PULSE-BY-PULSE PHOTON BEAM MONITOR WITH MICROSTRIPLINE STRUCTURE IN NSRRC

Chien-Kuang Kuan[1], Hideki Aoyagi[2], I.C. Sheng[1], Sunao Takahashi[2], Ching-Lung Chen[1], Zong-Da Tsai[1], Gao-Yu Hsiung[1], Duan-Jen Wang[1], Hideo Kitamura[2], June-Rong Chen[1].
[1]National Synchrotron Radiation Research Center
[2] SPring-8 / JASRI

Abstract

In order to diagnose pulse-by-pulse beam movement of photon beam, NSRRC (Taiwan) and SPring-8(Japan) have work together to develop a photon beam monitor with microstripline structure, which is designed to have specific impedance of 50 ohm. The detector head is composed of a metal line (copper), a ceramic plate (aluminum nitride) and a cooling base (cooper tungsten). The metal line function is as a photocathode. The metal line is directly connected to SMA feed-through connectors to have fast response time. The detector head has been fabricated in SPring-8, and mounted on the monitor chamber and installed in NSRRC Superconducting Wiggler (SW) front end. The beam monitor can be used to examine not only pulse-by-pulse photon beam, but also the storage ring intensity and the pulse timing [1,2]. Unique feature of the monitor is to produce unipolar short pulses. The design, fabrication and the measurement will be presented in this paper.

INTRODUCTION

The existing monitors of XBPM [3], screen monitor and Io monitor [4,5] are to diagnose the photon beam movement of low frequency. The pulse-by-pulse beam movement of photon beam is high frequency about GHz, so there need a photon beam monitor has a pico-second response. NSRRC and SPring-8 have work together to develop a pulse-by-pulse photon beam (PPPB) monitor with microstripline structure, which is used in the front end. The detector head of the PPPB monitor was designed and fabricated in SPring-8, and then sent to NSRRC. The detect head was welded on a special flange and mounted on the monitor chamber. Now it has been installed in SW front end of NSRRC.

NSRRC has a new project of 3 GeV accelerator, Taiwan Photon Source (TPS), the PPPB monitor installed in the SW front end is also for testing the beam conditions similar to the TPS BM beamlines. The period of pulse-by-pulse beam is 2 ns in the storage ring of Taiwan Light Source (TLS). From the test result the PPPB monitor can detect the pulse-by-pulse photon beam and has pico-second resolution. The PPPB monitor is good instrument to installed in the future TPS.

DESIGN OF MONITOR

The PPPB monitor is microstripline structure. Figure 1 shows the detector head of PPPB monitor is composed of a metal line (copper), a ceramic plate (aluminum nitride) and a cooling base (cooper tungsten). The function of the metal line is as a photocathode. The metal line is directly connected to SMA feed-through connectors to have fast response time, which is designed to have specific impedance of 50 ohm.

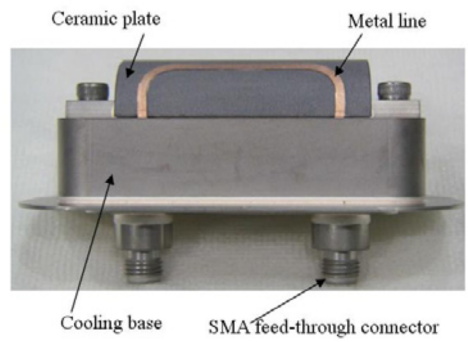

Figure 1: The detector head of pulse-by-pulse photon beam monitor.

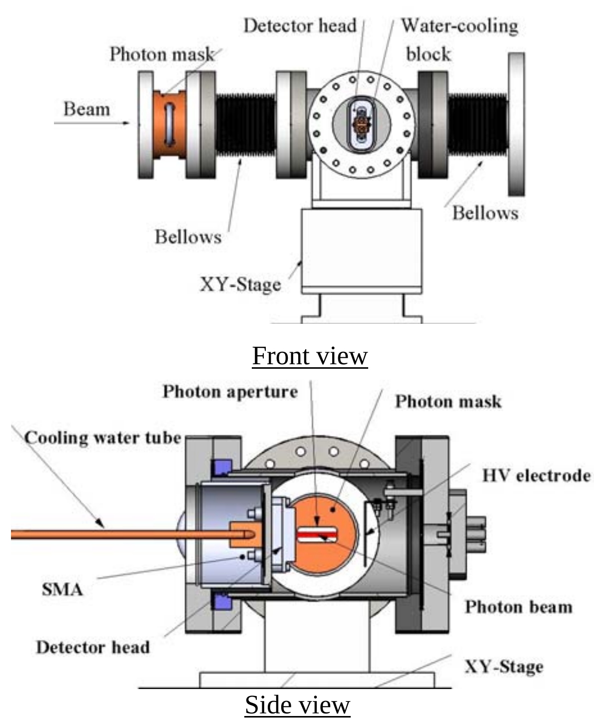

Figure 2: The assembly of pulse-by-pulse photon beam monitor.

Figure 2 shows the assembly of the PPPB monitor, the detector head is installed vertically. In order to prevent too much heat load on the detector head and have good signal performance, we use the photon mask and the XY-stage to keep the detector head to be irradiated between 3 to 4 mm from the edge. The air side of the cooling base is connected with a water-cooling block. The High voltage (HV) electrode is to reduce the noise from the scattering light. The signal cable uses the helical N-type to prevent the decay of signal. Due to the helical N-type cable is too hard to bend, there use a short length of SMA-type cable between the detect head and helical N-type cable. We use the Tektronix DPO-7254 oscilloscope, which has a sampling rate 40GHz in one channel, to receive the pulse-by-pulse photon beam signal.

TEST OF MONITOR

The detector head of PPPB monitor is designed to have 50 ohm impedance. By using the network analyzer to test the radio frequency (RF) property of the detector head up to 6 GHz. Figure 3 shows the detector head has small decay of the transmitted energy (S12), and small reflected energy (S22).

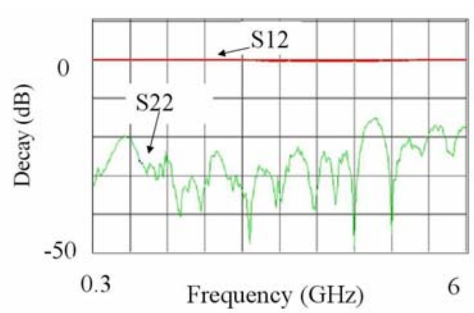

Figure 3: Using the network analyzer to measure the S12 and S22 of the detector head

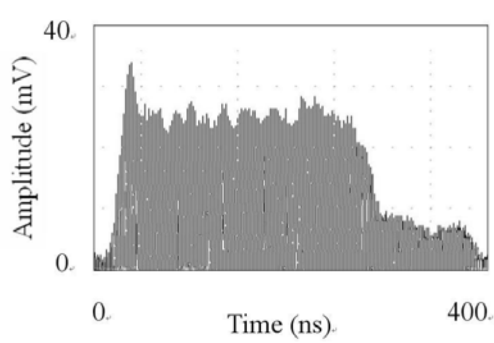

Figure 4: The filling pattern of TLS storage ring captured from the oscilloscope

The circumference of TLS storage ring is 200 meters, the electron beam needs 400ns to run one turn. The pulsed signals of SR beam are 2ns bunch separated, it always fills about 120 bunches. The filling pattern of TLS storage ring is shown in figure 4 obtained by PPPB monitor with bias voltage 300V.

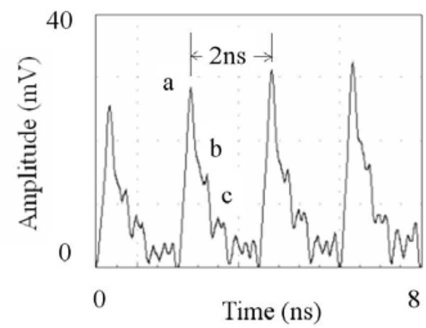

Figure 5: The pulse-by-pulse photon beam in TLS storage ring

Figure 5 shows that the peak-a is the pulse-by-pulse photon beam with 2 ns period. The peak-b and peak-c display there are some noise into the signal. The signal can be suppressed by applying higher bias voltage on the HV electrode, but it will not disappear. The basic problem is where the noise came from. The scatting light from the photon mask is the first noise source. The second noise source is the connector of the signal cable.

By applying different bias voltage on the HV electrode, the amplitude of the signal will change. The higher the bias voltage is applied, the higher the amplitude is changed. In the figure 6 the HV electrode is applied positive bias voltage 300V and negative bias voltage 300V. It shows that the amplitude of part D is still the same level, so it is believed to be noise. It need more study to understand where the signal came from.

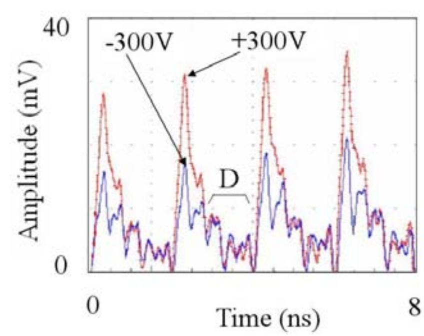

Figure 6: The pulse-by-pulse photon beam in TLS storage ring

The amplitude of the signal is proportional to the pulse beam current [1]. In figure 5 each peak-a has different amplitude, we can obtain the intensity of the pulse beam. In the figure 4 case, the sum of all peak-a amplitude divides by beam current in the storage ring is about 1 mV/mA. The PPPB monitor can be used to be an intensity monitor and the resolution is less than 1 %. Because the detector head of PPPB monitor is installed vertically, so it has the advantage of less sensitive to beam position.

CONCLUSION

The vertical type of PPPB monitor has been installed and tested in SW front end of TLS. The PPPB monitor can diagnose pulse-by-pulse photon beam of pico-second resolution. To be an intensity monitor, the pulse beam current to the voltage from the PPPB monitor is about 1 mV/mA with the bias voltage 300V. We can use the intensity monitor to study and modify the filling pattern of the storage ring, which affects the beam stability.

The next work about the PPP monitor, we will modify the photon mask, HV electrode and signal cable to suppress the noise. In the future TPS project, the PPPB monitor will be useful and will be installed in the diagnostic beam line to provide more beam information.

ACKNOWLEDGE

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