A beam position monitor system is operated for two kinds of orbit measurements, a relative measurement and an absolute measurement. The former is to measure the orbit displacement from the initial or standard orbit when some optics perturbation is applied. The latter case is to measure orbit position relative to the geometrical monitor center. This function will be essential for maintaining stable operations in a ring where the optics depends strongly on the orbit, particularly near nonlinear optics elements. Closed orbit stabilization and correction routine operation for VEPP-2000 ring [1, 2]. To stabilize the beam orbit, the absolute beam position should be measured. The output data from a position measurement system usually pass through the vacuum chamber to the electric monitor center, not the geometrical center. So we should calibrate each beam position monitor to know the location of the electric center with respect to geometrical one i.e. relative to the reference frame of each BPM.

Moreover the system needs calibrating not only because of pickup characteristics (center displacement, sensitivity and nonlinearity) caused by machining, installation, cable matching, and signal processing circuits, but in order to meet the requirements on the accuracy of the measured beam position.

Basically there are 1 BPMs installed in VEPP-2000 ring, but there is reserve one. In order to test characterize and, align, and provide data for calibration, a general purpose test stand was designed and constructed in 2006. All BPMs needed for operations was calibrated and data analyzed in the same year, and last one was processed in 2009 because of some replacement actions.

1. INTRODUCTION

A beam position monitor system is operated for two kinds of orbit measurements, a relative measurement and an absolute measurement. The former is to measure the orbit displacement from the initial or standard orbit when some optics perturbation is applied. The latter case is to measure orbit position relative to the geometrical monitor center. This function will be essential for maintaining stable operations in a ring where the optics depends strongly on the orbit, particularly near nonlinear optics elements. Closed orbit stabilization and correction routine operation for VEPP-2000 ring [1, 2]. To stabilize the beam orbit, the absolute beam position should be measured. The output data from a position measurement system usually pass through the vacuum chamber to the electric monitor center, not the geometrical center. So we should calibrate each beam position monitor to know the location of the electric center with respect to geometrical one i.e. relative to the reference frame of each BPM.

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2. CALIBRATION TEST STAND

BPM Block

The electrostatic BPM for VEPP-2000 ring consist of four 15 mm diameter button style electrodes are mounted on the diagonals of its housing and are centered symmetrically. Buttons orientation is ± 5 degrees to avoid the fan of synchrotron radiation. All parts precisely machined from solid stainless steel blocks, isolated the electrodes and leadthroughs with ceramic material. The electrode surface is smoothed with that of the vacuum chamber, so the impedance induced by the electrode may be reduced greatly.

The vacuum chamber was scanned along constant lines and measurements were made with the antenna positioned at x = 0.82, 0.46, 0 mm and y = 0.32, 0.46, 0 mm grid-points, where x and y corresponds to the geometrical center. Figure 3 shows a nomogram of measured x and y, as defined in (3). The horizontal lines drawn at constant Y position, while the vertical lines correspond to X constant. The distance between lines is 2 mm. It shows that there is a good linearity in the central area of BPM, while pin cushion distortion appears clearly far from the central.

3. CALIBRATION AND ERROR ANALYSIS

Calibration of all monitors was made in the laboratory at a test bench. Now the voltages (A, B, C, D) on the BPM functions as a position are known and position is the desired variable. The challenge is to invert the function and solve for the position of the wire as a function of the voltage on the electrodes.

\[ V(A, B, C, D) \rightarrow f(x, y) \]  \hspace{1cm} (1)

A simple approximamtion involves linearization of summing over the difference

\[ x = k_x \cdot b_x + y = k_y \cdot b_y + v \]  \hspace{1cm} (2)

where kx and ky are calibration factors set by the geometry of the BPM, and signals (A, B, C, D) normalized as defined in (3).

\[ b_x = \frac{A}{k_x}, b_y = \frac{B}{k_y}, v = \frac{C + D}{k_x + k_y} \]  \hspace{1cm} (3)

Though accurate when the wire beam is close to the center of the BPM, these equations are not accurate at large deviations from the center. The lack of accuracy is unfortunate because the need for the BPMs is the most acute when the wire is not near the center. So one have to use nonlinear least-square fitting method. After calibration data are obtained, the mapping data are fitted by least-square method to fourth polynomials of (4), where

\[ x = k_{x1} \cdot x^4 + k_{x2} \cdot x^2 + k_{x3} \cdot x + k_{x4} \]  \hspace{1cm} (4)

\[ y = k_{y1} \cdot y^4 + k_{y2} \cdot y^2 + k_{y3} \cdot y + k_{y4} \]  \hspace{1cm} (4)

The repeatability of the scheme has been measured. Wire was placed in the same position after every 10 wire movement, and differences of the buttons voltages was compared. The difference of all three results were no more than ±0.1 V. These results show the accuracy of electronics system is about ± 1 µm.

4. SUMMARY AND CONCLUSION

The BPM calibration system has been established and tested. It was a theoretical resolution capability of 0.01 mm, as limited by the movable stage system. We designed a new calibration scheme, measuring the position on each grid point sequentially by the spectrum analyzer. Although we have not verified to this accuracy, we have obtained the clear BPM mapping using 1 mm step of wire movement. The calibration of the BPM system has been shown to be better than the requirements which VEPP-2000 BPM system wants. All calibration results saved as a tables of polynomial coefficients appropriate for using in software or other calculations.

References

