

CONTROL SYSTEM FOR A BUNCH/PROFILE MONITOR AT THE KEK e^+/e^- LINAC

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Abstract

An elaborate beam-monitoring system is indispensable in order to realize stable operation of the electron/positron linac with high-current beams for KEKB. In this connection we have provided a brief accommodation for the control system of a bunch/profile monitor employing optical transition radiation (OTR).

In order to utilize the excellent features of the OTR monitor, it should be associated with an adequate control system for such components as optical/timing devices and a streak camera.

Since the components had not been designed integrally, we had to bring them together so that they can work as a single monitoring system. The components were connected to the operator console through Ethernet, GPIB and serial lines. The software was designed to organize separate devices into a single control object. We developed a graphical user interface on X-Window. The entire system works satisfactorily and serves as an effective tool for beam diagnosis.

Introduction

In the next KEK B-factory project (KEKB) [1] the electron/positron linac at KEK should provide beams with better quality and stability in order to achieve a higher luminosity in the ring. Extensive studies must be carried out in order to understand the beam characteristics with improved beam energy and current.

The injector section, which comprises a sub-harmonic buncher, prebunchers, and a buncher, is one of the most crucial parts for studying the beam characteristics. It is therefore important to simulate the beam behavior on computer codes, and to measure the transverse/longitudinal distributions of the beam in this region.

Due to the benefit of a fast time response, the combination of optical transition radiation (OTR) and a streak camera becomes a good system for investigating the longitudinal behavior of the beam. The OTR monitor serves not only as a beam-bunch monitor, but also as a beam-profile monitor without a halo.

However, the number of such instruments is usually small, or only one, and it normally requires special configurations. It is therefore not economical to design an interface for a single piece of equipment, and such instruments

often are not accompanied with reasonable remote-control systems, although it is useless without a control system.

In this paper we describe the control system for the beam bunch/profile monitor which was built without designing dedicated hardware. This may be a typical case for such a measurement system.

System Description

Transition Radiation Monitor

The transition radiation monitor was intensively investigated at the KEK linac, and showed good results [2]. It comprises a polished stainless-steel radiator, a radiator mover, an optical system, a CCD camera, a timing and delaying system, and a streak camera. The CCD camera provides a video signal for the beam profile, and the temporal analyzer of the streak camera provides analyzed data for beam-bunch information.

We use a streak camera (Hamamatsu Photonics Ltd., C1587) having a time resolution of 2 ps. The details of the monitor and its performance have been given elsewhere [2].

Since the distance between the radiator and the streak camera is large, the optical system must be precisely aligned in order to gather radiation light. Two sets of three-axis movers were installed in order to resolve this problem. These movers are used to precisely align light-guiding lenses.

An accurate adjustment of the beam trigger is also necessary in order to acquire data with multiple bunches without jitters. We use a coarse delay which is synchronized to the linac rf frequency, and a fine cable delay having a minimum step of 30 ps.

Control System Design

Since each component for the monitor has not been designed integrally, it is important to bring them together so that they comprise a single monitoring system when it is viewed from the operator side. The system was constructed while associating the components with each other.

The part for the beam-profile monitor, which comprises a radiator mover and a CCD camera, is controlled by a normal profile-monitor control system. An entry was merely added to the system database table so as to enable this monitor. The OTR monitor shows a greater linear

response compared to our alumina profile monitors. The profile can be examined by an image analyzer at the operator's console.

For the beam-bunch monitor part, since the number of monitors is only one, we did not design a dedicated controller. Instead, we built a system with commercially available hardware and the software library which has already been developed and used for the linac accelerator control system.

Component Interconnection

The linac control system was designed as software and hardware components that are interconnected with Internet-protocol (TCP/IP) networks [3]. The bunch monitor was also designed so as to connect with the control network, converting the equipment-specific interface of each component. Table 1 lists the components and their interfaces.

Table 1: List of the components of the bunch-monitor system and their interfaces.

| Component | Interface |
|------------------------------|---------------|
| Optical System | |
| 3-axis mover for lens 1 | RS232C |
| 3-axis mover for lens 2 | RS232C |
| Trigger System | |
| beam synchronous 2.1ns delay | GPIB-CAMAC |
| 30ps fine delay | GPIB |
| Streak Camera System | |
| temporal analyzer | GPIB & RS232C |
| remote controller | RS232C |

Each component has either a serial line (RS232C) or a general-purpose interface bus (GPIB) interface. Components which have RS232C interfaces are connected with a terminal server, which accepts host-computer initiated TCP/IP connections. Instruments having GPIB interfaces are attached to an Ethernet-GPIB gateway box.¹ A system block diagram is presented in Fig. 1.

The monitor is operated at the linac console room. Most of the software runs on a Unix workstation of the accelerator control system, and an interactive user interface has been provided on the X-Window server, as shown in Fig. 2.

Software Design

Since the RS232C and the GPIB are not reliable compared with other parts of the control system, great care has been taken to handle any failure recovery and to avoid a deadlock situation. For this purpose, our TCP/IP

¹We use ET488 from Sony Tektronix Inc., which gateways the GPIB and TCP/IP on Ethernet.

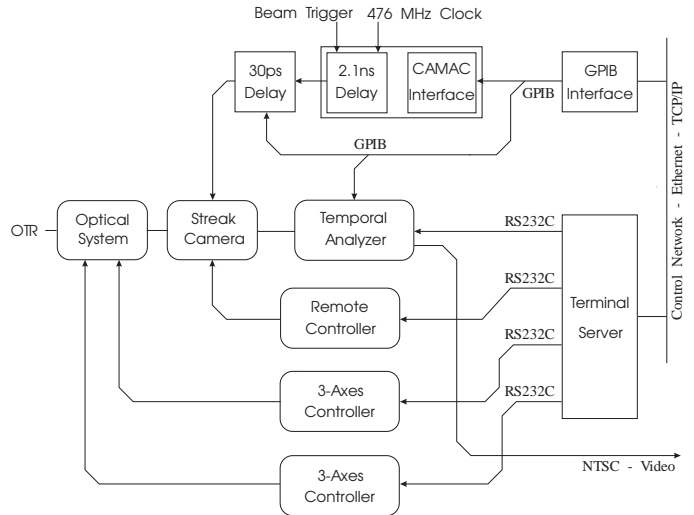


Fig. 1: Block diagram of the bunch-monitor components in the control system. The optical, timing and streak-camera systems are connected to a control network.

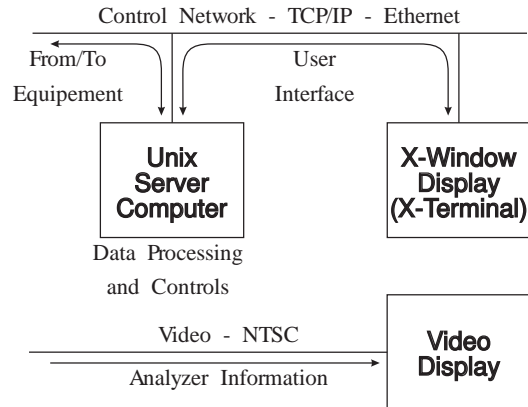


Fig. 2: Operation of the beam-bunch monitor from the linac console room.

socket library routines, which reasonably handle time-out and other failures, were used [4].

The software library for the GPIB was written so as to be compatible with those on Unix workstations and VME systems, so that it can be adopted for other applications. If the situation changes, we can even replace the hardware for the bunch monitor with the VME system. However, the software for the RS232C interfaces could not be made compatible with those on other systems because of failure-recovery procedures.

Since the configuration of this type of monitor may change frequently, we designed the software in an object-oriented way. Each component was built so as to be able to behave independently, so that each software component can be easily replaced. However, at the same time, the entire assembled software is intended to form a single object of a bunch monitor.

In order to make the operator's manipulation easier,

the software components were designed so as to exchange information with each other. For example, precise calibrations of two beam-trigger delays, and the delay inside the streak camera, which depends on the sweep ranges, are treated consistently within the system.

Operator User Interface

In order to build prototypes of the graphical operator interfaces quickly, we used Tk toolkits for the X-Window system [5]. This has enabled us to make user interfaces to equipment very quickly. Figure 3 is an example of the interface windows.

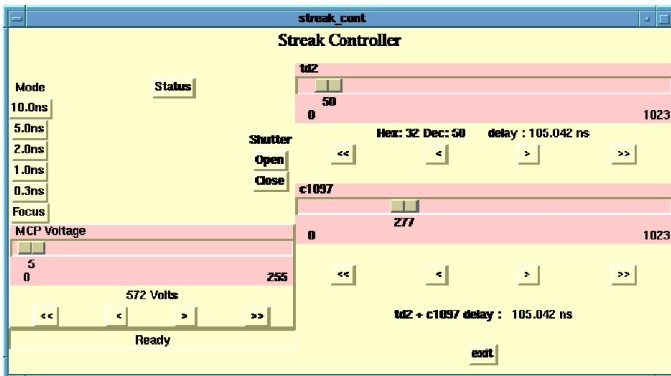


Fig. 3: One of the graphical user interface panels on X-Window to control the bunch monitor system. This was built using Tk toolkits.

Since we can not spend much effort on each single system, we need well-designed graphical user interfaces. Tk toolkits are suitable for such applications as beam studies. Further, it can make complicated graphical applications simple. In addition, the event-driven structure of the language system is appropriate for the control-system software.

Since Tk follows the Motif look-and-feel criterion for the graphical user interface standard, it meets our needs. However, since Tcl language, on which Tk is based, is not a standard computer language, we have not yet decided whether Tk is appropriate for use in normal control applications.

Discussion and Conclusions

We could build a reasonable control system for our bunch monitor in a short term by employing commercially available hardware components, object-oriented software design and Tk prototyping toolkits for the user interfaces. This enables us to efficiently study the beams.

This method to build a simple control system may be applied to minor measurement systems, which may be installed in order to improve the linac operation for KEKB.

However, points to be considered still remain. First of all, we must connect and monitor the interlock system

of the CCD device in the streak camera. We have not yet found any proper devices for it. Without interlocking it may be easily spoiled.

Not all data-manipulation methods which are available on the temporal analyzer are provided on a workstation yet. Since such methods as Fourier transformations are often useful for understanding the beam characteristics, we should implement them and provide a user interface to them.

The GPIB gateway that we used is suitable for isolated GPIB equipment. More GPIB instruments for special measurements will be used in the future. They can be readily installed in the control network using GPIB gateways. They are also inexpensive, compared with VME crates with a GPIB board. However, if the number of items becomes larger, a VME crate may be used.

Under normal accelerator operation we do not yet use the bunch monitor effectively, mainly because it is hard to predict the beam behavior in the injector section. We are considering to build operator interfaces to simulation codes such as PARMELA for buncher sections. A preliminary version was built using Tk toolkits. We hope that the combination of beam monitors, such as a bunch monitor and online simulation codes, improve the linac beam quality for the KEKB upgrade.

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