A BEAM POSITION MONITOR USING AN AMORPHOUS MAGNETIC CORE

Toshiaki Kobayashi, Toru Ueda, Yoichi Yoshida, Takahiro Kozawa, Mitsuru Uesaka and Kenzo Miya

Nuclear Engineering Research Laboratory, Faculty of Engineering, University of Tokyo
22-2, Tokai-mura, Naka-gun, Ibaraki 319-11

Seiichi Tagawa

The Institute of Scientific and Industrial Research, University of Osaka
8-1, Mihogaoka, Ibaraki, Osaka 567

Hitoshi Kobayashi

National Laboratory for High Energy Physics
1-1, Oho, Tsukuba, Ibaraki 305

ABSTRACT

A beam position monitor for an electron accelerator has been developed by using an amorphous magnetic core. The position is detected by the difference of leakage inductances of four pickup coils wound on the amorphous magnetic core. The accuracy of the beam position monitor is less than 1mm for the various electron pulses from nanosecond to microsecond.

INTRODUCTION

For the fine operation of the linear accelerator, it is important to measure the current, the pulse shape and position of the beam. A beam current monitor using an amorphous magnetic core (ACM) for measuring short pulse beam was been developed in 1987. The ACM shows fast response and good S/N ratio due to the high permeability of the amorphous magnetic core [1 - 4].

The pulse shape from the ACM does not depend on the position of the beam, because, the leakage inductance of the troidal pickup coil wound on the amorphous core is very small. On the other hand, a pickup coil wound on the small region of the core, the leakage inductance can not be neglected. The leakage inductance depends on the position of the beam. By using this effect, a new beam position monitor has been developed.

CONSTRUCTION

Fig. 1 shows the structure of the beam position monitor. The monitor is composed of an amorphous magnetic core, the four pickup coils (5turn), housing, SMA type connectors and four 50 ohm terminations. This monitor is mounted on the outside of a ceramic beam duct in the atmosphere. The pickup coil is 0.3mm diameter wire and its end part is shorted.

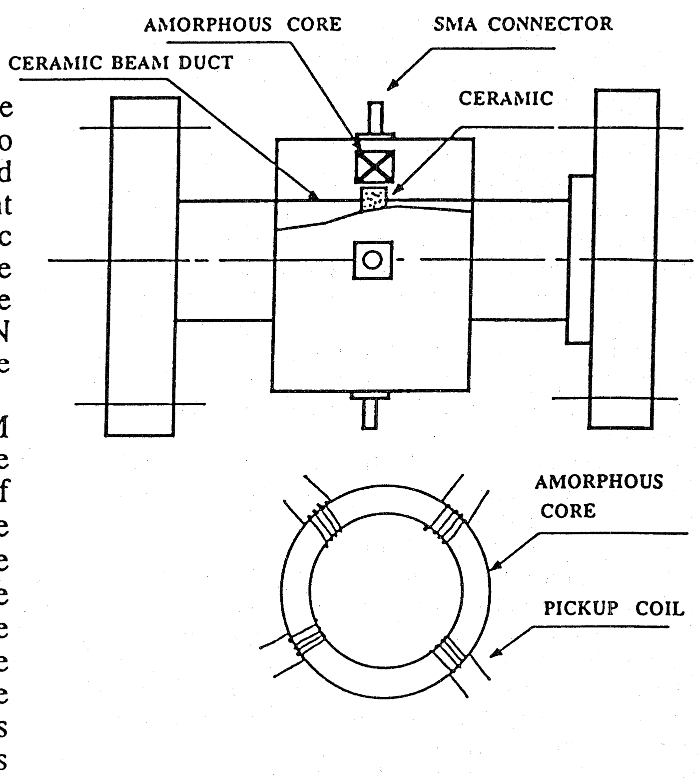

Fig. 1 Schematic cross section of beam position monitor

PRICIPLE

This beam position monitor picks up the magnetic field generated by electron beam. Fig. 2 shows the equivalent circuit. The induced voltage, V, at pickup coil for the input voltage of the step function is described as follows,

$$V = (4RE/L)\,t\,e^{-2Rt/L},$$

where R is the load resistance, L is the leakage inductance, C is the stray capacitance, E is the input voltage and t is the time.

The leakage inductance depends on the beam position. The rise time of the induced voltage is especially changed. Therefore, the beam position can be obtained by analyzing the time-profile of the rise shape.

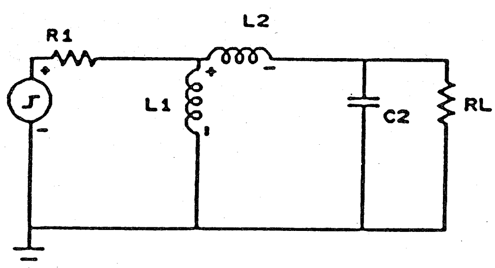

Fig. 2 Equivalent circuit of the beam position monitor

CALIBRATION OF THE MONITOR AND SIMULATION

For calibration of the beam position monitor, a test bench using a pulse generator, a single wire, the position monitor, matching register (50 ohm) and X-Y stage were constructed. The test bench is shown in Fig.3. The pulse current through the single wire was measured by using a fast current probe (tektronix CT-2, inner diameter 1mm) and the beam position monitor.

Fig. 4 shows the position dependent response of the monitor. Upper traces (4a) were detected by adjusting the wire at center position of the core. The pulse shapes from the four pickup coils were quite agreed. Lower traces (4b) were detected by moving the wire to the position 20mm away from the center. The difference of the pulse shapes from the four pickup coils depended on the position of the wire. The pulse shapes of the beam position monitor were simulated by an electric analysis code (MICROCAP-3). The results are shown in Fig. 5. The preliminary experimental results almost agreed with simulative results.

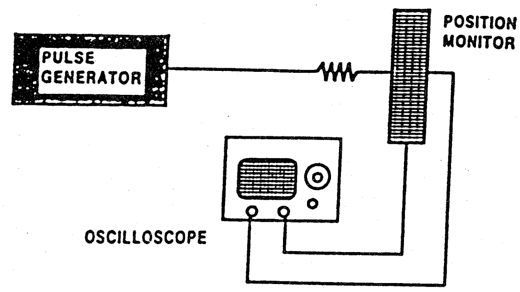

Fig. 3 Block diagram for test bench of calibrating beam position monitor

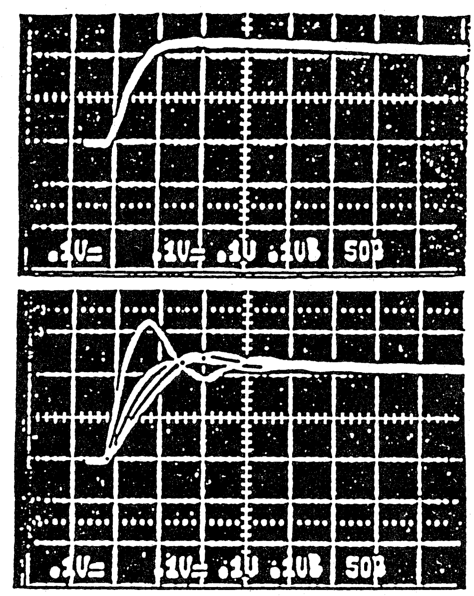

Fig. 4 Pulse shape of the beam position monitor using test bench

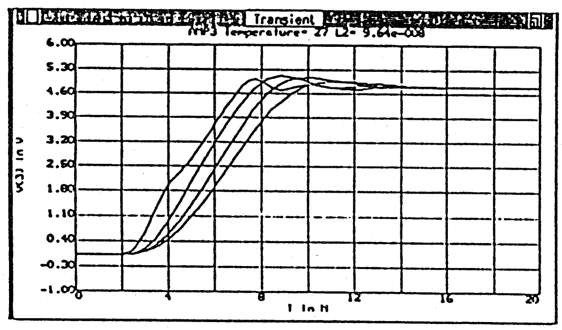

Fig. 5 Simulation of the beam position monitor

PERFORMANCE OF THE POSITION MONITOR

The accuracy of the beam position measurement was measured by using the electron beam from a 28MeV linear accelerator [5 - 6]. The beam pulse width and the peak current were 80ns and 60mA, respectively. The position monitor was assembled on the vacuum duct with the accuracy within 1mm.

Fig. 6 shows the pulse shapes from the four pickup coils. Upper traces (6a) were obtained when the beam passed the center of the core. The pulse shapes of the four pickup coils were agreed approximately. Also, lower traces (6b) were obtained when the beam passed the position 20mm away from the center. The difference of the pulse shapes from each pickup coils depends on the position of the beam monitor.

As a next step, we are going to study the computer tomography by using this monitor.

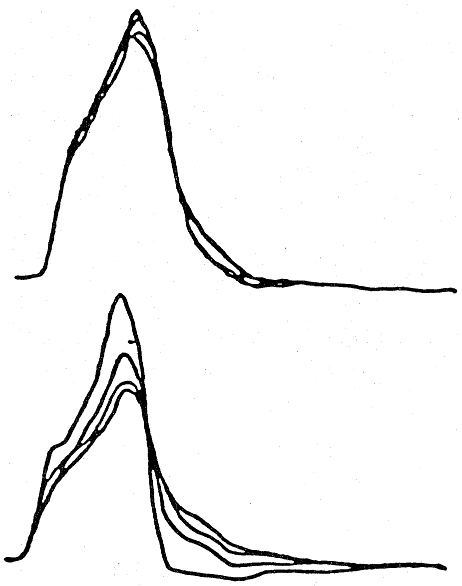

Fig. 6 Pulse shape of the beam position monitor using a 28MeV linear accelerator

CONCLUSION

A beam position monitor for an electron accelerator has been developed by using an amorphous magnetic core. The accuracy of the beam position monitor is less than 1mm for the various electron pulses of which pulse width were from nanosecond to microsecond.

ACKNOWLEDGMENT

The author would like to thank Dr. H. Shibata for his suggestion and M. Yuura (Pulse Electric Engineering Co.) in several discussions.

REFERENCES

[1] T. Kobayashi, IONICS (1988) 1.

[2]T.Kobayashi,OYO-BUTURI,57 (1988) 1382.

[3] T. Kobayashi, T. Ueda, Y. Yoshida, K. Miya, S. Tagawa, H. Kobayashi, Proc. 17th linear accelerator meeting in Japan (1992) 210.

[4] T. Kobayashi, T. Ueda, Y. Yoshida, K. Miya, S. Tagawa, H. Kobayashi, Nucl. Instr. and Meth., in press.

[5] H. Kobayashi, T. Ueda, T. Kobayashi, S. Tagawa and Y. Tabata, Nucl. Instr. and Meth. 179(1981) 223.

[6] H.Kobayashi,T.Ueda, T.Kobayashi, S.Tagawa and Y.Tabata, UTNL-R-0252,Nucl. Engng. Res. Lab., Faculty Engng., Univ. Tokyo, (1990) 38.