BEAM POSITION MONITORING IN THE PHOTON FACTORY STORAGE RING

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1. Introduction

The beam position monitoring system in the Photon Factory storage ring consists of 45 sets of electrostatic position monitors and the associated data-taking system.[1,2] The beam position measured with the monitors was compared with position data obtained by other independent methods. The position accuracy and resolution are sufficiently good to correct the closed orbit distortion.

2. The Beam Position Monitors and Data Processing

Figure 1 shows the data processing system for the position monitors. Six electrode signals from a position monitor are coax-switched into a cable which is connected to another coax switch in the succeeding substation. Each time the coax switch controller selects a position monitor, the signal level is adjusted with a programmable attenuator. The signal is then processed in the amplifier and detector. The DC output is relayed to the ADC, from which it is collected by the computer through its GP-IB link.

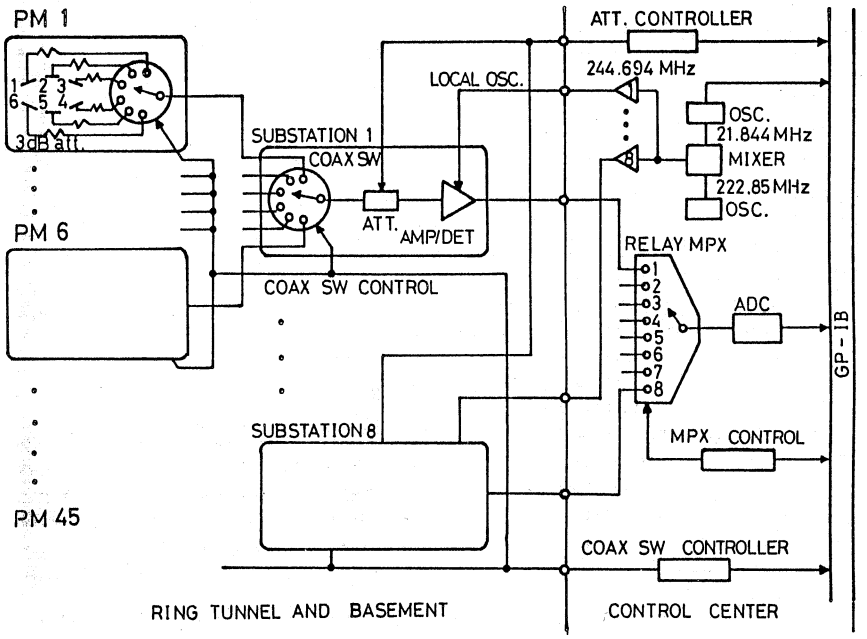

Fig.1 Data processing system for the position monitors (PM).

3. Measuring Performance of the System

The measuring performance is dependent on two major factors: 1) the inherent resolution of the whole electronic system and 2) the installation accuracy of the monitors in the storage ring.

The electronic resolution of a position measurement depends upon fluctuations in processing signals. The signal level deviates mainly due to fluctuations in the insertion losses of attenuators and coax switches. The 3 dB attenuators used for better signal transmission from each electrode, are expected to have errors of ±0.2 dB at 500 MHz, according to the catalog. A selection procedure was applied to classify them into groups so that each group of six attenuators lies within a smaller deviation of 0.015 dB. The coax switch typically has an insertion loss of 0.1 dB with a standard deviation of 0.05 dB at 1 GHz. This is acceptable, since a deviation of 0.06 dB corresponds to a position resolution of 0.1 mm. As long as the local oscillator frequency is stabilized within about 100 Hz, fluctuations from the amplifier and detector are acceptably small. Altogether, this guarantees an electronic resolution of 0.1 mm.

Installation of the monitors in the ring was made as follows: The relative separation between the electrical and mechnical centers in each monitor was measured on a test bench. The uncertainty of this measurement was less than 50 μm. Then, the monitors were fastened to the quadrupole magnets, with mechnical-setting errors less than 50 μm, by supporting the vacuum duct with accurately machined massive frames. The overall installation error is expected to be at most 100 μm.

4. Experiment with the Stored Beam and Results

Two types of experiments were made with the stored beam: 1) a closed orbit experiment to correct the orbit distortion and 2) a beam lifetime experiment with scrapers to find the apertures. These provide two independent checks of the position monitor reliability.

The closed orbit experiment can give a measure of the precision of the beam position measuring system by detecting the beam repeatedly at a fixed position. The fluctuation of the beam position in the horizontal direction was twice as large as that in the vertical direction. This suggests that the beam was deviating in the horizontal direction from time to time. The resolution of the position measurement is now of order 0.1 mm.

The beam lifetime experiment provides information on the beam location within the vacuum duct by inserting a scraper gradually into the duct and measuring the beam lifetime at each location of the scraper.[3] When the beam was shifted by making a local DC bump in the beam orbit, both position monitor and scraper read almost the same shift, i.e. within 0.1 mm. The beam center was measured by inserting two scrapers from opposite sides. The result differs from that obtained with the position monitor by 0.25 mm. This difference can reasonably exist when comparing the two systems because installation of both systems in the ring was made independently, with setting errors of 0.1 mm.

5. Summary

To date, the position monitoring system has worked nearly as desired, that is, the beam position was measured with both a resolution and accuracy of 0.1 mm. Further experimental work will be made during the coming operation period of the ring. Intentional deviation of 0.1 mm will be made to verify the apparent fluctuation of the horizontal beam position.

References

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2. T. Katsura, H. Nakagawa and S. Shibata, IEEE Trans. NS-28, 2353(1981).
3. T. Yamakawa et al., to be published.