BUNCH LENGTH MONITOR USING AN RF DETECTOR

Takao Ieiri

National Laboratory for High Energy Physics (KEK)

A longitudinal emittance is given by a bunch length and a momentum spread of a bunch. A circuit has been developed for easily measuring the bunch length. The bunch length is obtained from a peak value of a bunch and an average beam current. The circuit is tested using a beam in the KEK Booster and the Main Ring. It is found experimentally that the bunch length measured by this method agrees with a usual direct measurement of a bunch.

Supposing that a current distribution of a bunch is parabolic as illustrated in Fig. 1, an instataneous current i is

$$i = i_m \{ 1 - (\varphi / \varphi_1)^2 \} \qquad (1)$$

where i_m is a peak current of a bunch, φ is phase and $2\varphi_1$ is equal to the bunch length in a longitudinal direction. An average beam current I made by B bunches is

$$I = B \cdot \frac{1}{2\pi} \int_{-\varphi_1}^{\varphi_1} i \cdot d\varphi \qquad (2)$$

supposing that B bunches are same particles and distribution. From (1) and (2), we have

$$I / i_m = \frac{B}{3\pi} \cdot 2\varphi_1 \qquad (3)$$

Then, the I/i_m shows a relative value of the bunch length.

An rf detector is bench tested using a pulse generator. It is used to detect a peak value of a bunch simulated by a pulse. Its frequency response has from 0.1 to 1000 MHz. An output level of the detector is about 0.2V lower than a peak value and depends little on an amplitude, frequency and a width of an applised pulse. A revising bias voltage of 0.2V is added to the output of the detector for decreasing an error as small as possible. A schematic diagram for measuring the bunch length is named Bunch Length Monitor (BLM) as shown in Fig. 2.

The BLM is tested using in the Booster. A measurement is done during a latter half of accelerations. The bunch length picked up by a transformer is directly measured on an oscilloscope for comparison. The results are shown in Fig. 3. The two values are normalized at 17 msec after the injection. They are agreed within 10 percent. Next, the BLM is tested around the phase transition in the Main Ring. A bunch signal picked up by a WCM[1] and a current monitor[2] are used. A typical example is shown in Fig. 4. It is observed that the bunch length is rapidly increased and bunch-length oscillations are simultaneously excited after the rf phase jump.

The BLM makes the time variations and fluctuations of the bunch length seen easily. It is a nondistractive monitor, the length is always observed on an oscilloscope.

references
1) H. Nakagawa et al., IEEE Trans. NS-26,No.-3 (1979) 3367
2) S. Hiramatsu et al., Proceeding of the 2nd Symposium on Accelerator and Technology p.121,1978

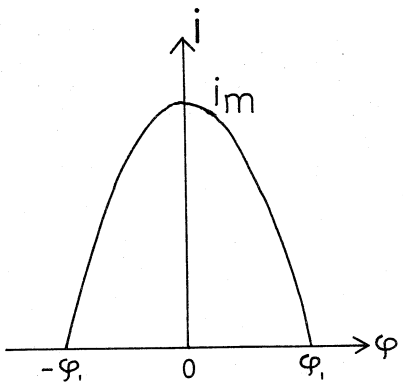

Fig.1 Current distribution of a bunch

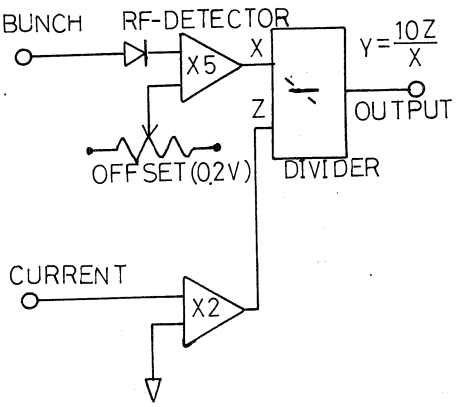

Fig. 2 Schmatic diagram of bunch length monitor (BLM)

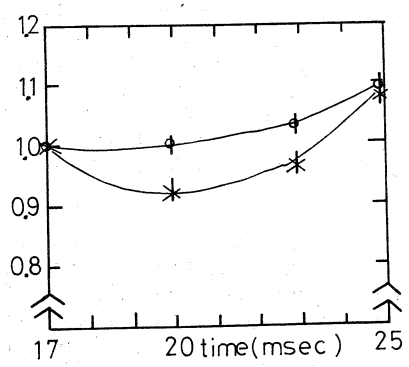

Fig.3 Relative bunch length at booster extraction
Φ is direct measurement of bunch.
✳ is obtained from I/i_m.

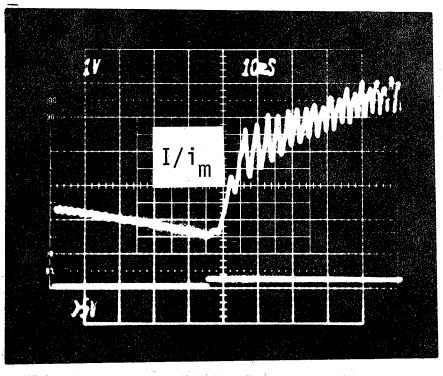

Fig.4 Bunch length around phase transition