Beam Diagnostics

Haruo OHKUMA
Shigeki SASAKI
Shiro TAKANO
Masazumi SHOJI
Mitsuhiro MASAKI
Kazuhiro TAMURA

1. Introduction

The monitors of the SPring-8 Storage Ring for beam diagnoses, i.e., beam position monitors (BPMs), current monitors, tune monitor and so on, were explained in previous Annual Reports of SPring-8 [1]-[3].

The performance of each of the monitors was confirmed as the beam commissioning of the Storage Ring was progressing. In addition, improvements to the monitors and their data acquisition systems were described.

2. BPM

The aim of the BPMs is to obtain the lateral positions of the beam bunches at the longitudinal BPM positions along the Storage Ring. The measured quantities, however, are voltage signals from the button pickups of the BPMs. The position calculations from the voltage signals, therefore, require parameters and calibration constants such as the linearity correction for the signal processing circuits, the position sensitivity of the signal, the insertion loss balance between the pickups, etc. Before the commissioning of the Storage Ring began, these parameters were acquired and saved to the parameter database; therefore, positions can be calculated from voltage data.

The resolution of the BPMs was estimated to be less than 10 μm, which was deduced from position data repeatedly measured in a short period of time. To obtain a good resolution, all of the buckets of the ring should be filled with electron bunches. When all of the buckets are filled, the side bands of the main rf frequency (508.58 MHz) are suppressed resulting in the absence of the saturation effect of the amplifiers of the signal processing circuit.

As the beam commissioning was progressing, unexpected large offsets were observed. The main cause was found to be fairly large reflection coefficients at the connectors of the coaxial cables and imbalances between four electrode signals. These imbalances were corrected by comparing the positions calculated from three electrodes; four combinations of the three electrodes were available out of four electrodes, and consequently, four positions were obtained and compared. Additional imbalance parameters were introduced to make these four positions the same.

Another phenomenon relating to the reflection was jumps of the position data, which appeared when the attenuators were switched. The attenuators were installed to avoid saturation of the amplifiers when the beam signal was large during high beam current operation. When the attenuators were switched, the reflection condition changed and this caused a shift of the imbalance between electrode signals.

We plan to improve the signal processing system of the BPMs during the summer shut-down period of 1998 in order to settle these problems.

3. Monitors at No. 4 cell

A Direct Current Current Transformer (DCCT), a Bunch Charged Monitor (BCM), striplines, and button pickups were installed in the straight section of the No. 4 cell. Signal cables except for the DCCT are led to a room through a pit under the Storage Ring tunnel. The room which is located near the No. 4 cell is arranged for beam diagnoses, e.g., such as tune measurement, beam observation in the frequency domain and in the time domain, and so on.

The betatron tune monitor consists of a beam shaker, a power amplifier, and a spectrum analyzer with a tracking generator. The electron beam is excited with the amplified output signal of the tracking generator. The power of the signal is less than 1W. The frequency of the signal is down converted by the rf frequency because the amplifier has a frequency response from 0.1 to 20 MHz.

The beam shaker was designed with four stripline electrodes [3]. At present, however, only one of the stripline electrodes is being used for the beam shaker. One of the other three is being used as a signal pickup electrode for tune measurements; a 50Ω terminator is connected on the opposite side of it. The pickup signal passes through a band-pass filter, and the filtered signal is fed into the rf input of the spectrum analyzer.

The rf timing signal is also sent to the room from the rf phase control room to be used as a trigger signal or timing signal for machine study, and so on. The beam signal from the button pickup is always monitored by an oscilloscope and the filling pattern of the bunches is observed. In addition, a FFT analyzer and a vector voltmeter are used to measure the synchrotron tune.

These instruments are remotely controlled by GPIB on VME systems. The data from the spectrum analyzer and the FFT analyzer can be sent to workstations by using graphical user interfaces. The video outputs of the oscilloscope and the spectrum analyzer are sent to the central control room via optical cables.

4. Current Monitors

As mentioned above, to monitor the stored beam current, two types of current monitors, the DCCT and the BCM, were installed in the straight section of the No. 4 cell.

The DCCT is used for monitoring DC components of the stored beam. The DCCT has two current ranges (±300mA/±30mA). At present, we are using the ±30 mA range because the maximum stored current is 20 mA. The output signal of the DCCT is digitized by a 6´ digit integrating voltmeter (HP 34401A supplied by Hewlett-Packard Company) with an integration time of 167 msec (10 PLC). The digitized value is fed to the VME system via the GPIB board, and then transformed into the current value by a factor of 3 (30mA/10V). The beam current is measured every second, and the current value is recorded into the database. The resolution of the current measurement is less than 1μA for 167 msec integration. The fluctuation of the measured value is about ± 2μA in terms of the current.

Now, we are investigating the cause of the fluctuation. A zero drift after two weeks of operation was within +5μA. This drift was negligibly small during the operation.

To reduce the effects of the magnetic fields from bending, quadrupole, sextupole, and steering magnets, the DCCT sensor is surrounded by cylindrical shields. When the steering magnet near the DCCT is excited with the maximum current, the output signal of the DCCT varies about ±80μA in terms of the current, however. At present, this steering magnet is not being used.

The BCM is being prepared to measure the bunch charge in the single bunch operation mode.

5. Beam Diagnostics Using Visible SR

The beamline BL38B2 has been assigned for beam diagnoses by using synchrotron radiation (SR) from a bending magnet. During the winter shut-down period, the vacuum chamber for extraction of visible components of the SR was installed at the end of the photon extraction line of the No. 38 cell in the Storage Ring tunnel [4]. Therefore, visible SR is reflected by a water-cooled Cu mirror in the vacuum chamber and passes through an optical window made of sapphire to be extracted to the atmosphere. Five Al-coated mirrors in the atmosphere lead the visible SR to the experimental hall from the Storage Ring tunnel. A darkroom in which optical components and detectors have been set up was constructed in the experimental hall.

The visible SR will be used to monitor the beam profile, beam oscillation, single bunch purity, and so on. We plan to construct beam diagnostic beamline BL38B2 to consist of a front-end and an optical hutch in 1998 and 1999.

References

[1] S. Sasaki; Annual Report of SPring-8, 1994, p. 32.
[2] S. Sasaki et. al; Annual Report of SPring-8, 1995, p. 23.
[3] H. Ohkuma et. al; Annual Report of SPring-8, 1996, p. 20.
[4] H. Ohkuma et. al; see the chapter entitled “Vacuum System” in this Annual Report.