BEAM POSITION MONITOR OF the ATF-DR

M.Tejima, N.Terunuma, Y.Takeuchi, Y.Funahashi, J.Urakawa,
F.Hinode*, T.Mimashi and H.Hayano
Accelerator Department
KEK, National Laboratory for High Energy Physics
1-1 Oho, Tsukuba-shi, Ibaraki-ken, 305 JAPAN

Abstract

The Beam Position Monitor(BPM) of the ATF Damping Ring(ATF-DR) was developed anew in consideration of the following conditions: the measuring performance of the beam position is very high resolution, the higher order mode coupling impedance becomes as minimum as possible and the high vacuum feedthrough necessitates sufficient strength.

The pickup electrode prototypes have been tested for mechanical strength and their electrical characteristics. Forty BPM blocks were subsequently manufactured, and used to measure the mapping for the each calibration to obtain the dispersion of the offset and the distortion of the sensitivity. This paper introduces the examination results and the performance.

1. Introduction

The ATF[1] is now under construction at KEK to be used for experiments concerning the feasibility of the linear-collider(JLC[2]). The ATF-DR is operated at 1.54 GeV, that produces multi-bunch electron beams with a vertical emittance of 5×10^{-11} m rad. In order to achieve extremely low emittance beams, we must correct the dispersion of the orbit, which is small (η<2 mm) in the long wiggler section of the ATF-DR. Therefore, we need to precisely measure the dispersion. We usually obtain the actual dispersion by comparing each closed orbit distortion under conditions of different RF frequency($\Delta f^{RF} \approx 10$kHz). For this reason, the requirement for the resolution of the BPM is less than 5μm.[3]

The parasitic mode (PM) loss generally causes beam instabilities. To avoid an instability due to PM loss, the value of the longitudinal impedance must be less than 0.2 Ω. The result of a tracking simulation indicated that the impedance is very small on the electrode of button type compared with the directional coupler type.[4] Therefore, we selected the button type electrode for the BPM.

We need to consider any heating up of the electrode due to beam interception and synchrotron radiation by high current beam of 600 mA at maximum. In order to avoid direct irradiation, we designed a button electrode which was set slightly back from the inner surface of the vacuum chamber.

* JSPS Fellowships for Japanese Junior Scientists
Present address:National Laboratory for High Energy Physics, Oho 1-1, Tsukuba, Ibaraki, 305 Japan

2. Configuration of the Beam Position M

2.1 Pickup electrode

As shown in Fig.1, we fabricated ten electro as a trial before mass production. The feedthr of a central conductor, an outer conductor w connector and an insulator. The central conduct Kovar, the insulator is ceramic Al_2O_3 and the ou is made of aluminum alloy, which is joined connector made of titanium by a transition welding.

Some electrodes have been tested for mechan and thermal variation. The threshold level of th the central conductor is 60kg against a tensil vacuum leak dose not occur during heat cy liquid nitrogen temperature up to 200°C. Fur also welded on the flange of the electrode, vacuum leaks in order to examine the influence to locally heating.

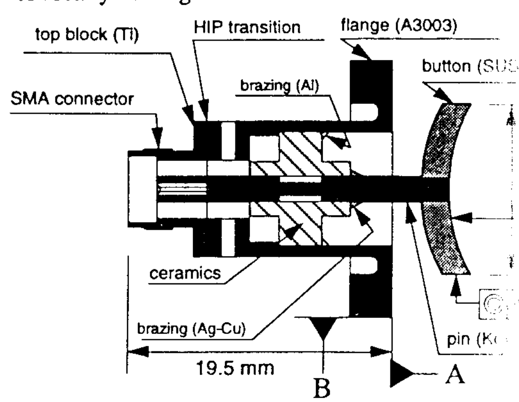

Fig.1 Pickup electrode

Pickup electrodes of 200 units were manufac the last fiscal years. All of electrodes wer regarding their mechanical tolerance, vacuum le heat cycle tests and dielectric strength by the ma

The mechanical tolerance of the pickup el good value, as shown in Table.

Table Specification and Tolerance

He-leak test	< 10-9 Tor
Heating cycle	liquid Nitroge
Dielectric strength	≥ 1000 V
Co-axial degree of pin(1)	≤ 0.1m
Outline degree of button(2)	≤ 0.1m

(1),(2) are shown in Fig. 1.

2.2 BPM Block

In the ATF-DR, each BPM is set near to almost every quadrupole magnet and sextupole magnet; the amount will be about 120 units. We have already manufactured 40 BPM blocks during the last fiscal years. The BPM block was machined from a mass of aluminum alloy, and four pickup electrodes were welded onto the block, as shown in Fig.2.

It has both horizontal and vertical reference planes with an accuracy within 50μm. Both planes become a reference for the calibration process so as to obtain electrical mapping of the BPM block. After installation of the BPM block on the end of the Q magnet or on an independent stage, the BPM offset from the field center of the Q magnet is also measured by using the reference plane.

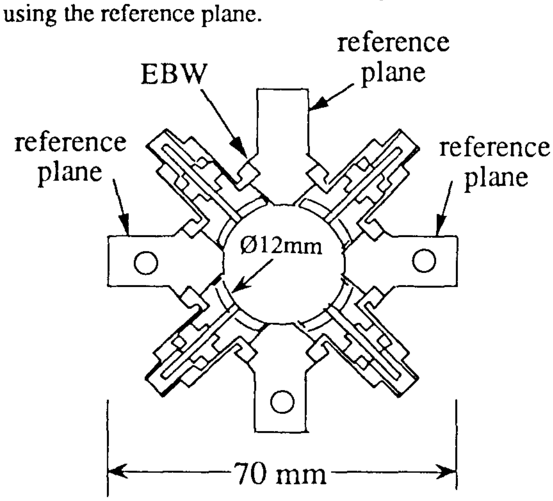

Fig.2 BPM block for the ATF-DR

3. Electrical characteristics

3.1 Characteristics of electrode

The feedthrough for the pick-up has been developed anew; the voltage standing wave ratio was improved compared with that of the TRISTAN BPM. It is less than 1.2 in the frequency region from dc to 5GHz. In addition, we observed the reflected waveform by using a time domain reflectometer (TDR), as shown in Fig.3.

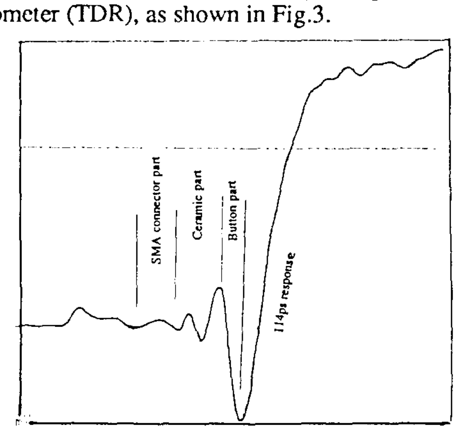

Fig.3 TDR response of a electrode
50mV/div., 100ps/div.

Before and after the electrode was mounted on the block, the capacitance of each electrode was also measured using a capacitance meter at a frequency of 800Hz. The electrical capacitance values are distributed in the 2.5~ 4.7pF region, as shown in Fig.4. Thus a group of the four pickup electrodes having a similar capacitance value was mounted onto the monitor block.

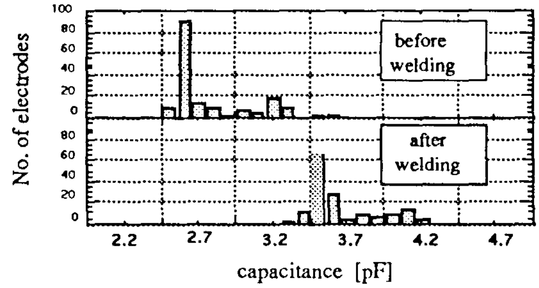

Fig. 4 Distribution of the electrode capacitance

3.2 Mapping for the calibration

Every BPM block was calibrated to obtain the offset between the mechanical and so as electrical center of the BPM block.[5] The mechanical center is defined according to the designed position from the horizontal or vertical reference plane. Also we can obtained the electrical center from mapping data for the calibration

The bench for the calibration is shown in Fig. 5. The BPM block was mounted on a fixed stage, and a 50μm diameter tungsten wire was strung coaxially in the BPM block. Both ends of the wire were placed in V-shaped groove made of ceramics, which was installed on the both of the two x-y movable stages with a high accuracy of better than 0.1μm. One side of the wire was soldered to SMA connector; the other end was terminated to match into a 50Ω line and attached 100g weights to give a constant proper tension. The wire was put in the base position of a gauge observed directly by a microscope. Thus, the wire was aligned precisely to the mechanical center of the BPM block. The alignment accuracy was obtained to be better than 40μm.

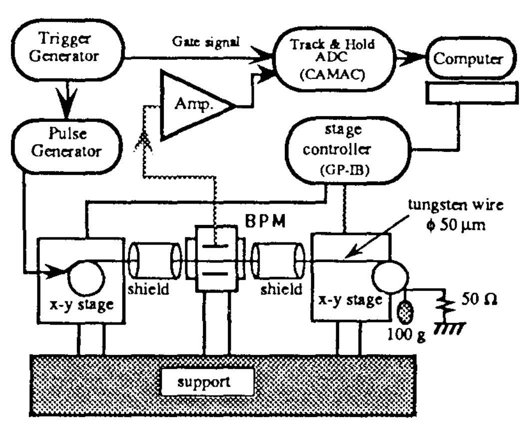

Fig.5 Block diagram of the calibration system

The calibration is performed by using 5ns rise time pulse signal. The signal processing is based on the same principle as one for FFTB.[6] A pair of electric circuits require for four pickup electrodes; the electrical circuit is a combination of a pulse stretcher amplifier, a Track&Hold ADC and a pulse generator.

We measured the four output signals (V1,V2,V3,V4) induced electrostatically on each electrode due to pulse signals transmitted on the wire. Now, in order to obtain the beam position, the following two calculation steps are necessary. The first is a normalization procedure (x',y'), given by

$$x' = k\frac{V2 - V4}{V2 + V4} \quad and \quad y' = k\frac{V1 - V3}{V1 + V3}$$

where the k is a coefficient of the sensitivity. It was obtained with an analytical method, which is determined by the geometry of the monitor chamber. Secondly, we converted the normalized results to the geometrical position (x,y) according to

$$x = \frac{\sqrt{2}}{2}(x' - y') \quad and \quad y = \frac{\sqrt{2}}{2}(x' + y')$$

In this way, we obtained a relation between the geometrical coordinates (x,y) and the mechanical coordinates (X,Y) of the wire position for each monitor. Fig. 6 shows the typical mapping. The calibration was performed at 169 points in the central area, which is a 3.6 mm square region with 0.3mm step. In the result, there was not remarkable distortion in the mapping of all BPM. In the central region, the distortion was less than 10μm and was 100μm at 2mm away from the center. This distortion is no problem in practical applications.

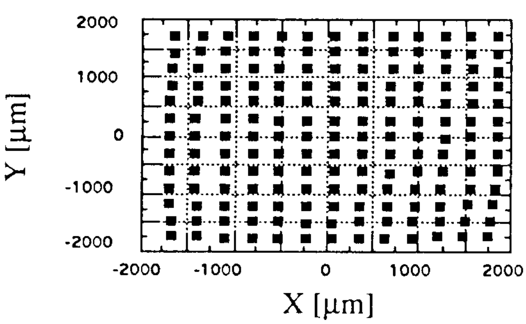

Fig. 6 Mapping of BPM block

We obtained the distribution of the offset from these mapping data, as shown in Fig. 7. The mean values of the offset are X=-19μm and Y=58μm, and the standard deviation is σx,y=90μm. Since there are some uncertainties in these values, we can not accurately illustrate the dispersion of the offset of each BPM block. These uncertainties are caused from the setting error of the wire.

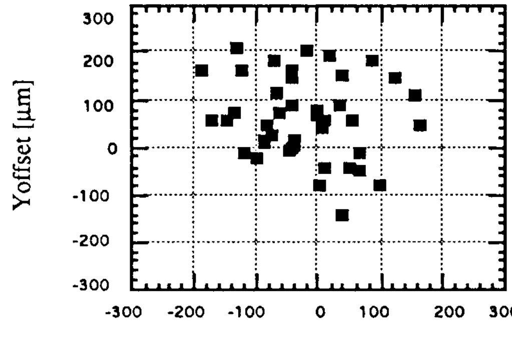

Fig.7 The distribution of the offset

4. Summary

This June, we performed measurements of the offset and a distortion in the central area of each BPM block, which was fabricated for the ATF-DR; the total amount is 40 units, one third of the whole. In the result, each offset indicated dispersion on the order of 90μm, although the distortion of the sensitivity was within 10μm. Therefore, first the construction for the BPM was satisfactory.

However we found some weak points in the following calibration process: alignment of the wire position, handling of the wire setting, moving of the x-y stage and shielding of the signal line. We will improve the inadequate parts of the bench for the calibration until the second construction of the ATF-DR BPM this fiscal year, considering these experiments.

The bench will also be applied to the LINAC BPM of the ATF. Therefore, we would like to construct a test bench with a higher performance.

5. References

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