Beam Position Monitor for the SPring-8 Synchrotron

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1. Introduction

The beam position monitors, which are placed around the SPring-8 booster synchrotron, are designed to measure a closed orbit distortion (COD). The BPMs are located at the upstream positions of 80-quadrupole magnets. Each BPM pickup consists of four button-type electrodes which are mounted on the wall of the vacuum chamber. The diameter of all the electrodes are 18 mm.

Output signals from the electrodes of 20-BPMs are selected by fast PIN-diode switches, and the amplitudes of these signals are measured by the same detection system. Four detection systems are used at the same time for 80-BPMs, and it is expected that the measurement time of this system is less than 30 ms.

The relationship between the beam position and the output signals of the electrodes are measured by the calibration system which have an antenna to simulate an electron beam. The antenna is mounted on the X-Y table which is driven to x, y, and s directions by the pulse motors. The 508.58 MHz signal, which is the acceleration RF of the synchrotron, is supplied from the tracking generator to the antenna. The output signals from the electrodes are measured by the spectrum analyzer.

2. Structure of BPM pickup

The BPM pickup consists of four button-type pickup electrodes which are attached to the SMA-type coaxial feedthroughs that are welded on a racetrack-type vacuum chamber. The diameter of the electrode is 18 mm and the capacitance of the electrode including a feedthrough is about 6.8 pF.

We use three types of BPM pickups. The type 1 BPM pickups have 80x30 mm^2 racetrack-type vacuum chambers. The horizontal distance between the center of the vacuum chamber and the electrodes is 14 mm. They are placed at the upstream positions of 78-quadrupole magnets. Figure 1 shows a cross-sectional view of a type 1 BPM pickup.

The type 2 and the type 3 pickups are located on the straight-section where the beam extraction systems are placed. The type 2 pickup has a 100x30 mm^2 racetrack-type vacuum chamber. The horizontal position of B and C electrodes are x=-14 mm, and A and D electrodes are x=24 mm to measure the beam positions on both the reference orbit and the bump orbit for the beam extraction. The type 3 pickup has also a 100x30 mm^2 vacuum chamber, and the position of the electrodes are as same as the type 1.

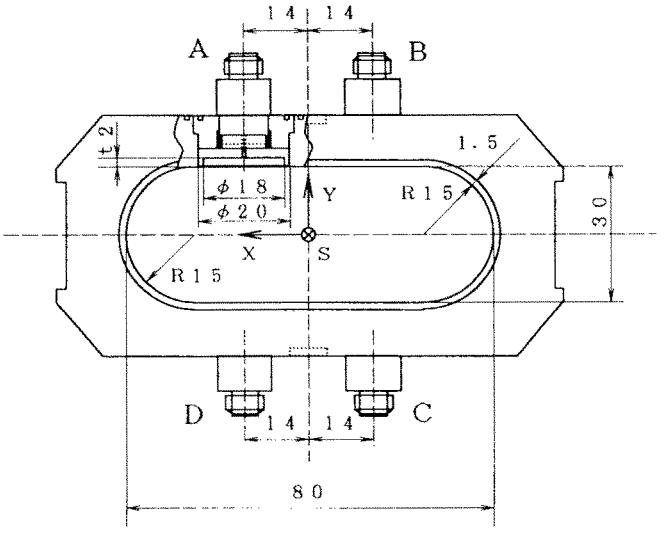

Fig. 1. The cross-sectional view of a type 1 BPM pickup

3. The electronics of BPM

The block diagram of BPM electronics for COD measurement is shown in Fig. 2. The output signals from the BPM pickups are transmitted through the 3 dB attenuators and the coaxial cables to the electrode-selector which consists of fast PIN-diode switches and a 600-MHz low-pass filter (LPF). The switching time of the PIN-diode is less than 0.01 ms, and the duration of an one-electrode selection is 0.35 ms. The output signals from the electrode-selectors are transmitted through low-loss, high-frequency cables (WF-H50-4) to the BPM-selector.

Heterodyne circuit is used at the signal detection system. The 508.58 MHz signal, which frequency is the same one as the acceleration RF in the synchrotron, is transformed to a signal of 70 MHz intermediate frequency by mixing with a 438.58 MHz signal from the local oscillator. The 70 MHz signal is converted to DC level as position signal by the synchronous detector and the 3.5 MHz LPF.

One detection system obtains output signals from 20-BPM pickups, and four detection systems are used at the same time for 80-BPMs. Thus, it is expected that the total measurement time of 80-BPMs is less than 30 ms.

To measure a beam position in single-bunch operation, the output signals from a BPM pickup are observed simultaneously by digital sampling oscilloscope (SONY Tektronix CSA803A, sampling

head SD-26). Five BPM pickups and electrode-selectors have functions to change over from COD mode to single-bunch mode. They are located the position just before the beam extraction systems.

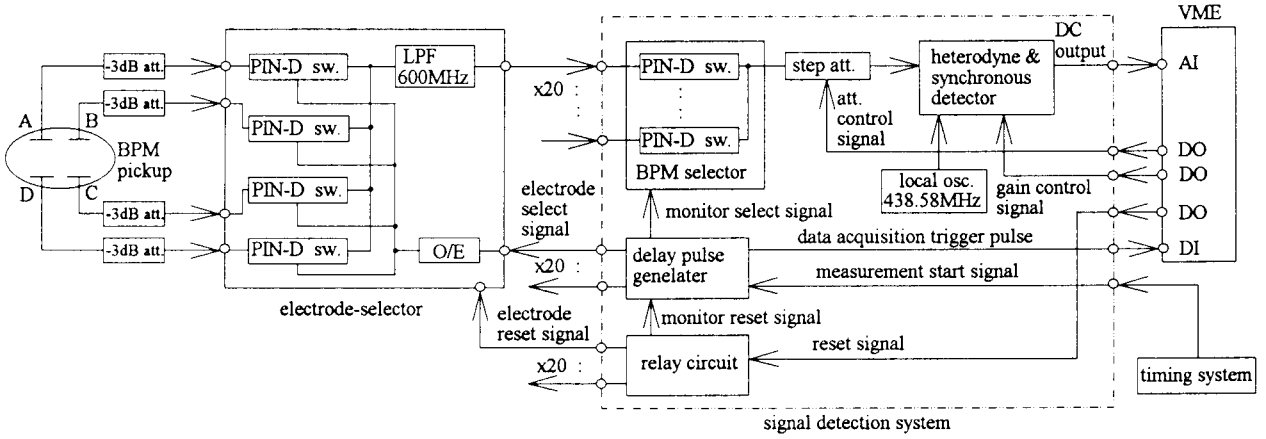

Fig. 2. The block diagram of BPM electronics for COD measurement

4. Calibration system

We develop a BPM calibration system for easy and accurate calibration. The schematic diagram of the BPM calibration system is shown in Fig. 3. To simulate an electron beam, semi-rigid coaxial cable (UT-85) is used for an antenna and is mounted on the X-Y table which is driven to x, y, and s directions by the pulse motors. The coaxial cable is inserted in the stainless steal sleeve which has 3 mm inside diameter and 5 mm outside diameter. The length of the inner conductor out of the sheathe is 50 mm. The optical sensors are used to set the antenna at the initial position before every measurement.

The 508.58 MHz signal is amplified and is supplied to the antenna from the tracking generator of the spectrum analyzer (HP 8560E). The output signals from the electrodes: V_A, V_B, V_C, and V_D are switched by electrode-selector and are measured by the same spectrum analyzer. The spectrum analyzer, the motor controllers, and I/O box are controlled by HP model 362 that is connected with GP-IB cables. The offset distances between the initial position of the antenna and the center of the BPM pickups have been measured previously, and they are compensated on the software.

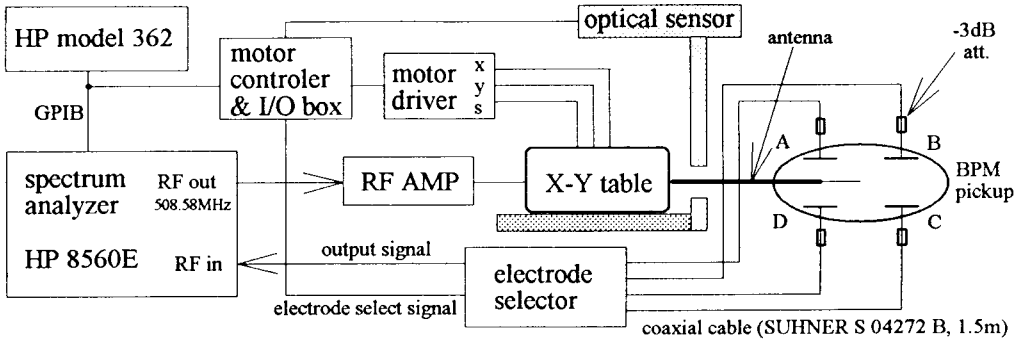

Fig. 3. The schematic diagram of BPM calibration system

To simulate a distribution of electromagnetic field in the BPM pickup and beam duct, two dummy ducts are attached both ends of the BPM pickup. To suppress a noise signal by the leaked electromagnetic wave, electromagnetic shield rubbers are stuck on the inside of dummy ducts and on the base of the antenna. At the longitudinal position more than 60 mm from the end of sleeve, electric field distribution is nearly constant. Therefore, the X-Y table is driven to s-direction where that position comes at the center of the electrodes.

5. Conclusion

Precedig 10-BPM pickups were manufactured and the calibration system was developed. The preceding BPM pickups are calibrating and remaining BPMs are now under construction.