EMBEDDED EPICS CONTROLLER FOR KEK LINAC SCREEN MONITOR SYSTEM

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Abstract

A screen monitor is one of the fundamental beam diagnostic tools to measure the transverse beam profile. In the KEK electron/positron injector linac, the screen monitors have been utilized for the daily beam tuning. The screen monitor system comprises a screen monitor, a camera, and a control unit. In 1995, the compact screen monitor system has been previously developed and installed into the linac beam line. The VME-based computer control system has been also developed at that time. However, the previous screen monitor control system becomes obsolete and hard to maintain after more than decade of operation. Recently, a new screen monitor control system for the KEK injector linac was developed and fully installed. The new system is an embedded EPICS IOC using the Linux-based programmable logic controller. In this paper, we present the new screen monitor control system in detail.

INTRODUCTION

A screen monitor (SC) control system has been newly upgraded towards the SuperKEKB project. The SC of the KEK injector linac is a simple beam diagnostics device to measure the transverse beam profiles with fluorescent screen. The screen material is made of 99.5% Al_2O_3 and 0.5% CrO_3 (AF995R, Demarquest Co.) by which a sufficient amount of fluorescent light can be obtained when the electron and positron beams impinge the SC. By detecting the fluorescent light with a camera embedded with a charge-coupled device (CCD), the transverse spatial profiles of the beam can be easily measured.

The compact SCs were previously developed in 1995 for the commissioning stage of KEKB project. One hundred fifteen compact SCs were installed into the linac beam line at that time. The mechanical design was reported in detail elsewhere [1], and a VME-based computer control system [2] was also developed in order to perform fast and stable control of the monitor system. The compactness of the monitor along with the fast control system made it possible to decrease the consumed time for driving the monitor from its home position to the center of the beam line.

The previous SC system has stably worked until the full stop of the KEKB operation in the end of June 2010. However, after fifteen years from the commencement of the KEKB operation, it is very difficult to maintain the control system because the most VME modules used in this system go out of production. This is the reason why we need to develop a new SC control system towards the next SuperKEKB project.

A photograph of typical SC is shown in Fig. 1. A block diagram of the whole SC system is shown in Fig. 2. The screen actuator comprises a driving rod and an air cylinder driven by compressed air through a solenoid valve. The actuator inserts (removes) the SC into (from) the center of the beam line. The fluorescent light emitted from the SC through a glass viewport is guided down to a floor level by two optical mirrors, and the fluorescent light is detected by a CCD camera. All CCD cameras are shielded by a lead block with a shape of cylinder for avoiding the radiation damage. The video signals of the camera are sent to a monitor control station at the linac klystron gallery, where a video-signal selector selects a particular channel corresponding to the required SC. Then, the selected video signal is sent to the main control room through the optical-fiber cables after converting an electrical signal to an optical signal by an electro-optic converter. The transverse beam-profile image can be obtained by an ordinary TV monitor. The digital data of the beam profile image is also available because the image signal is also fed to a network-based video encoder (AXIS 241Q). Figure 3 shows the beam profile image captured by the video converter. The digital profile images can be easily uploaded to the Web page for the operations electric logbook.
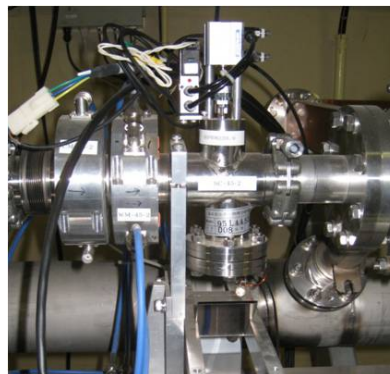

Figure 1: Photograph of the typical screen monitor installed in the KEK linac beam line.
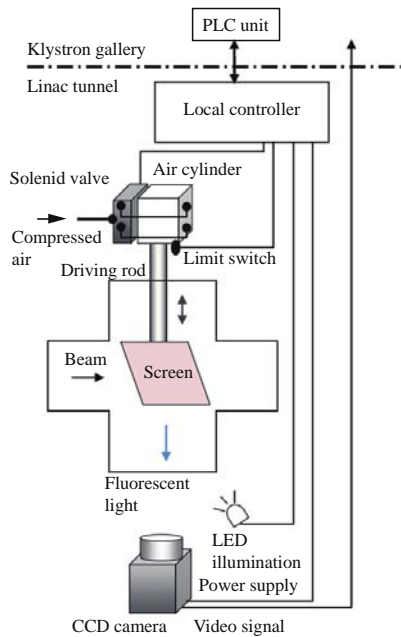
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Figure 2: Block diagram of the screen monitor system in the KEK injector linac.

Figure 3: Transverse beam profile captured by video encoder system in the KEK injector linac.

A local controller installed for each SC in the linac tunnel controls remotely mechanical motion of the SC according to a command through the control system. The driving force of a rod is generated by pneumatic air pressure. The mechanical position status of SC is readable by detecting a voltage level from a mechanical limit switch through this local controller. A LED light is shined on the screen to clearly reflect beam profile image.

NEW SCREEN MONITOR CONTROL SYSTEM

A new control system of SC is a programmable logic controller (PLC) based control system. We adopted the Linux-based PLC from Yokogawa Electric Corporation as the new SC control system [3]. The Linux-based environment enables the easy and rapid software development in comparison with the ordinary ladder PLC programming. Photographs of the front and rear views are shown in Fig. 4. The server programs are running in EPICS environment as shown in Fig. 5 [4]. The basic functionalities are an actuator control and selecting the specific video signals.

When the server receives a control request from an operator interface (OPI) through the linac control network, it selects a channel of a digital relay output (DO) module corresponding to the specified SC, and then the DO implements the actuator control as shown in Fig. 5. The limit switch signal of the actuator positions is fed into a digital input (DI) module. The DO module is also used as
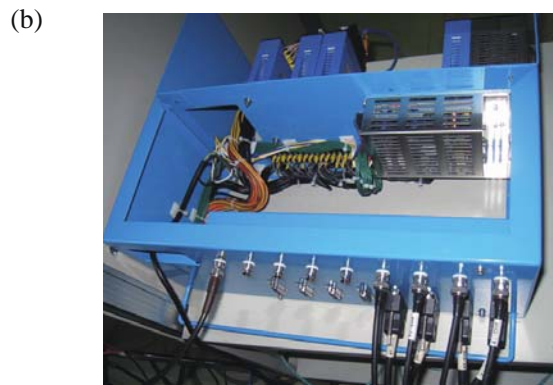
(a)

(b)

Figure 4: Photograph of the PLC-based screen monitor control system, (a) front view and (b) rear view.
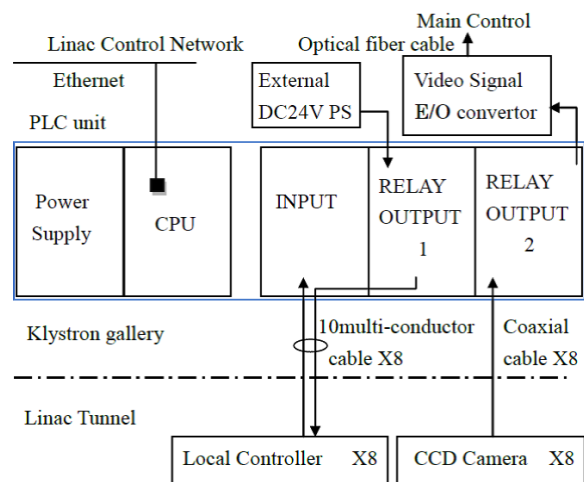

Figure 5: Block diagram of the PLC-based screen-monitor control system.
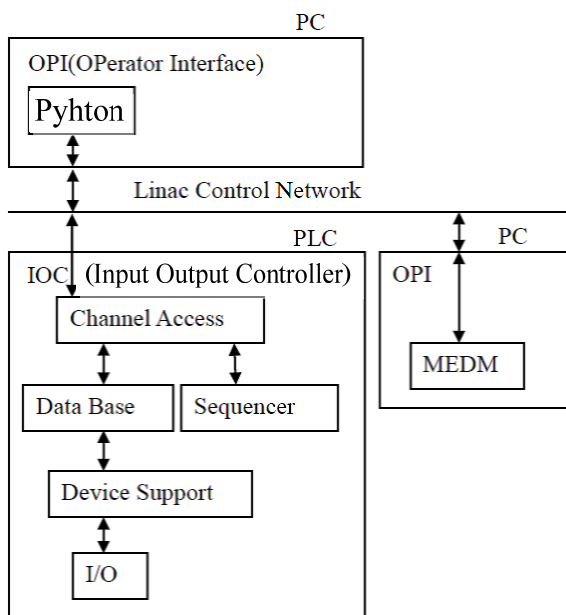
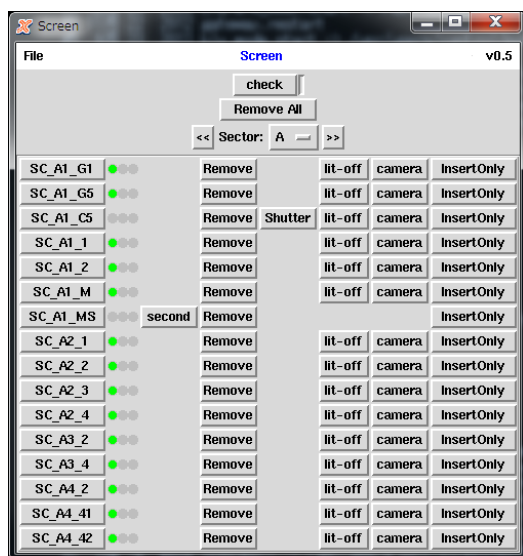Figure 6: Flow chart of the control software in the PLC.

Figure 7: Operation panel of screen monitor developed by Python scripting language.

a video-signal selector in which a video signal outputs from 8 input channels.

The software of the new control system was developed in EPICS and Linux environments. Figure 6 shows the flow chart of the control software. Through an OPI running on the Windows- or Linux-based PCs, a linac operator gives a command to work a specified SC. An EPICS IOC on the Linux-based PLC selects a specified I/O channel through a device support corresponding to the specified SC by following the EPICS database file. At the same time, a sequencer program reads position status for

all other SCs. If any other SCs work with actuator status "ON", the sequencer exclusively changes the actuator status "ON" to "OFF" just before controlling the status of the specified SC. The sequencer control developed by using State Notation Language is utilized for a complicated function though a simple function has been implemented by the EPICS database.

The original OPI has been developed by the Tcl/Tk scripting language in Linux/PC environment. For the new SC control system, the main OPI program was developed by using a scripting program language Python as shown in Fig. 7. It is basically ported from the previous OPI based on Tcl/Tk. Using this OPI, an operator can easily insert and remove the specific SC, and turn on and off the LED light. When the SC is inserted, the green coloured filled circle is changed to the red coloured one by detecting the limit switch signal in Fig. 7. Another OPI was also developed for the rapid program test by using Motif Editor and Display Manager in EPICS environment.

SUMMARY

Twelve four new PLC-based SC control systems in total have been developed and finally replaced in the summer 2011 instead of the previous VME-based ones. Now whole the new SC system has been well working without any fatal troubles, and it is made full use of the KEK injector linac stable operation.

REFERENCES

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[3] http://www.yokogawa.com/
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