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NEW SCREEN MONITOR SYSTEM FOR THE KEKB INJECTOR LINAC

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Abstract

The KEKB injector linac is now being upgraded for the KEKB project. A new screen monitor system has been developed in order to reinforce the beam-profile monitoring system. The compact screen monitor was developed in order to diminish the spatial sizes of all the mechanical components because the available space of the new beam line is required to be as large as possible. A new VME-based computer control system was also developed in order to perform fast and stable control of the monitor system. The compactness of the monitor and fast control system made it possible to decrease the driving time of the monitor (~0.2 sec) to the center of the beam line. This report describes the hardware and software design of the new screen monitor system in detail.

1. Introduction

The KEKB injector linac is required to supply a certain amount of electron beams($8\times10^9e^-$/bunch) and positron beams($4\times10^9e^+$/bunch) for the KEKB high-energy and low-energy rings[1]. High-current primary electron beams($6\times10^{10}e^-$/bunch) are also required to produce such an amount of positron beams. The screen monitor system is important and essential in order to easily handle the beam orbits and to measure the transverse spatial size of such high-current beams. About one hundred screen monitors in total (eleven monitors /sector on the average) are being installed in the new beam line of the linac. A compact screen monitor was designed and developed in order to diminish the spatial length along to the beam line. A new VME/OS9-based computer control system was also developed in order to reinforce the beam-monitoring system which was connected with the linac control system. The new control system offers fast and stable operation of the beam-monitoring system.

2. System Design

Overview

The screen monitors have been controlled by the linac control system, which comprises VME front-end computers with the OS-9 operating system and UNIX-based workstations[2,3]. In 1993, the number of screen monitors was typically 2-5 per each sector. As a part of the KEKB project, we decided to improve our beam-monitor system:

a) increase the number of screen monitors,
b) introduce new beam-monitors (beam-position monitors and wire scanners), and
c) digitize the waveforms of wall-current monitors.

Since the existing front-end computers do not have sufficient CPU power for these new requirements, new front-end computers were introduced for exclusive use. The new ones are essentially the same as those of the linac control system; however, the main CPU ha been upgraded from MC68040(25 MHz) to MC68060 (50 MHz). A more detailed discussion has been given elsewhere[4].

A new network system was also introduced in conjunction with the KEKB project. As shown in Figure 1, all of the front-end computers are linked to a switching-hub with a star-topology. Fiber-optic cables are used for physical connections in order to avoid electromagnetic noise from high-power klystrons. The hub has a link to the linac control network, where UNIX workstations and man-machine interfaces are connected.

All of the screen monitors are controlled by eighteen front-end computers and a few UNIX workstations. Each front-end computer is located on the linac klystron gallery (an upper floor over the linac tunnel) at a nearly equal interval along the beam line, and takes care of the above-mentioned monitor systems for a half sector. Six screen monitors on the average are controlled by each front-end for a half sector of the beam line.

Mechanical design

Figure 2 shows a picture of the new screen monitor. The monitor is made of stainless-steel chamber (SUS 304), an actuator, and a screen material. The length between the flange ends was reduced to be 85 mm from 160 mm (old design). The vacuum pipe can be directly joined with a beam pipe of a current monitor by welding, which is insulated by a ceramic insulator. A quick-release flange (manufacturer's standard KF flange) is used which couples by a clamp chain coupling with a metal gasket in order to make it possible to easily mount the monitor on the beam line. A small viewport (ICF70) is coupled to the bottom port of the chamber to extract fluorescent light emitted from the screen. The actuator comprises a central shaft, a compact cylinder with a size of 16 (bore) mm × 5 (stroke) mm, driven by a compressed-air system (5kgf/cm^2) in the linac and a micro-solenoid valve. A compact commercially available actuator was selected so as to be directly mounted on the chamber. The driving speed of the actuator is adjustable by speed-control tuners which control the amount of compressed inlet and outlet air. The central shaft stroke is 3mm, limited by two stopper screws which accurately set the screen center position to the center of the beam line. The driving position of the screen is monitored by a non-contact micro sensor switch (solid state type) mounted just on the cylinder. The sensor signals are sent to the monitor control system, which monitors the position status of all the screen monitors. Details concerning the mechanical design has been reported elsewhere[5].

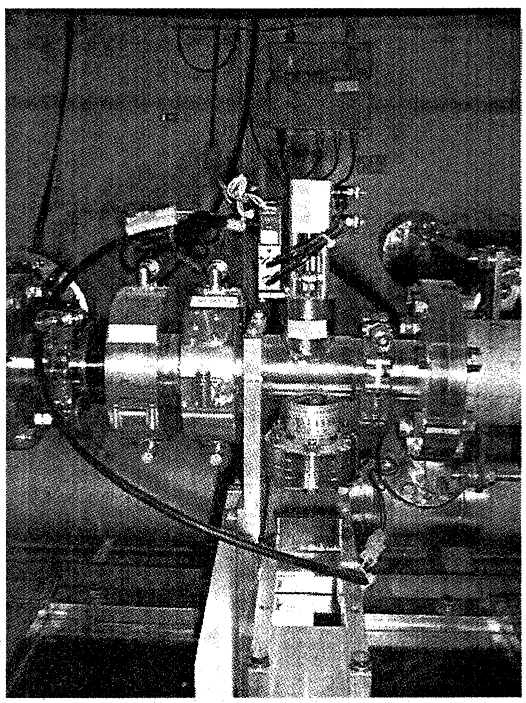

Fig. 2 Photograph of the new screen monitor.

Beam profile monitoring

A commercially available screen material (AF995R[6]), which is made of 99.5% Al_2O_3 and 0.5% CrO_3, is used to obtain a sufficient amount of fluorescent light. The screen size ($25\times33\times1^t$ mm^3) was reduced in comparison with that of the old design ($50\times50\times1^t$ mm^3) because of the compactness of the chamber. This size is large enough to measure the transverse spatial size of even a positron beam.

A block diagram of the screen monitor system is shown in Fig.3. Fluorescent light emitted from the screen through the viewport is guided down to a support table of the linac by optical mirrors, and is received by a standard CCD camera. The video signals are sent to a monitor control station, in which the required signal is selected by a video-signal selector. Then, the selected video signals are sent to the main control room through optical-fiber cables after converting them to optical signals by electrooptic converters (E/O modules). The beam-profile images can be monitored by TV monitors in the main control room.

Local controller

A local controller set for each screen monitor in the linac tunnel is mainly used to test the monitor drive by manual switches and to tune the speed of the actuator at the time of linac commissioning. The controller also supplys power sources for the actuator (AC 200V), screen illumination light (DC 24V) and a CCD camera (AC 24V). The limit switch signals, which show the actuator's position status, are sent to monitor selector modules through this controller.

Control software

The server program for the screen monitors are always running at UNIX workstations during linac operation. The basic functions provided by the server are: a) actuator control (up and down), and b) selecting the specified video signal.

When a server receives a control request, it searches for the fron-end computer where the specified screen is installed, then asks for "some work" to the front-end computer. The communication between UNIX workstations and front-end computers is made over the linac control network using the TCP/IP protocol[4,7]. As shown in Fig.3, the font-end computer has digital in/out modules[8]. Actuators are controlled by a digital output module. The limit switch signals of the actuator positions are fed into a digital input module. The digital output module is also used for controlling video-signal selectors, which output a video signal from eight input signals. At the end of "the work", the fron-end informs the server that the work has been completed.

Since we utilize the software of the present control system, no additional developments for the basic control software were needed in the present upgrade. However, the device drivers (digital in/out) were modified in order to use them with the new CPU chip (MC68060).

Man-machine interface

Two man-machine interfaces are available at the main control room. One is touch-sensitive terminals based on the NEC PC (80x86, DOS-based)[9]. This system was developed as a part of the present control system, and has been operational since 1992. Another is a new Windows-NT application, which was developed in recent years[10]. The application supports mouse-oriented operation without keyboards. Visual Basic has been used as a development language so as to realize easier maintenace and better visualization. Both interfaces send control requests to a server according to the operator's requests.

3. Summary

A compact screen monitor system has been developed, and is being installed in the new beam line for the KEKB injector linac. The monitor length along to the beam axis is about half compared with the old type. The compact screen actuator makes it possible to shorten the driving time (~0.2sec) to the center of the beam line. A new VME-based control system and man-machine interface were also developed in order to perform fast and stable operation for the beam-monitoring system.

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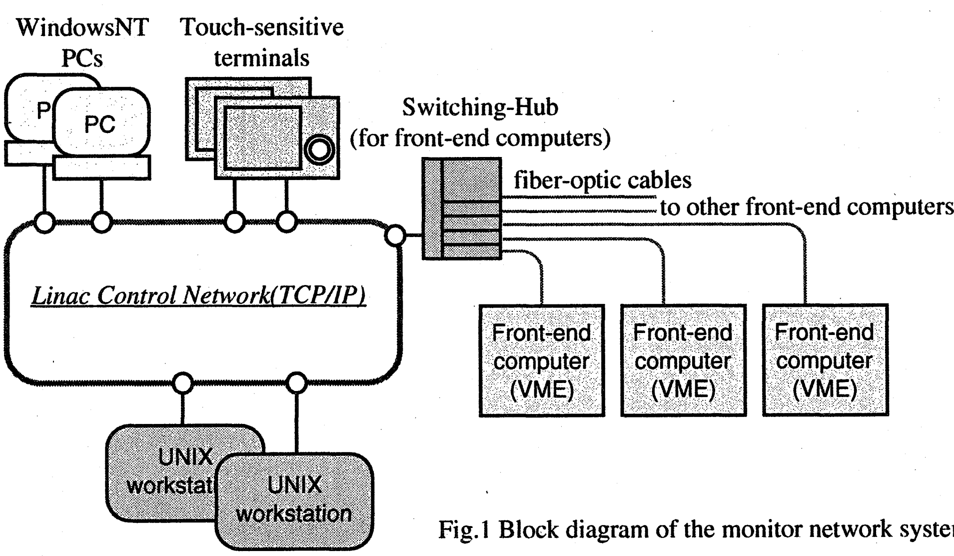

Fig.1 Block diagram of the monitor network system

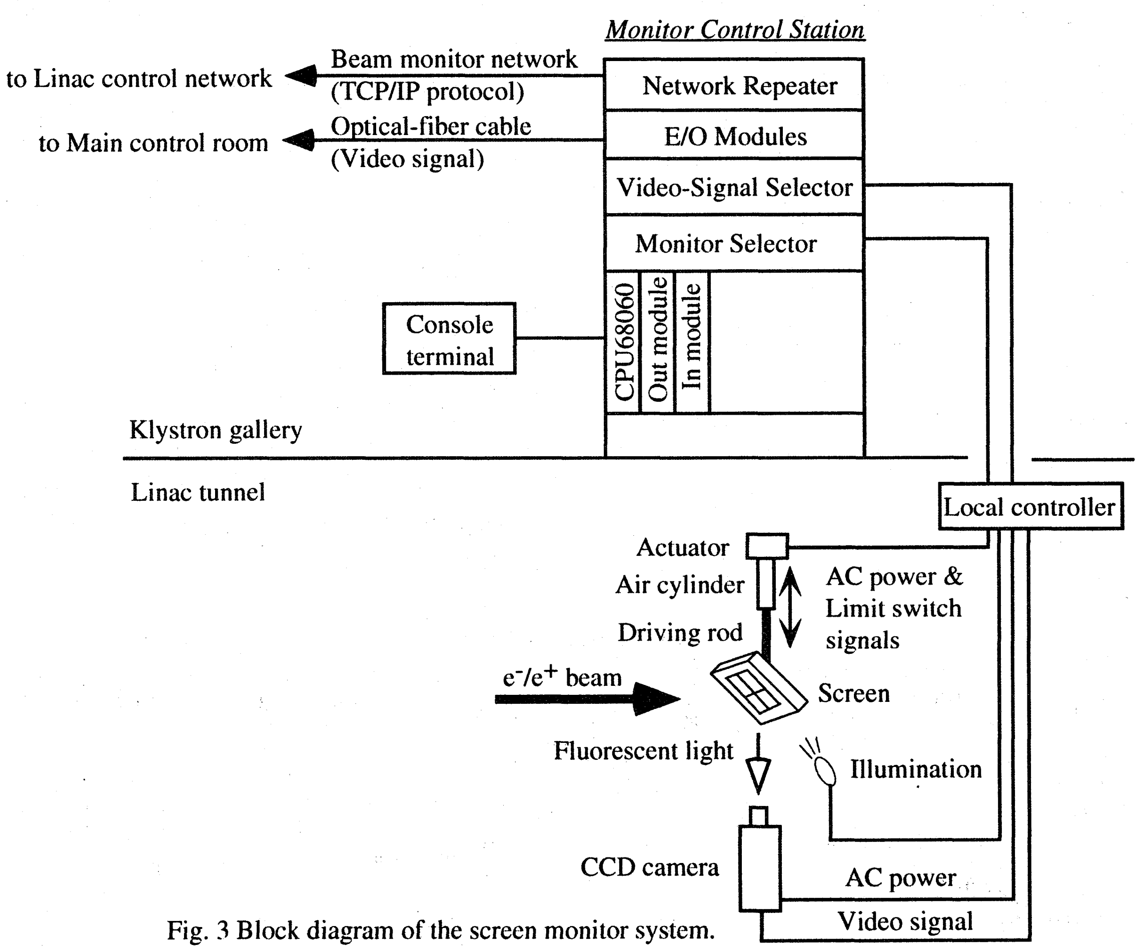

Fig. 3 Block diagram of the screen monitor system.