KEKB Accelerator Control System

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Abstract

The KEKB accelerators are composed of High Energy Ring(HER) which stores 8 GeV electrons and Low Energy Ring(LER) which stores 3.5 GeV. positrons. The accelerators are installed in the 3 km circumference tunnel where former TRISTAN Main Ring was. All the magnets, RF cavities and vacuum chambers were dismantled and carried away from the tunnel.

Design of the control system started in 1993[1] following the standard model, composed of presentation layer, equipment control layer, and device interface layer. After discussions, the EPICS(Experimental Physics and Industrial Control System) was chosen as the control software toolkit for KEKB accelerator control system[2]. The operator's interface layer is composed of a server workstation with 2 CPUs and 20 GB RAID disks. X-terminals are used as operators' consoles and printers are connected to the server. The equipment control layer is composed of 93 Input Output Controllers(IOCs) with VME board using Power PC 750 CPU. These IOCs are used to extend field buses such as CAMAC Serial Highway, GPIB, ARCNET, Modbus+ and RS-232C. In the device interface layer, there are CAMAC modules, GPIB devices, Power Supplies, PLCs and measuring instruments connected to RS-232C.

PCs are used as X-terminals and for generating video signals and voices. Network stations made by IBM are used as inexpensive X-terminals at the local control rooms, Macintoshes and small PCs are also used as X-terminals with multiple screens. Large 18-inch TFT LCDs with resolution of 1280 x 1024 pixels are used as display screens. The combination of a PC and LCD screens enable us to have a very compact console operated by a keyboard and a mouse.

1 SYSTEM HARDWARE ARCHITECTURE

The KEKB control computer system is based on the "Standard Model" using EPICS toolkit. The model consists of three layers: presentation layer, equipment control layer, and device interface layer. System configuration is shown in Fig. 1.

1.1 Presentation Layer

The highest level, presentation layer consists of a server workstation, X-terminals, and peripheral devices. On the server, ORACLE database system runs under HP-UX operating system. X-terminals are used as standard man-machine interface equipment. There are several kinds of X-terminals corresponding to the purposes. Standard X-terminals are used for developing software. IBM Network Stations are used as terminals in the local control rooms because they are very simple and have no disk and fan. The software for the Network Station is downloaded from the server workstation through the network. Pcs and Macintoshes are used as intelligent terminals. And they can have multiple screens for operators by using multi-screen video interface board or additional video board. It is very convenient for operators to have multiple screens with only one set of keyboard and mouse.

1.2 Equipment Control Layer

This layer includes VME-bus based computers: Input Output Controllers(IOCs). A VME subrack with modular plug-in power supply unit and plug-in fan unit is used for each IOC in order to get good maintainability. Ninety-three CPU modules with Power PC 750 or MC68060 are implemented in the IOCs. Each IOC has an Reliability-Availability-Serviceability(RAS) board which monitors power supply voltages of the VME subrack and generates alarm messages when the voltage becomes unusual. The RAS board also accepts commands from outside through an RS-232C port and responds to various commands. One of the commands is system reset. The system command is very useful for us because we can reset the VME-bus and re-boot the system remotely. The IOCs are used mainly for driving field buses such as CAMAC serial highway, ARCNET, GPIB, MXI-bus, Modbus+ and RS-232C. CAMAC serial highway is used for RF and vacuum controls. ARCNET is used for controlling magnet power supplies. A plug-in module with embedded CPU was developed as the power supply controller module that is plugged-in to the magnet power supply itself. On each ARCNET line, up to 20 poser supplies are connected. An example of connection of power supplies is shown in Fig. 2. GPIBs are used to communicate with measuring instruments such as digital voltmeters. MXI-bus is for connecting VXI mainframes with the VME-bus. Modbus+ is used for communicating with PLCs. RS-232C is used as the general-purpose communication method with various equipment such as mass analysers of the vacuum system, sextupole magnet movers, and PLCs.

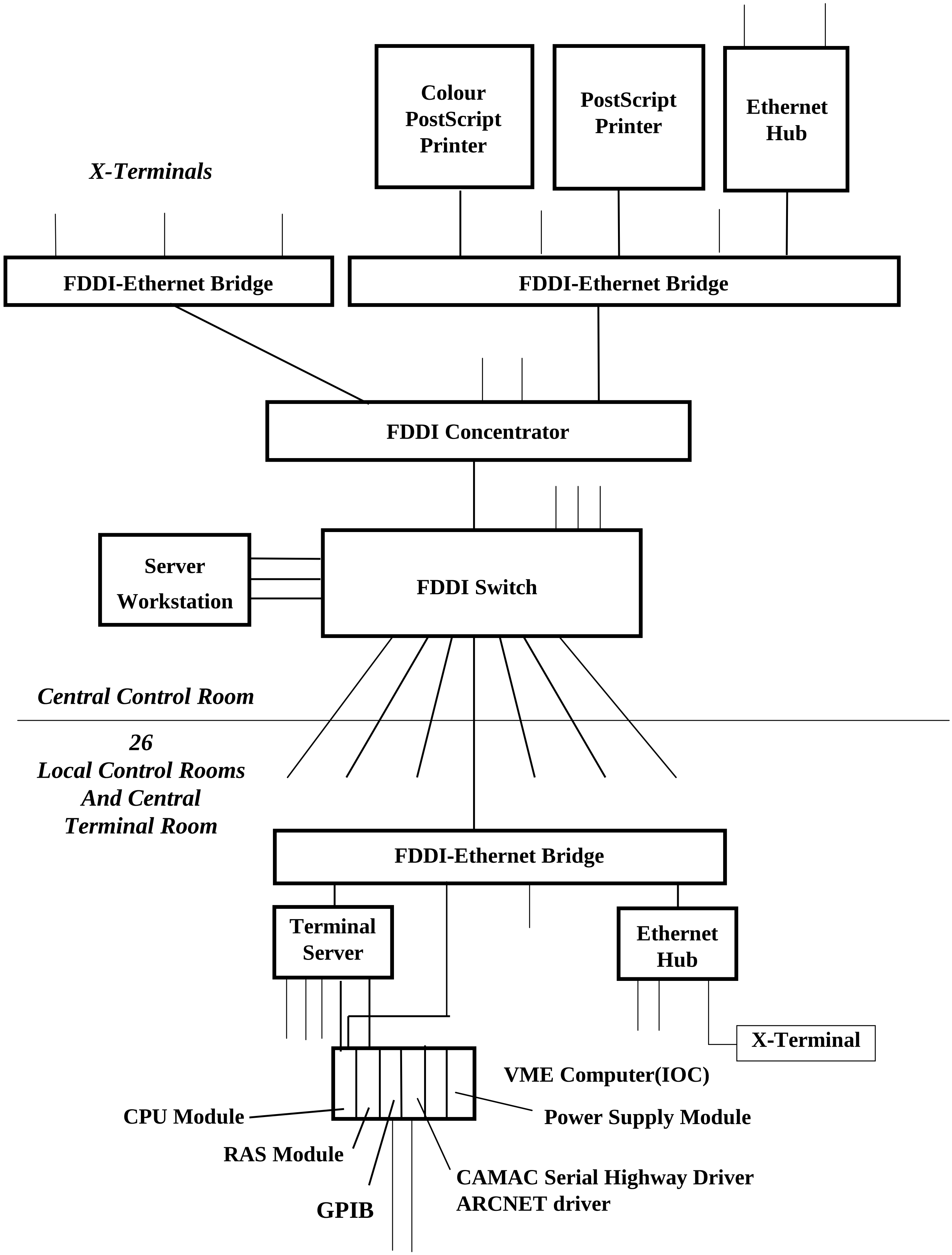

Fig. 1. System Configuration of the KEKB Accelerator Control System

1.3 Device Interface Layer

This layer consists of various kinds of interface modules and equipment based on the field buses mentioned above. We have many kinds of CAMAC modules for digital input/output, analog input/output, and pulse output. VXI modules for FFT analysis and signal multiplexing for beam position monitors are put in the VXI main frames and connected through MXI-bus. Magnet power supplies are controlled by ARCNET power supply controller modules[3] but monitored by digital voltmeters using GPIB. PLCs are used for controlling devices and monitoring interlock status of magnets. They are connected to the IOC via Modbus+ or RS-232C.

1.4 Network System

Network system lies between the presentation layer and the equipment control layer. It was the most important point to get the most suitable network during the design phase of the KEKB accelerator control system. The circumference of the accelerator is about 3 km and it takes more than 10 micro-seconds to circulate a signal. To avoid wasting time, we decided to use a switched FDDI network as the back-bone. In the central control building, an FDDI switch(GigaSwitch by former DEC) was installed and 26 optical fibre links are extended from there to local control buildings. At each local control building, an FDDI–Ethernet bridge is installed to extend an Ethernet segment. Each IOC is connected to the bridge and the console terminal port and the terminal port of the RAS board are connected to the terminal server. In the central control room, there are several Ethernet segments in order to separate network traffics. One is for peripheral devices such as printers, DAT back-up, the other is for X-terminals.

2 SOFTWARE ARCHITECTURE

EPICS software toolkit is used as software environment. In the EPICS system, each signal from the accelerator equipment is read or written through standard method called “Channel Access(CA)” provided by EPICS. There are three modes of the channel access; get, put and monitor.

2.1 Presentation Layer

The operating system for the server workstation is HP-UX Version 10.2. For the presentation layer, Motif based EDM(MEDM) is used to create graphical screens and display accelerator data using EPICS channel access. Data gathered by the equipment layer are archived by the software called “archiver“ on the server workstation. All the accelerator information are stored in the database on the server workstation using Oracle 7 relational database system. The database contains machine parameters, interface information such as cabling, terminal numbers, interface module address, and so on. EPICS record database is generated from the database automatically. Therefore, after any change of the database, one can easily generate the revised edition of the record database.

Orbit correction is done by using SAD server workstation that simulates the orbits of the two rings. An interpretive language PYTHON is also supported in order to make it easy to write application programmes.

2.2 Equipment Control Layer

The software on the IOCs runs on the real-time operating system VxWorks and is cross-developed on the server workstation using Tornado cross-development system. It is down-loaded through the network. EPICS channel access record database is also down-loaded. Control programmes can be coded by using “sequencer” and channel access. EPICS core programmes monitors data whether the data is within certain limits or exceed the boundary values. If the data value exceed the limits, it generates alarm signals and the operator can know the fact on the MEDM screens.

2.3 Device Interface Layer

On this layer, all the intelligence is embedded in the controllers or equipment themselves. In the power supply interface controller module, software for controlling magnet power supply is implemented. The software contains direct current set up procedure and function generation scheme.

3 PCS IN THE SYSTEM

There are a little number of PCs in the KEKB accelerator control system. They are divided into two categories. The first is X-terminals, the second is for specific applications such as generating sounds or video signals.

3.1 X-terminals

PCs are used as the X-terminals by using X-Window emulation software. A PC can generate multiple display screens with high resolution by using multiple screen display controller. A multiple screen display controller named “Evolution 4” is installed in a small PC in order to generate up to four SXGA(1280 x 1024) screens. Macintosh personal computers are also used as X-terminals with multiple screens by putting multiple video cards into the Mac. By using these PCs or Macs, operator can see larger area than usual with only a set of a keyboard and a mouse. Especially by using the latest TFT displays, the operator’s console becomes so thin and light that the configuration can be easily changed.

3.2 Specific use of PCs

PCs are also used because of its variety of hardware and application software available. The above mentioned multi-screen display controller board is used in a PC in order to generate multiple VGA screens which can easily converted to NTSC video signals. We can generate up to four video signals by only one PC. A Macintosh is used to generate alarm message for operators[4].

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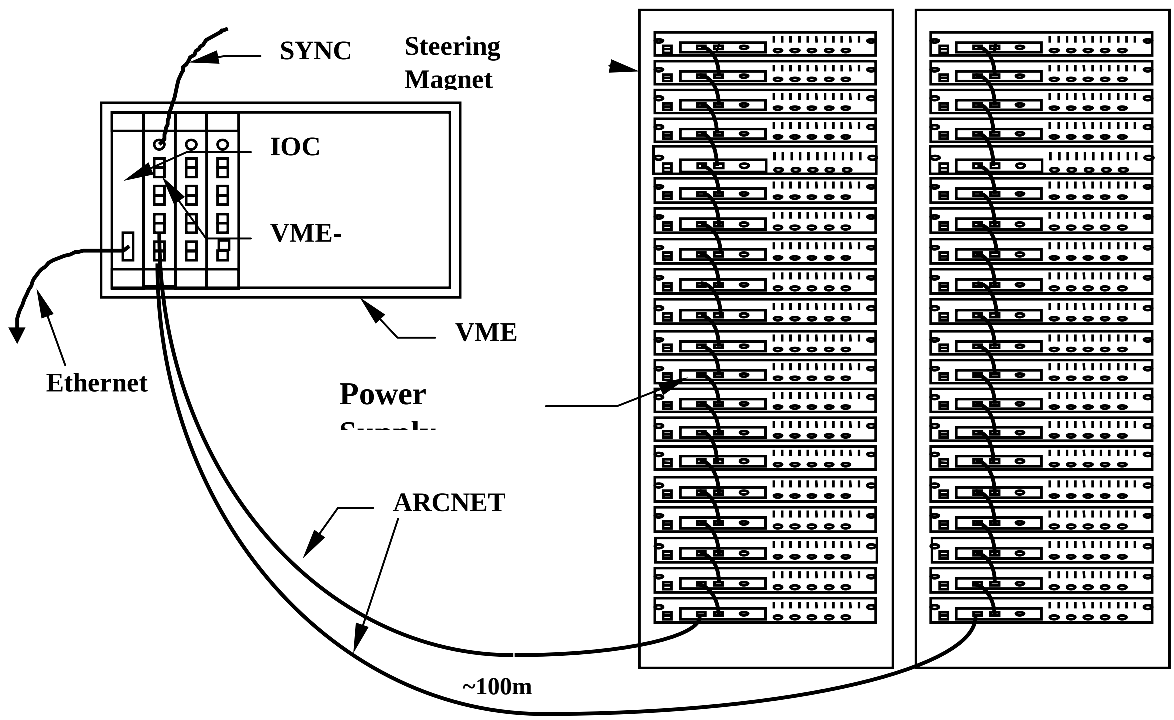

Fig. 2 Configuration of the Steering Magnet Power Supplies