IEEE Transactions on Nuclear Science, Vol. NS-26, No. 3, June 1979

IMPROVEMENT OF A BEAM POSITION MONITOR FOR ΔR FEEDBACK ON RF SYSTEM

Hajime Ishimaru, Motoo Kondoh and Shinkichi Shibata*

Introduction

When the beam intensity of the 12 GeV proton synchrotron is increased, oscillations occur in the radial direction of the beam, and the beam loss increases at the phase transition. The beam loss at the transition point was due to the ΔR feedback system on RF acceleration. The ordinary electrostatic pickup[1] used for RF feedback system was replaced with a new large size pickup.[2] Improvements were made in the following respects: 1. large size to obtain high signal to noise ratio, 2. no side walls to eliminate the noise due to beam hitting, 3. smooth ground for the shield electrode, 4. minimization of the distance between the electrode and vacuum feedthrough and the insertion of an oscillation damping resistor between them, 5. calibration wires were installed between the sensing electrode and the shield electrode. Electrode signals were processed by an average type rectifier and normalizer. The position signal was fed to an RF system through an analogue isolator. This paper deals with the modifications in the beam position feedback of the RF system.

Improved pickup

Fig.1 shows a new pickup electrode schematically. The new pickup electrode has a rectangular cross section and is 320 mm wide, 70 mm high and 320 mm long. The electrode is made of 304 stainless steel. The diagonally cut electrodes are insulated from the shielding electrodes by ceramic rings. Amplitude of the pickup signal is increased about three times because of the longer electrode. The gap between pickup electrode and shield electrode was increased to make stray capacitance smaller. The stray capacitance of each pickup electrode is 160 pF. There is no balancing capacitance to balance the stray capacitance.

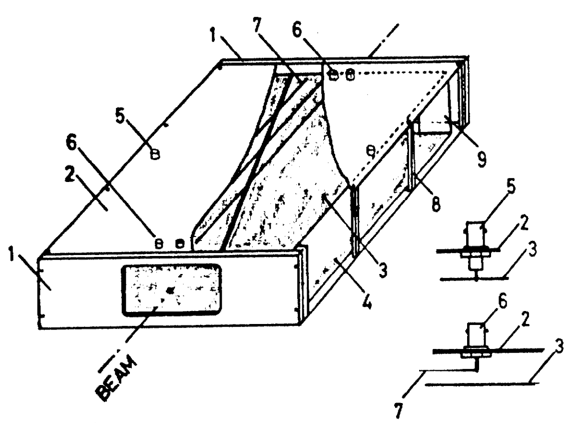
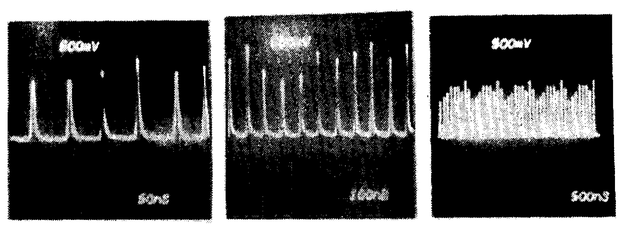


Fig.1 A new pickup electrode. 1. thick stainless steel window frame. 2. grounded shielding plate. 3. diagonally cut electrostatic pickup electrode (top). 4. pickup electrode (bottom). 5. BNC receptacle for signal out. 6. BNC receptacle for signal in and out of calibration wires. 7. calibration wire. 8. support between grounded plates. 9. connecting plate between top pickup electrode and bottom electrode.

The clearance of the pickup electrode and the shield electrode were adjusted precisely by insulated screw. If the balancing capacitance is installed on the outside of the vacuum chamber, small and fast oscillation is observed. The new pickup electrode is parallel diagonally cut electrodes with no side walls in order to eliminate the noise due to lost beam hitting. To obtain linearity of the sensitivity in the radial direction, a wide electrode is necessary. A smooth ground for the shield electrode is important for reduce the oscillation due to stray inductance and capacitance. The wall current must flows smoothly on the inner surface of the shield electrode, so that the beam bunching is not disturbed. The distance between the electrode and the vacuum feedthrough is minimized. To reduce the small and high frequency oscillation due to the inductance of the air interface, as damping resistor of 50 ohm is inserted between the pickup electorde and the cable driver. BNC-JJ[3] type vacuum feedthrough is used for the vacuum and air interface. A thick stainless steel window frame, of inner size smaller than the aperture of the pickup electrode, was placed upstream and downstream of the pickup electrode in order to suppress secondary charged particles. Calibration wires are installed between the pickup electrode and the shield electrode. These calibration wires are useful to check the position electronics.

The pickup electrode is connected to the average type normalizer via a cable driver and pair of low loss coaxial cables (10D2W) of about 250 m long. The



(a) (b) (c)

Fig.2 Typical beam bunch signal in front of the normalizer at the phase transition. (a) 50 ns/div, (b) 100 ns/div, and (c) 500 ns/div.

input impedance of the cable driver is 2.2 kΩ and the output impedance is 50 Ω.

A typical beam bunch signal is shown in Fig.2. The amplitude of the bunch is about 1 V at injection. The noise level is less than 10 mV. A typical beam bunch shape of an ordinary pickup is shown in Fig.3.

Signal processing

A block diagram of the improved position for ΔR feedback is shown in Fig.4. Old type position monitor consist of the pulse transformer, 100 nsec rise time integrator, fast amplifier and attenuator between the

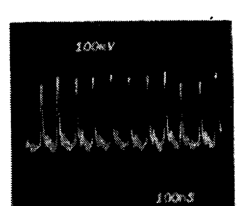


Fig.3 A typical beam bunch shape of the ordinary electrostatic pickup electrode.

* National Laboratory for High Energy Physics, Oho-machi, Tsukuba-gun, Ibaraki-ken, 300-32, Japan

0018-9499/79/0600-3361$00.75 © 1979 IEEE

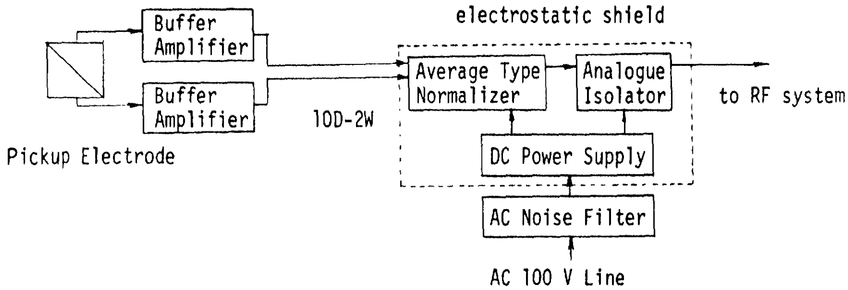


Fig.4 A block diagram of the improved position monitor for ΔR feedback in the RF system.

pickup electrode and the normalizer. A low pass filter was inserted between the normalizer and the RF system. The amplitude of the output was small, about 30 mV, and the noise and oscillation was rather high. A low pass filter such as a rise time integrator, was required between the cable driver and the normalizer to reduce bunch shape dependence of position signal. In the improved position monitor signal to noise ratio is improved without amplifier and rise time integrator. The signal processing circuits become very simple. The ground is isolated from the RF system using an isolated dc power supply and an analogue isolator. The rectifier for the beam signal in the normalizer is a pair diode followed by low pass filter.

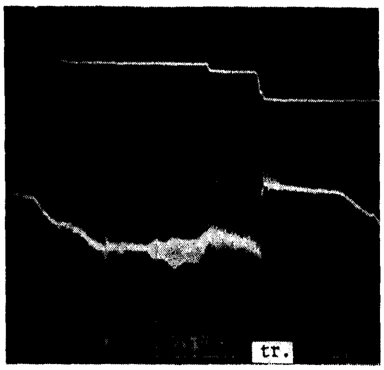


Fig.5a Before improvement of ΔR feedback system. top: beam intensity , bottom: beam position after acceleration start. 50 msec/div.

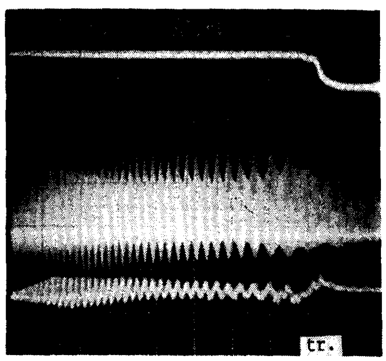


Fig.5b top: beam intensity, middle: beam position, bottom: fast intensity, 10 msec/div. $2f_s$ oscillation is observed.

ΔR Feedback

Before improvements of the position feedback system, two times of the frequency of the synchrotron oscillation appeared in the signal of the fast intensity monitor and the signal of the position monitor as shown in Fig.5 (a) and (b). The oscillation in the beam bunch correlates strongly the oscillation in the position signal. After improvements of the position feedback system, $2f_s$ oscillation disappeared in the signal of the fast intensity monitor and the signal of the position monitor as shown in Fig.6. But after transition, $2f_s$ oscillation comes out in the fast intensity monitor. Cancellation with $2f_s$ feedback control after the phase transition has been performed.[5] By these improvements the bunch signal became quite clean and beam oscillation before the phase transition was eliminated so that no beam loss at the transition point appeared as shown in Fig.7.

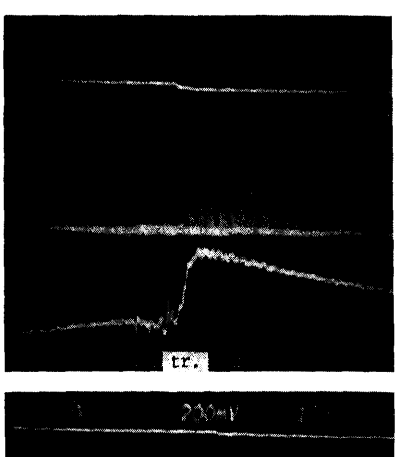


Fig.6a After improvement of ΔR feedback system. top: beam intensity, middle: fast intensity, bottom: beam position.

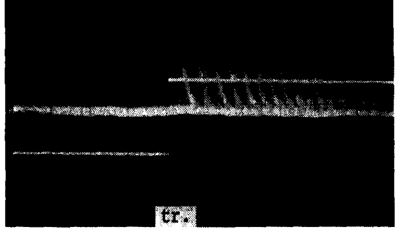


Fig.6b After improvement of ΔR feedback system without $2f_s$ feedback. top: beam intensity, middle: fast intensity, bottom: phase jump. 10 msec/div.

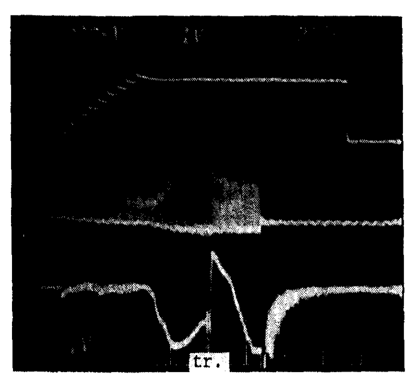


Fig.7 After improvement of beam position monitor in ΔR feedback system of RF. top: beam intensity, middle: fast intensity bottom: beam position.

References

1) S. Shibata, K. Muto, H. Ishii and Z. Igarashi, KEK Beam Position Monitor System, IEEE Transactions on Nuclear Science, Vol.NS-24, No.3, 1977.
2) H. Ishimaru, Z. Igarashi, H. Ishii and S. Shibata, KEK-ASN-80, 1977.
3) H. Ishimaru, BNC-JJ Coaxial Floating Shield Bakable and Coolable Vacuum Feedthrough Useful from DC to 4 GHz, Rev. Sci. Instrum. 49 (4) 1978.
4) H. Ishimaru, Z. Igarashi and S. Shibata, KEK-ASN-136, 1978.
5) E. Ezura and M. Kondoh, Report on Countermeasures for Beam Loss at the Transition of KEK Main Ring, KEK-ACCELERATOR-79-1, 1979.