BEAM MONITOR OF INJECTOR SYNCHROTRON FOR UVSOR

Hiromichi Yamamoto
Department of Electronics, Fukui Univ.

Toshio Kasuga
Institute for Molecular Science

1. Introduction

Cylindrical beam monitors were designed and made to detect both the position and the bunch shape of the electron beam in the injector synchrotron for UVSOR. The synchrotron consists of six bending sections and six straight sections in which the quadrupole magnets, the perturbators and the other devices are installed. Position monitors will be set up one by one in each of the straight sections, and a fast intensity monitor will be installed separately.

Electrons injected from the 15MeV linac are accelerated by the RF power of 90.2MHz. In the beginning of the acceleration cycle, the bunch length is about 1.6m, and about 0.19m at the end of the cycle. The electrostatic type is chosen as the fast intensity monitor which detects the change of the bunch length because of its simple structure and its good frequency response. And it is also used as the position monitor. As the space in the straight section is limited, we adopt the monitor with four sectors because that is capable of detecting both the horizontal and vertical displacement with single monitor head.

2. Cylindrical Beam Monitor

The angular distribution of the electric field arising from a point charge at rest is uniform, but in the case of the moving charge, the more the velocity of the point charge increases, the less the electric field component parallel to the velocity becomes by the Lorentz contraction. As the electric field of the point charge moving at the velocity of light has the same distribution as the line charge, it is easy to calculate the amount of charges induced on the monitor electrodes.

We calculated the sensitivity and the output voltage from the amount of charges. Two electrode configurations of four sectors shown in Fig. 1 may be adopted. The formulae of the relative sensitivity are also given in Fig. 1. The sensitivities, $S_x(X,Y)$, of Type A and B were calculated. The calculated values of $S_x(0,0)$ are 13.8(1/m) for Type A and 19.5(1/m) for Type B. The maximum deviations of $S_x(X,0)$ from $S_x(0,0)$ are 5% for Type A and 9% for Type B when the horizontal excurtion of the beam is within 30(mm). When the vertical coordinate of the beam is 20(mm), they increase up to 10% and 13% respectively. The linearity of Type A is better than that of Type B. And the output signal processing of Type A is easier than that of Type B. We chose the configuration of Type A from these calculations. The dimension of our monitor is shown in Fig. 2.

3. Measurement and Accuracy

We measured the linearity of Type A monitor on a bench assembly. The measurements were performed as follows. From a signal generator of 50MHz, RF signal was supplied to an aerial which simulated an electron beam going through the monitor. The signals appearing on the electrodes were fed to a matching transformer with an impedance ratio 4:1 in order to transform the impedance of the monitor head into the impedance of the observing system of 50Ω because the time constant of the monitor, τ=RC, must be longer than the time length of the bunch, where C is the capacitance of the monitor, R is the load resistance. The differences between the signals from two facing electrodes were obtained by means of a hybrid transformer, and were observed with an oscilloscope. The results of the measurements are given in Fig. 3. The vertical and horizontal axes show the amplitude of the difference signal and the position of the aerial respectively. The good linearity is obtained within X=±18(mm). The measured sensitivity agrees well with the calculated one.

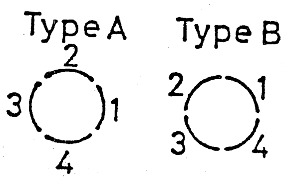
We will now discuss how the errors of the capacitances of the electrodes cause an offset on the measured beam position. The offset, ΔX_e, due to the capacitance error is represented by

$$\Delta X_e = \frac{\pi r}{8\sqrt{2}} \cdot \frac{\Delta C}{C}$$

where r is the radius of the monitor, ΔC and C are the capacitance difference of two facing electrodes and the average capacitance of the four electrodes respectively. In our case, r is 65(mm), C is 18.4pF and ΔC is 0.7pF. The offset of the position measurement will be 0.6(mm).

4. Conclusion

The cylindrical beam monitor of Type A is better than the Type B monitor with respect to the linearity and the easiness of the signal processing. Though the offset due to the capacitance error is not satisfactory, it is improved provided each of the capacitances of electrodes is corrected. The frequency range of the whole monitor system including the matching transformer is from 40MHz to 1GHz and it is sufficient for our purpose.



$$S_x \cdot \Delta X = \frac{Q_1 - Q_3}{Q_1 + Q_2 + Q_3 + Q_4} \quad (1) \qquad S_x \cdot \Delta X = \frac{Q_1 - Q_2 - Q_3 + Q_4}{Q_1 + Q_2 + Q_3 + Q_4} \quad (2)$$

Fig. 1 Two configurations of four sectors and relative sensitivity.

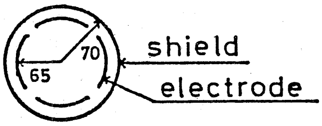


Fig. 2 Dimension of monitor.

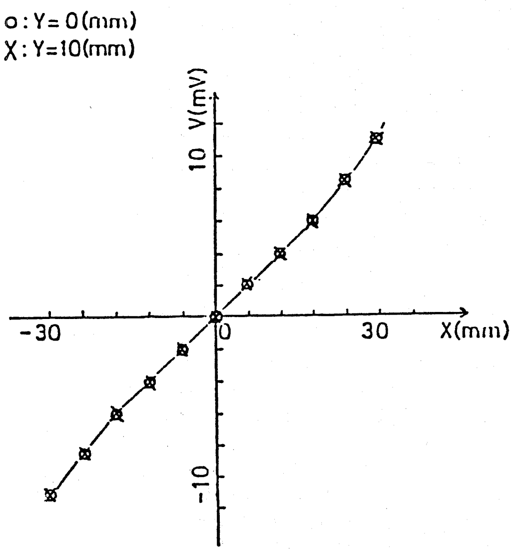


Fig. 3 Measurement of the linearity of Type A at 50MHz.

Reference

T.Katsura and S.Shibata
BEAM POSITION MONITOR FOR THE PHOTON FACTORY STORAGE RING
KEK Report 79-27, November 1979