

OPERATIONAL EXPERIENCE OF THE DISTRIBUTED CONTROL SYSTEM FOR SYNCHROTRON RADIATION BEAM LINES AT THE PHOTON FACTORY

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ABSTRACT A distributed control system has been used for controlling 20 synchrotron radiation beam lines at the 2.5-GeV Photon Factory storage ring. The system is a local-area network comprising 20 outlying nodes with a Z80A for each, and a central node (μ VAX-II); these are interconnected in a star configuration via optical fiber links. Each outlying node controls one beam line; within which are five vacuum valves and other components; it also monitors emergency-interlock signals. With the aid of a fast-closing valve, the system can protect the ultra-high vacuum of the storage ring and beam lines from an instantaneous vacuum failure at the experimental halls. Six years of experience in operating of the system has shown that the system have high reliability; the system does not disrupt the beam line operation, even when a failure of a beam line, or a part of the system, occurs.

INTRODUCTION

The 2.5-GeV electron/positron storage ring at the Photon Factory(PF) of the National Laboratory for High Energy Physics is a dedicated light source for synchrotron radiation research. The beam lines¹ feed synchrotron radiation to the experimental hall where experiments are simultaneously carried out (Fig.1). Up until the middle of FY 1989 there were 20 beam lines installed along lines tangent to the storage ring(Fig.1). This paper describes the operational experience of the distributed control system which has been constructed for these beam lines at the PF.

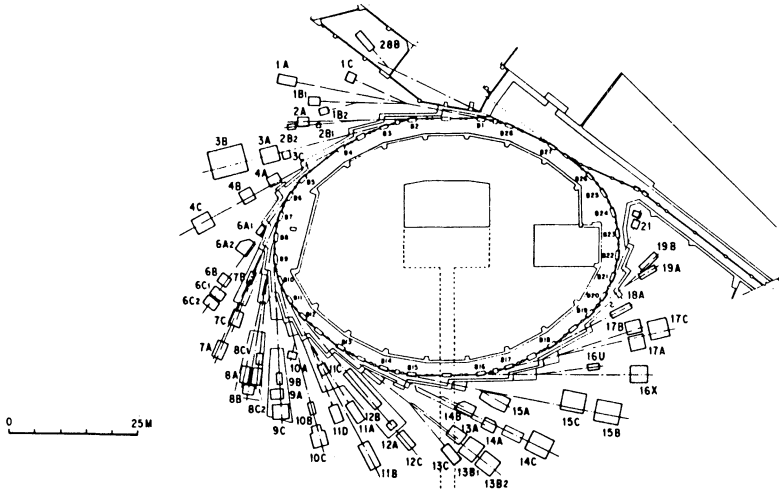


Fig.1 Beam lines around the storage ring. Each beam line is divided into a few branch lines at the downstream end of the beam line in the experimental hall.

SYSTEM CONFIGURATION

Figure 2 shows the configuration of the control system; there are 20 outlying node computers for beam lines as well as a central node computer. These are connected via optical links according to a star configuration. Since a detailed description of the control system appeared in ref.² we briefly describe here the conceptual configuration of the system.

As shown in Fig.3, each beam line has the following components: two vacuum valves, a beam shutter, a water-cooled SR absorber and vacuum pumps. In addition, there are the following interlock-signals: (1) an experimental-hall/ring interlock, (2) a ultra-high-vacuum pressure interlock, (3) a cooling-water interlock signal for the SR absorber,(4) a pneumatic pressure interlock for driving valves/shutters, (5) an atmospheric detector interlock. Upon detecting one of these interlock signals, to be in the 'NOT READY' state all valves/shutters must be immediately closed for an emergency shutdown of the beam line. It is especially important to close the beam line in response to the EXP/RING interlock in order to protect personnel from a radiation accident at the experimental hall and, in response to the UHV interlock, to protect the UHV of the beam line and the storage ring. Therefore, the control system must be reliable and able to provide sufficient real-time control functions.

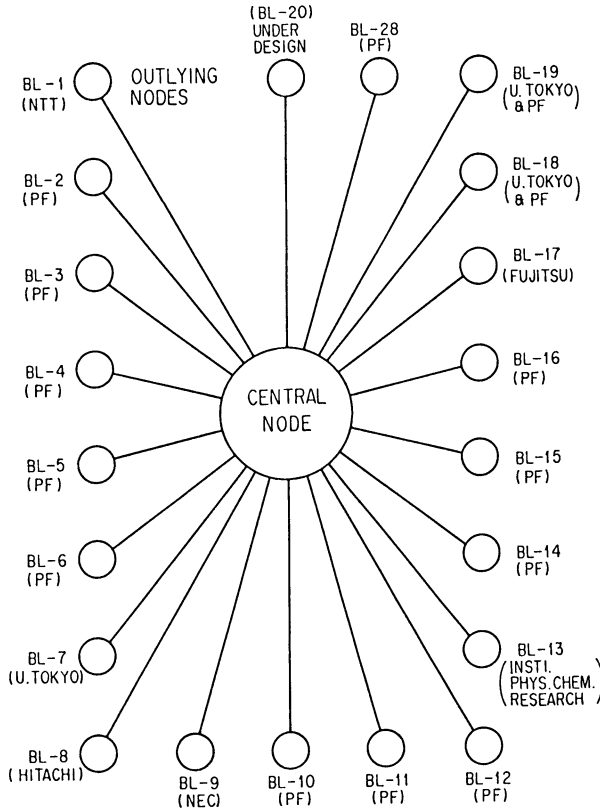


Fig.2 Star network for beam-line control.

The outlying node is a Z80A based on a microcomputer system with parallel I/O ports for the components of the beam line. The outlying node has a serial optical communication port (9600 baud) for the network, and a GPIB port (IEEE-488-1975 standards) for monitoring the ion current of each ion-pump and for the BA vacuum gauge. The outlying node controls all components of the beam line in accordance with a preprogrammed process, as well as any request signals from beam-line users and commands from the central node.

There are several functions of the central node: to monitor the activity of the outlying node, to intervene in the operation of the outlying node by an operator when necessary, to manage communication traffic in the network. Although the central node, itself, does not contribute to the real-time control of the beam line, it collects and logs operating information concerning the beam line.

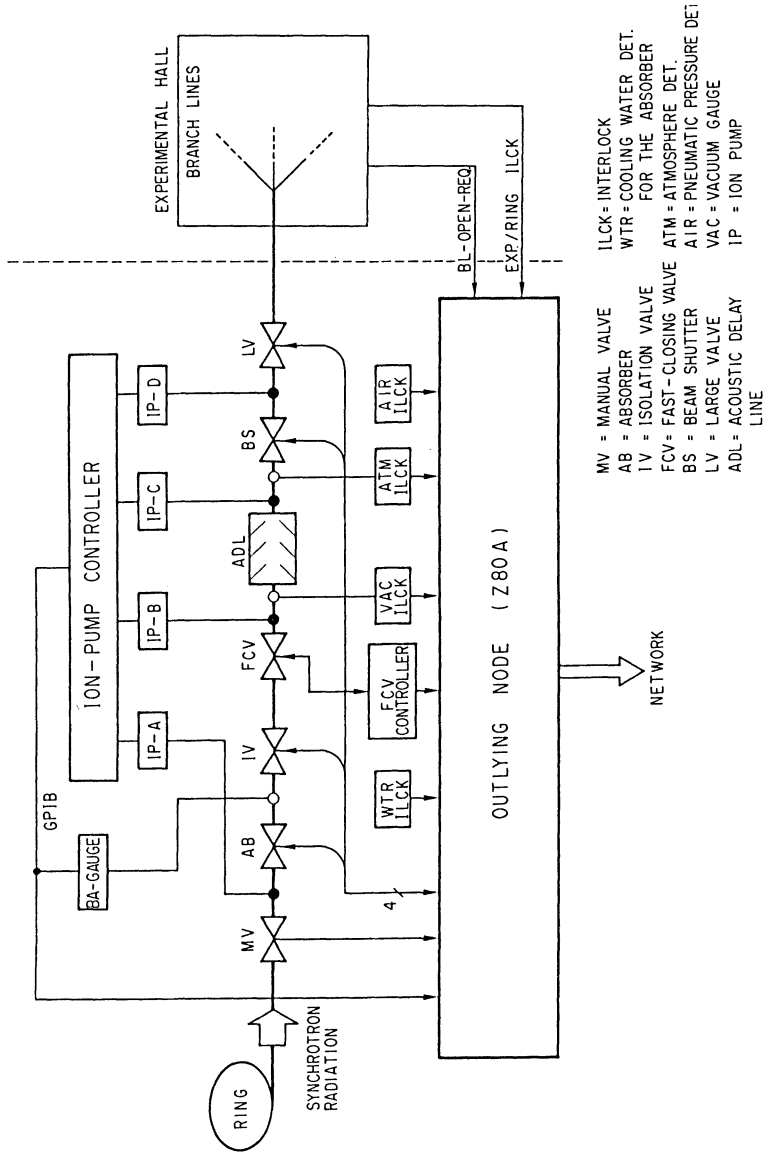


Fig.3 Outlying node and components of a beam line to be controlled.

OPERATIONAL EXPERIENCE OF THE SYSTEM

Construction of the control system started in 1983; since then, 3~4 beam lines and their control system have been increasingly developed during each fiscal year. Up until FY 1989, there have been 20 outlying nodes simultaneously operating each beam line.³ The resulting experience has shown that the system could be expanded without increasing the complexity of the system, and could provide modularity of the system configuration.

Since the outlying nodes control their own beam line, this feature of the distributed control system eliminates the risk of a total system failure, and allows the other beam lines to operate for synchrotron radiation research, even when a failure of a beam line occurs. For example, in the case of a failure of the commercial AC power line for the central node, which actually occurred in mid-1986, all of the outlying nodes could continue beam-line operation; therefore, the system did not disrupt the synchrotron radiation experiments. The control system has been reliably operated for 6-years of real operation without any trouble.

It is a heavy load for the outlying node's CPU to have network communication control because of its limited CPU processing power. Thus, a commercial network controller was employed to make the network capable of providing automatic communication traffic regulation. This choice was successful in providing independent real-time control for these beam lines. The response time was measured to be ~20 ms for both user's request signals and emergency interlocks. This response time was reasonable to drive/monitor all open/close-units with an opening/closing time of a few seconds. Since the outlying node was designed to monitor/control user's request signals and emergency interlock signals with highest priority, the resultant response time for an inquiry of the beam-line status from the remote central node was 1~2 sec, depending upon the operating condition of the beam line and the storage ring.

For vacuum protection, the aid of a fast-closing valve (FCV)⁴⁻⁵ was used for helping the control system suitably for protect ultra-high-vacuum of the storage ring against any instantaneous vacuum failure caused by a rupture of beryllium windows,⁶ or by an instantaneous gas leakage downstream of the VUV branch line. Upon receiving an FCV-interlock signal, the system immediately closes the beam line so as to avoid considerable damage to the storage ring; otherwise, costly evacuation procedures and shutdown time would result. For a high-power wiggler⁷ beam line, BL-16, the impingement of intense synchrotron radiation onto the closing blade of the FCV causes the temperature rise on the blade to reach its melting point within 0.1sec at a beam current of 500mA. This case can be avoided by dumping the beam upon detecting a vacuum failure before closing the FCV; the system simultaneously drives all open/close-units to close.⁸

The increasing demands for managing and monitoring those outlying nodes required the existing central node computer (LSI-11/23) to be

upgraded by a μ VAX computer with a disk capacity of 340Mb. For a hard/soft x-ray beam line, AR-BL-NE-1,⁹ which has been in parasitic use at the TRISTAN Accumulator ring, an outlying node computer, with its stand-alone mode, has successfully been used to operate the beam line.

CONCLUSION

The 6-year experience of the control system operation shows that the system provides highly reliable operation for 20 beam lines at the PF. Additional outlying nodes for two more new beam lines will be constructed till FY1990.

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