Short Bunched Beam Monitor

T. Naito, * H. Akiyama, J. Urakawa, T. Sintake and M. Yoshioka
KEK, National Laboratory for High Energy Physics
1-1 Oho, Tsukuba-shi, Ibaraki-ken, 305 Japan

* The Graduate University for Advanced Studies
1-1 Oho, Tsukuba-shi, Ibaraki-ken, 305 Japan

Abstract

In order to monitor the short bunched beam, two types of monitors were developed and tested. A core monitor using a Co-based amorphous core which has high μ characteristics and high frequency response can be used as a non-destructive current monitor for the beam in the range of 1ns to several μs pulse width. A wall current monitor designed carefully has been also tested. The wall current monitor has measured the beam shape with the pulse width of 200ps or less. In this paper the characteristics and overall performance of these monitors are described.

I. INTRODUCTION

In order to get high-current, low-emittance and multi-bunch beam in the injector of JLC(Japan linear collider), we are developing two schemes.[1] One is a RF gun and the other is a conventional thermionic gun using a fast grid pulser. The laser triggered RF gun at the test bench in TRISTAN Assembly Hall is expected to generate the beam of 20ps pulse width and the thermionic gun for ATF(Accelerator Test facility) in Nikko Experimental Hall is aimed to generate the beam of 700ps pulse width or less.[2] The non-destructive fast monitor is required for measuring and observing these beams. But ordinary core monitors and wall current monitors haven't adequate fast response time.[3] Therefore we have tried to improve the characteristics of these monitors using new material and making careful design.

The characteristics and overall performance of these monitors are presented in the following two sections.

II. AMORPHOUS CORE MONITOR

A Co-based amorphous core was used as the material of the core monitor. The amorphous core has high μ characteristics and high-frequency response. We used 6025F(made by VACUUMSHMELZE GmbH) type troidal core. The main parameters are that inner diameter 40ϕ, outer diameter 50ϕ, thickness 5mm, Bm 0.4T, Hc 0.004A/cm and μ_s ~100,000. The core monitor using the amorphous core can reduce the winding coil and consequently can respond to more fast pulse beam.[4] In order to improve the characteristics for more fast beam response, we measured the response of the amorphous core monitor to which a fast pulse has been fed using tapered pipe and inner conductor. The winding of the monitor has been arranged for matching the fast pulse. Finally, 3mm width copper tape as the winding coil was used for reducing the inductance. The monitor and the pulse response are shown in Fig.1. At the version using one turn pick-up coil, the monitor can respond to 200ps pulse but not sufficient(a). At 1ns pulse, the monitor can respond sufficiently(b). It has 500ps rise time. This version has the droop over 10% which is observed with the input over 10ns pulse width. At the version using ten turns pick-up coil, the monitor can respond to 1μs pulse or more but small ringings are observed(c),(d),(e).

III. WALL CURRENT MONITOR

To observe more fast beam, we made a carefully designed wall current monitor. Same ceramic duct as the amorphous core monitor was used for the monitor. The ceramic was covered with copper tape except 1mm distance for attaching chip resistors which have low inductance. Ten or more resistors for microwave circuit are used for balanced current flow on the duct, which can use up to 12GHz. A 3ϕ semi-rigid cable is connected directly to the pick-up. The high frequency response of the monitor is determined by CR time constant only and the estimation of CR about used 5Ω resistors is about 20ps. Fig.2 shows the photo of the monitor and the pulse response obtained using same instruments as the core monitor. The monitor could respond to both 200ps pulse(a) and 1ns pulse(b), adequately.

TRANSVERSE POSITION DEPENDENCE When the fast beam in pico-second range moves on off-center of the duct, the signals induced to each resistor are not same and a current is azimuthally flowed. But the azimuthal current doesn't arrive at the same time. The arrival time of the signal from the opposite side to the pickup is over 200ps.[5] Consequently, the output of the monitor has a transverse position dependence. Therefore, we use the wall current monitor for observing the wave shape only, not use for measurement of the current value.

CABLE RESPONSE The fast beam signal is transmitted from the pick-up to sampling scope at the outside of the radiation shield through the cable. The response of the cable with step function is explained by error function.[6][7] From the reference 7), the equation of the 10% to 50% rise time is

$$t_r = 0.9\, k_0\, l^2,$$

where

$$k_0 = 6.6\times10^{-8}\frac{A(\mathrm{dB/km})}{\sqrt{f(\mathrm{MHz})}},$$

l : length of the cable, A : cable loss at f: the frequency, respectively. Therefore, the cable has to make short and use low loss type.

In the case of the thermionic gun of ATF, the cable of about 10m length LHPX-10D(Hitachi Cable, Ltd.) was used. The estimation of the rise time of this cable is less than 200ps by using this equation. In the case of the RF gun at the test bench, semi-rigid cable of 3m length is used. It has about 50 ps rise time.

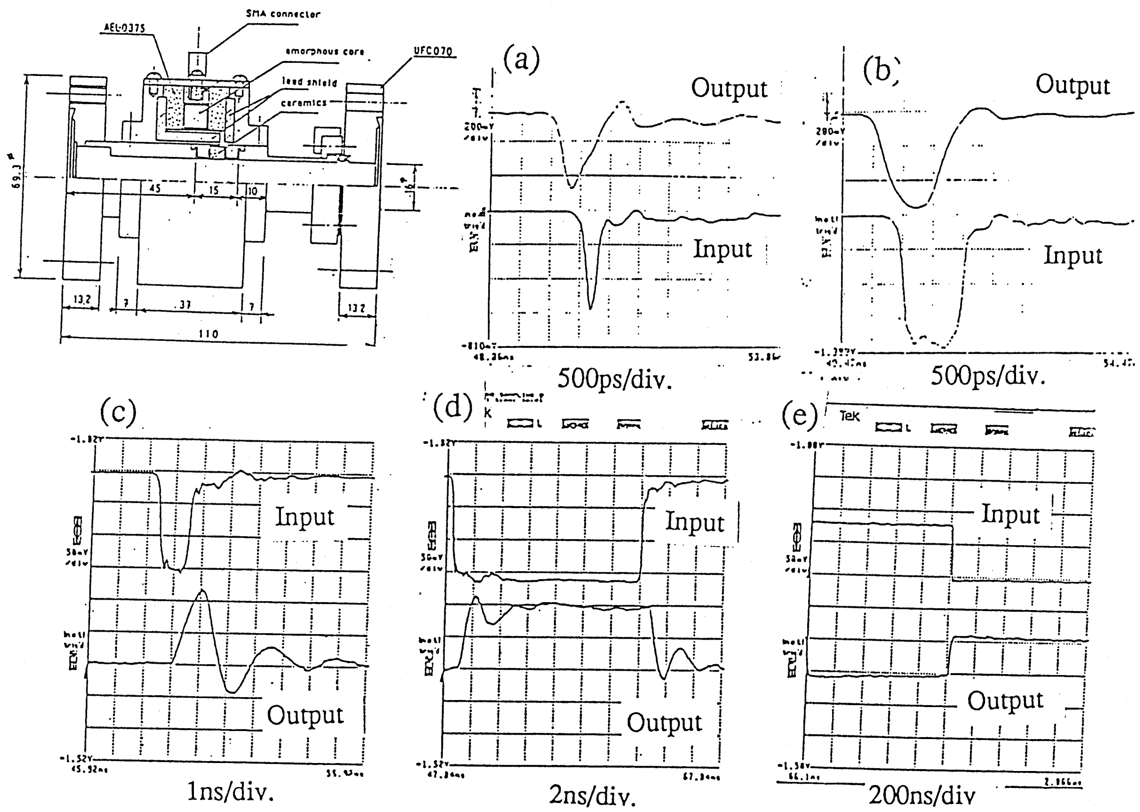

Fig.1 Characteristics of amorphous core monitor -- The waveform of the core monitor obtained using the pulse simulating the beam. With 1 turn pick-up coil (a)at 200ps pulse input and (b)at 1ns. With 10 turns pick-up coil (c)at 1ns pulse input, (d)at 14 ns and (e)at 1μs.

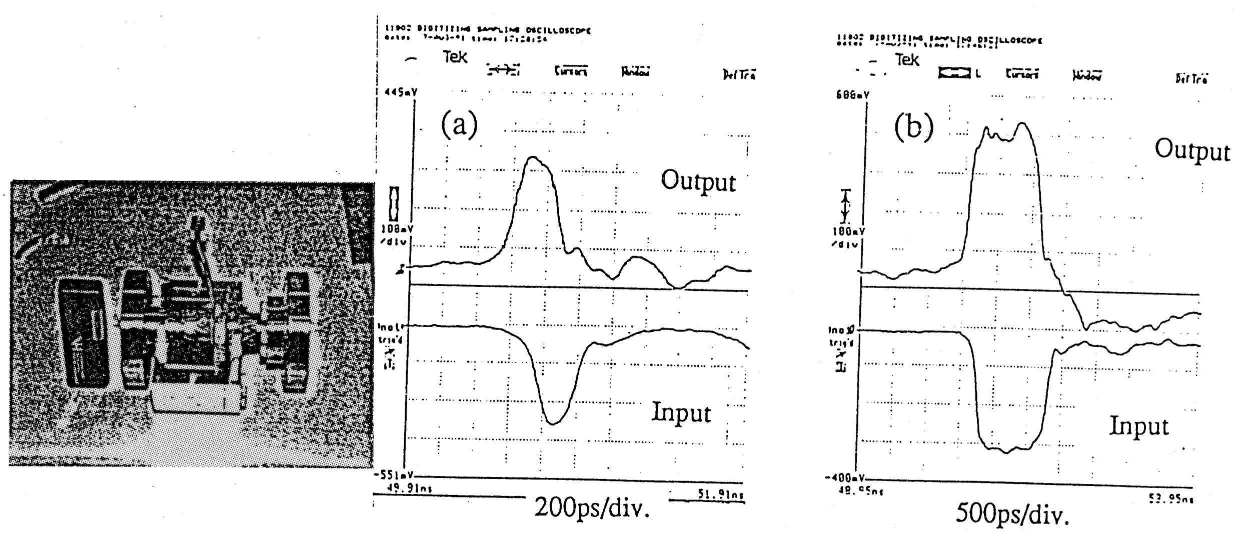

Fig.2 Characteristics of wall current monitor -- The waveform of the wall current monitor obtained using the pulse simulating the beam. (a) at 200ps pulse input and (b)at 1ns.

IV. BEAM MEASUREMENT

In the case of the thermionic gun of ATF, Y-796 cathode response was tested using a fast grid pulser which generates the output of 1ns pulse width. Using the amorphous core monitor, the emission current, which was 6A at the peak and 2ns at full width, was measured.(Fig.3) And the same beam was observed by the wall current monitor.(Fig.4) In Fig.4, you can see more sharp beam shape and the dependence of the beam shape on the grid bias voltage of the gun. Fig.4 indicates that the beam less than 1ns pulse width was generated.

Also we are preparing the measurement of the beam from the RF gun. We will present the measurement of beam shape in this conference.

V. ACKNOWLEDGEMENTS

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VI. REFERENCES

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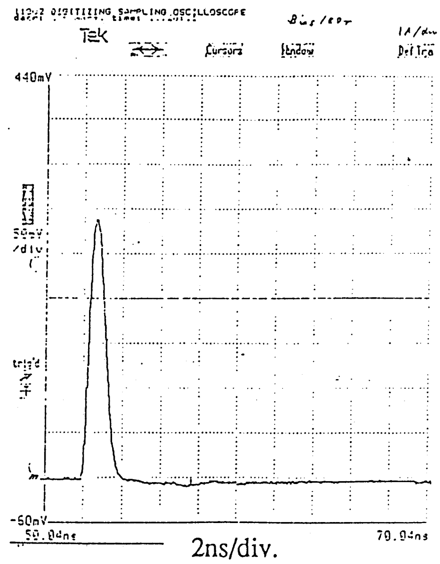

Fig.3 Emmision current of the thermionic gun of ATF measured by the amorphous core monitor.

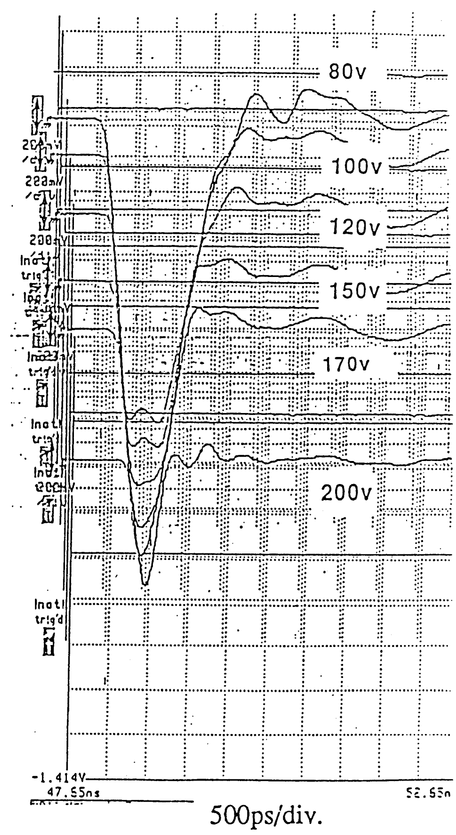

Fig.4 Emmision current of the thermionic gun of ATF observed by the wall current monitor.