunch charged monitor consists of a pulse current transformer and a signal processing circuit that generates the subtracting and integrating time window from an external trigger signal. This monitor is used for the single bunch operation mode, as well as for the "multi-single bunch" operation mode. The multi-single bunch means that the equally spaced buckets are filled with electrons up to about 10 to 20 bunches. The DCCT and the pulse current transformer were installed on the same vacuum chamber assembly that contains one ceramic gap for guiding the magnetic field associated with the beam passage to the transformer toroidal core as shown in Fig. 2.

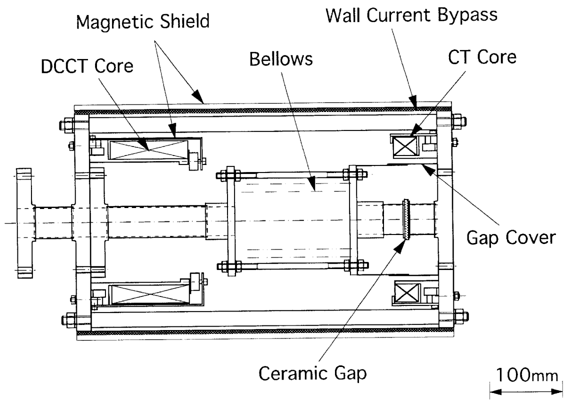

Fig. 2. Side View of the Current Monitor Assembly.

The tune monitor consists of a beam shaker, a signal source for power feeding to a beam shaker, an amplifier, pickup electrodes, signal processing circuits, and a measuring device such as a spectrum analyzer. The beam shaker unit has four 50Ω stripline electrodes. Each electrode is 450mm in length and is supported by two N-type coaxial feed-throughs at both end of the stripline. The beam is sensitive to the driving force from the shaker by responding to the power to the shaker. The frequency of the driving force

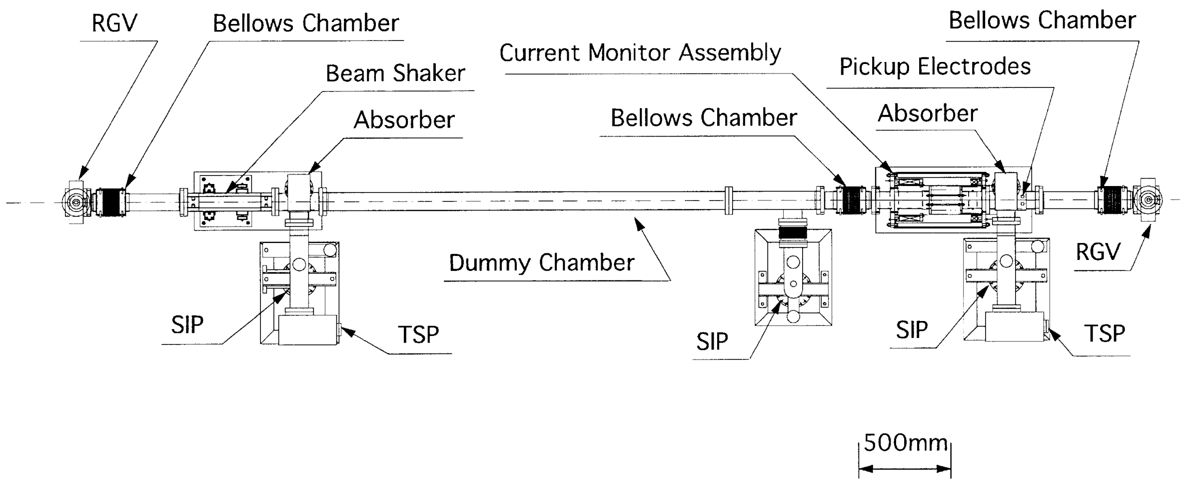

Fig. 1. The layout of the Beam Diagnostics Straight Section.

resonates with the characteristic frequency of the betatron oscillation, which results in the increase in the amplitude of the coherent betatron oscillation. This betatron oscillation will be observed by the signals induced at the pickup electrodes. The pickup electrodes are connected to the spectrum analyzer input through signal processing circuit. The peak in the spectrum analyzer gives the betatron tune value.

4. Fluorescent Screen Monitors

The fluorescent screen monitors were installed near the beam injection point of the SSBT to permit the observation of the position and beam profile for the beam injection adjustment. The beam pattern on the fluorescent screen can be observed through a glass viewing port. It can be viewed on a TV monitor in isolated locations, or in the central control room of the accelerators.

The fluorescent screen is made of a chromium oxide doped alumina plate. A commercial trade name of this is AF-995R which is supplied by the Desmarquest Co. Ltd. in France. The monitor assembly is driven by an air cylinder, the stroke of which is 24mm. When the electron beams are injected to the storage ring, the monitor assembly is lifted.

Reference

[1] S. Sasaki et al.; Spring-8 Annual Report, 1995, p.23.