APPLICATIONS OF PC BASED OFF-THE-SHELF MEASUREMENT SYSTEM

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Abstract

We introduce an off-the-shelf system for the synchronizing measurements and controls of accelerator devices. The PC based measurement system, WE7000, supports many modules such as digitizer, function generator, thermometer, digital I/O and so on. The PC is running with Linux OS (RedHat 6.2), and WE7000 API libraries are prepared to attach any UNIX based control system easily. We have developed application software to fit the SPring-8 standard control framework. Using this framework, it is possible to control the measurement system remotely, and we can collect measured data to database via Ethernet.

1 INTRODUCTION

In third generation light source, SPring-8, many experimental users are performing various kinds of experiments by using fine tuned synchrotron radiation light. In order to produce the brilliant and stable light, fluctuation of electron beam orbits in the storage ring should be controlled below the submicron level. We started a project to stabilize the electron beams in 2000. It was necessary to find a high-resolution digitizer system measuring many channels of beam position monitors (BPMs) simultaneously. Also, the outputs from various devices needed to be digitized to take the correlation between the insertion device (ID) operations and orbit fluctuation. Because the accelerator devices were distributed widely over the SPring-8 site, a remote control communication via Ethernet was one of the essential features of the system.

In the past years, we had to use storage oscilloscopes for digitizing many signals in DC ~ several kHz frequency ranges. Those measurement devices provided very limited functionality because the device was stand alone, time consuming for data analyses, and signal data transfer was in off-line. An interface of data transfer was not fast enough because the GP-IB bus was chosen in the most of cases. On the other hand, the fancy measurement system such as VXI is fast enough but it is expensive and too heavy to adopt for the quick measurements. It was a long waiting to have an inexpensive measurement system to fit our purpose.

We selected a PC-based off-the-shelf measurement system, WE7000, made by Yokogawa Electric Corporation [1]. This system supports many kinds of modules for control and measurement, see figure 1. The features of the system are summarized as follows: 1) Each module has a shielded case in consideration of noise resistance. 2) It is not necessary to configure the address setting or install driver software by "Plug and Play" feature. 3) The station has trigger signals and clock line on the back plane to synchronize modules. 4) The system has a 100Base-T Ethernet interface that communicates with UDP/IP. 5) The high-resolution isolated digitizer module is available.

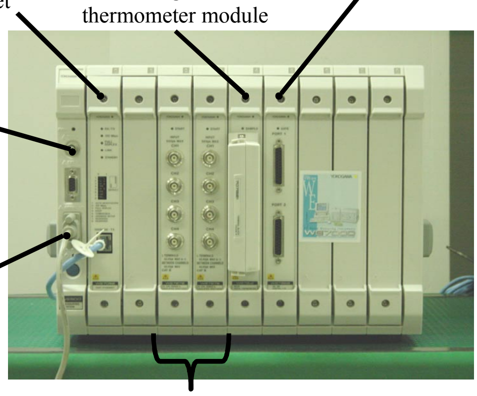

Figure 1. A typical set up of the WE7000 system.

2 SOFTWARE

The system has a Windows-base graphics toolkit to support the rapid development in its standard package. We can develop prototype control programs by using this toolkit. The vender also provides a network communication library for Linux OS with the open source license. We can control any module with the same function call and command syntax.

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The software framework of SPring-8 control system [2] adopts the client/server structure with message-driven middleware running on HP-UX and Linux [3]. In our control scheme, an equipment manager (EM) programs are running on front-end VME systems to control accelerator devices. It is necessarily to incorporate the WE7000 communication functions into our software framework. We easily developed the equivalent software working as an EM on PC-Linux by using the provided API library. The API library connects WE7000 system with EM by the socket like communication with UDP protocol. We can get data in the form of binary array and save it to a local ASCII file on a PC. The control software structure can be seen in Figure 2.

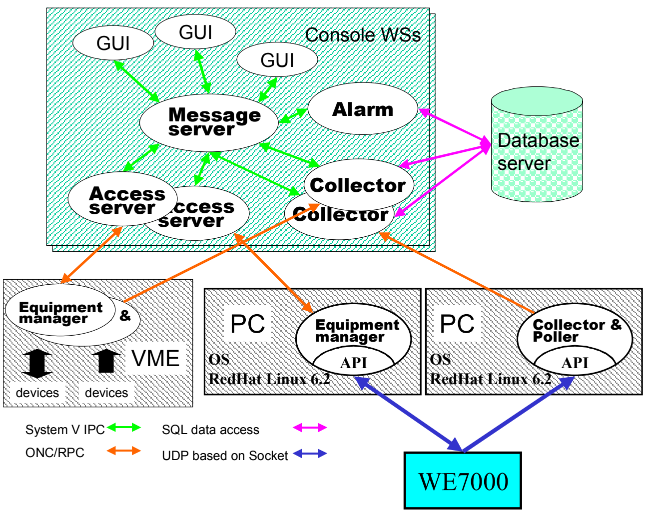

Figure 2: Software scheme with WE7000 system in SPring-8 controls.

We installed the WE7000 API library to the software development environment with RedHat Linux release 5.2, kenerl-2.2.10, libc-5.3.12-27 and glibc-2.0.7-29. We prepared controller PCs installed Linux (RedHat Linux release 6.2, kernel-2.2.14) to run the EM and other data taking programs.

3 APPLICATIONS

3.1 Measurement of orbit distortion with ID operation

An ID installed in cell23 in SPring-8 is an APPLE-2 (Sasaki) type undulator [4]. This ID can generate either a linearly (in horizontal and vertical plane), an elliptically or a circularly polarized light by phase shift of the magnet rows (see figure 3). The periodic phase shift is about 0.1Hz.

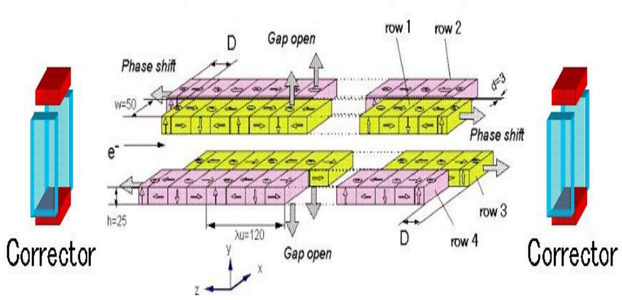

Figure 3: APPLE-2 type undulator.

A closed orbit distortion (COD) of electron beams caused by the phase shift is corrected by magnets (correctors in figure 3) installed upstream and downstream of the ID23. The correctors are operated according to the COD correction table at the period of 30 milliseconds.

We make the table for feedforward correction. The orbit fluctuation is measured with eight BPMs and 4 X-ray BPMs. We measure output voltage from the BPMs by using 4-CH 100kS/s isolated 16bit digitizer module (WE7272) at 100Hz sampling rate through the ~50Hz filters. Total 24 points of the measuring signals are translated to the horizontal and vertical beam position with the submicron precision.

We synchronously acquire the ID phase shift and the orbit fluctuation data. Correlation of the phase shift and the orbit fluctuation becomes very clear as shown in figure 4. We have been able to correct the orbit fluctuation by the correctors according to the high accuracy correction table.

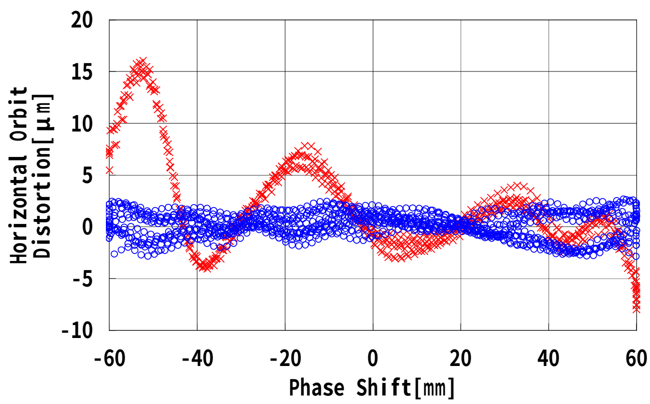

Figure 4: Improvement of the horizontal orbit fluctuation with phase shift. The crosses are before correction and the circles are after.

3.2 Monitoring system of main Magnets of booster synchrotron

SPring-8 booster synchrotron accelerates electron beams from 1 GeV to 8 GeV with the repetition rate of 1 Hz [5]. Five power supplies of main magnets are operated with the 1 Hz trapezoid patterns using 10 kHz digital outputs of VME systems. To supply stable electron beams to the storage ring, the stabilities of current outputs must be less than 10^{-4} order, and synchronization of each output pattern is required. The monitoring system of the outputs of the magnetic fields of sample magnets and power supplies locates in the different rooms.

The requirements of digitizer of this monitoring system were follows; 1) resolution higher than 14 bits, 2) isolated analog input, 3) range selectable at individual channel, 4) low pass filter available, 5) conversion starts with an external trigger, 6) sampling clock of higher than 10 kHz, and 7) buffer memory larger than 10k samples per channel. To satisfy these requirements, we selected WE7272 digitizer modules of WE7000 system.

The WE7000 system has the feature that several PC's can control multiple WE7000 systems. We prepared a WE7000 system at 3 different rooms and two PC's at the control room. The external trigger of 1 Hz is distributed to WE7000 systems using timing system optical-fibers. One PC works to get the individual data with 1 kHz clock and 1 k samples. Those data are used to display the waveform on the operator console. The other PC works to get all data every 5 seconds and store 3 fixed timing data to database. Those data are used to check the long-term stability and analyze the effect to the beam qualities.

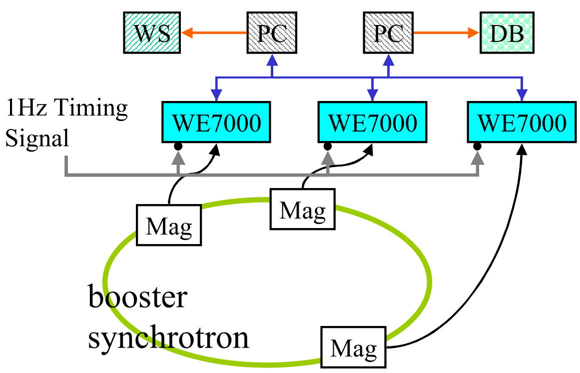

Figure 5: Monitoring of magnets at the booster synchrotron with WE7000 systems.

3.3 Fast Control of Magnets

An ID installed in cell25 (ID25) has the tandem magnetic circuits that reversed the turn direction of a helical magnetic field. When an electron passes through the ID, the two contrary polarized synchrotron radiation beams are generated. We are switching the polarized light from ID1 and ID2 by switching two sets of the fast steering magnets (FS).

We synchronously control five FSs with trapezoid patterns and 4 fast correctors (FC) with arbitrary patterns by 4-CH 100kHz D/A modules at 64kHz. The polarized light switching at frequency of 1 Hz has become possible by this operation. This system will be operated by experimental users in the near future.

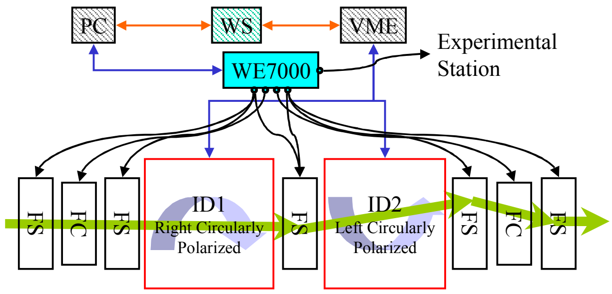

Figure 6: Fast control of magnets for helicity switching. The yellow-green arrows are the electron passes when the polarized light from ID1 is taken out.

4 SUMMARY

We introduced a PC based off-the-shelf measurement system, WE7000, to our control system. The system is portable, reliable, networked and powerful to diagnose accelerator devices with enough precision. We have been working with this system non-trouble for two months.

5 REFERENCES

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