Synchronous Beam Diagnostic System Using Cordless Telephones at SPring-8

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1. Introduction

By a periodic correction of the closed orbit distortion (COD), the electron orbit of the SPring-8 Storage Ring is automatically stabilized to be less than 10 μm per day [1]. The correction is performed every minute, so that a small amount of the orbital distortion remains mainly in high frequency. Since the accuracy of the beam position monitor (BPM) system of the storage ring is 4 ~ 5 μm in an r.m.s. value, the remained distortion is difficult to measure with the BPM. Even though the electron beam fluctuation is small and negligible at the light source point, it is hard to perfectly stabilize the synchrotron radiation (SR) at the experimental hutch, which is distant from the source point.

There is an X ray beam position monitor (XBPM) at each beamline(BL) front end, the accuracy of which is less than 1 μm. They are installed at a point about 20 m distant from the source point, so that they can sensitively detect the angle of the electron beam as well as the beam position. Furthermore, the XBPM has high frequency response [2]. Then, we planned to develop a novel beam monitoring system using the XBPMs to contribute to the beam stabilization.

If the XBPMs are synchronously started to take in data with a trigger signal, it is possible to observe the oscillation of the SR beam position all through the storage ring. However, it is not easy to realize the system by laying cables for all BLs, because the storage ring has a circumference of about 1.5 km. For this reason, we developed the synchronous beam diagnostic system using a cordless telephone system (Personal Handy-phone System: PHS) to convey the trigger signal. This phone system is used as an everyday tool for communication among the staff and users in the SPring-8 campus.

We applied this system for the following cases.

The high frequency phase-shift of the variable polarizing undulator has been predicted to have a malign influence upon the SR beam position at other BLs [3]. The effect is larger than the tolerance, therefore the effect should be quantitatively evaluated. In SPring-8, this type of undulator is installed at BL23SU (one of the Japan Atomic Energy Research Institute BLs), and first operation using the high speed driving of the undulator was attempted tried in 1999. For evaluating this case, a trigger signal which coincides with the timing of the ID23 driving pattern was also developed to start measurement.

2. System Description

2.1 Total System

The total system is shown in Fig.1. At the beginning, a primary trigger is sent from the central control room to a timing module at the BL23SU by PHS. In the timing module, the primary trigger coincides with the ID23 driving pattern, and a secondary trigger is generated. The secondary trigger is sent to BL47XU and BL10XU (SPring-8 public BLs) by PHS. The secondary trigger make Keithley 2000 digital voltmeters start to measure the signals of XBPMs at each BL. The data are taken through GPIB, and are saved in a network folder of a PC at the central control room through the LAN.

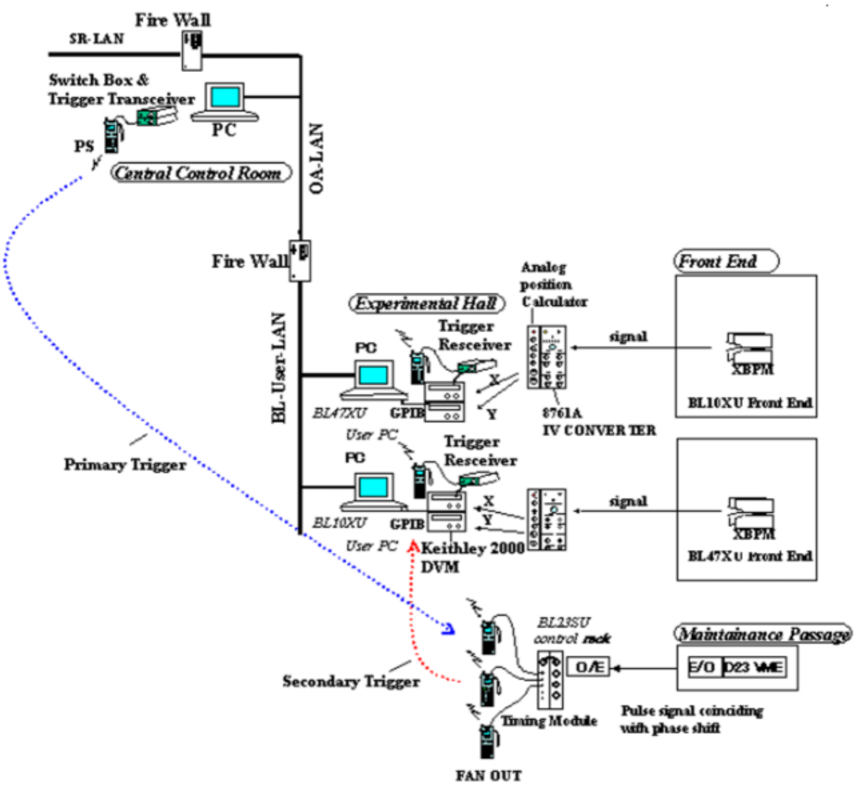

Fig. 1. Total system of synchronous beam diagnosis using cordless phones. The primary trigger is sent from the central control room to the timing module at BL23SU. The secondary trigger signal is sent from BL23SU to each beamlines where the SR beam positions are observed by XBPMs.

2.2 Components

A) PHS trigger transceiver and switch box (Fig. 2): The PHS trigger transceiver is used for broadcasting the trigger signal. A TTL signal is loaded to an MIC jack of a Personal Station (PS) through 100 kohm resister. Then, the TTL pulse could be broadcasted by PHS.

Fig. 2. PHS trigger transceiver, switch box and PS.

B) Timing module (Fig.3): The initial trigger is received by a PS at BL23SU. The trigger is taken out as a sound signal from the earphone-jack of the PS. The sound signal is processed by the comparator and the mono stable multi-vibrator, so that the uniform TTL pulse is obtained. The TTL is coincided with the signal from ID23 VME (Fig. 4). The fan out signals are loaded to two PSs. Then, the secondary triggers are sent to BL10XU and 47XU. They arrive at both BL simultaneously, and the measurements are synchronously started.

Fig. 3. Timing module for ID23 phase shift trigger.

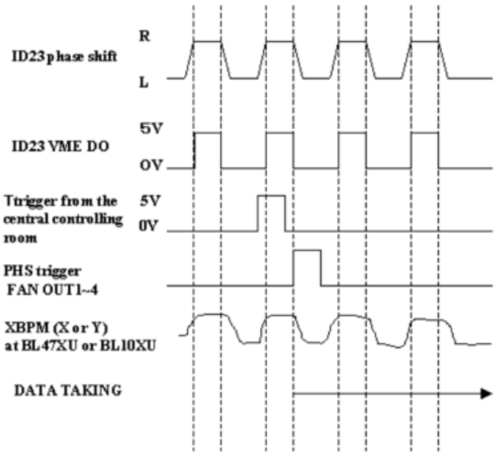

Fig. 4. Time chart of diagnosis for the ID23 phase shift driving.

C) PHS trigger receiver (Fig. 5): The secondary trigger signals are received by PS at each BL. The trigger is taken out as a sound signal from earphone-jack of the PS. The sound signal is processed by comparator and mono stable multi-vibrator, so that the uniform TTL pulse is obtained. The pulse signal starts the measuring equipments.

Fig. 5. PHS trigger receiver and PS.

D) Performance Test of the Trigger: The performance of the PHS trigger conveyance was examined using two PSs. One is connected to the PHS trigger transceiver, and the other is connected to the PHS trigger receiver. A TTL input to the transceiver (the upper line in Fig. 7) and a TTL out put from the receiver are observed (the lower line in Fig. 7) by an oscilloscope.The delay time is 18 msec.

Moreover, the delay time was measured using a long coaxial cable (~1 km), and it was confirmed that the time was 17±1 msec anywhere in the experimental hall. Therefore, it was concluded that a synchronous trigger signal of ±1 ms accuracy could be distributed by the PHS system.

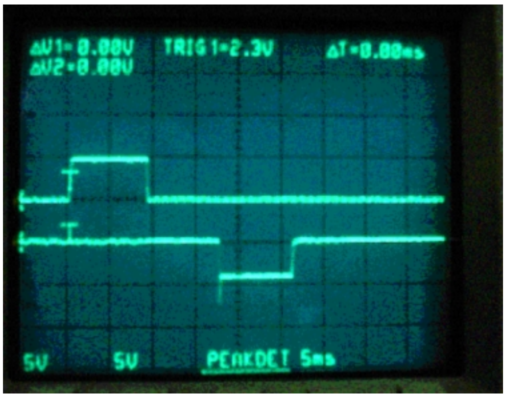

Fig. 6. Delay time of PHS trigger.

2.3 Personal Computer Display

At the BLs and the central control room, the GUIs are displayed on PCs as shown in Fig. 7(a) and 7(b). The GUI is developed using Lab View [4]. The data acquisition speed can variably changed by use of the GUI.

At the central control room, an operator switches on the PHS trigger transceiver, and after that, the data is displayed as shown in Fig. 7(b). At the same time, the data are automatically saved in to the network folder of the PC at the central control room through the LAN.

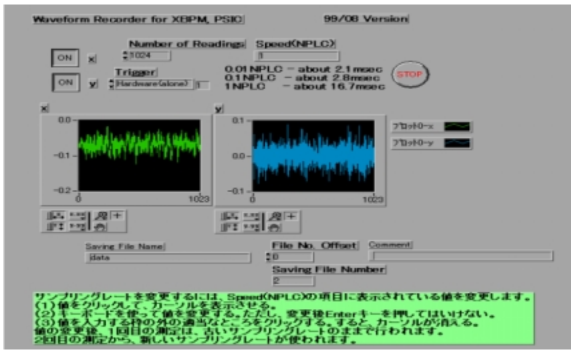

Fig. 7(a). GUI at each BL PC.

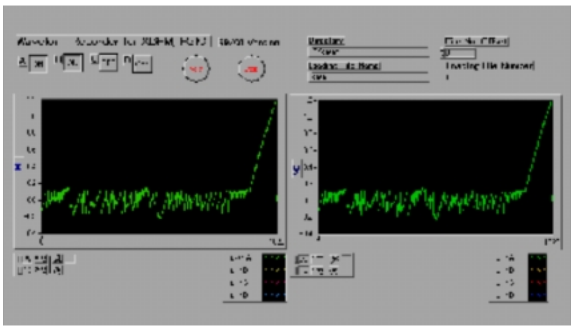

Fig. 7(b). GUI at the central control room.

3. System Performance

Using this system, the stability of the SR beam position was evaluated during the ID23 phase shift driving. The examiniation has been under way since September 1999. We found that the ID driving caused a small synchronous beam oscilation of the SR beam all through the storage ring (Fig. 8).

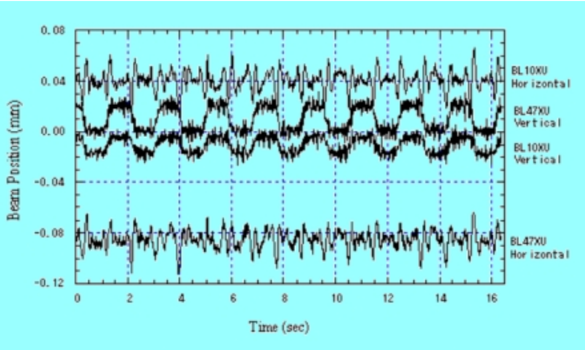

Fig. 8. While ID 23 is driven by phase switching in 0.5Hz, a small SR beam fluctuation was simultaneously observed by this system at BL10XU and BL47XU. The fluctuation was obvious in a vertical direction, and its frequency was 0.5Hz, which agreed with the phase switching frequency.

4. Next Steps

Presently, a new system is being planned, in which optical fibers are used to collect the signals from the XBPMs and position sensitive ionization chambers [5] in the experimental hutches.

The optical fiber system has some following advantages. (a) The difference of data acquisition time is less than 5 μsec among each BL, which is a great improvement over the PHS trigger system (about 2 msec). (b) It is not required to connect PSs to each other before the measurement, so the measurement can be started anytime. (c) All data are simultaneously sent not only from each BL but also from the BPMs of the storage ring.

References

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