Magnet Power Supply Control System for the SPring-8 Storage Ring
-- Fiber Distributed Remote I/O system for VME --

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Abstract

A fiber distributed remote I/O (RIO) system was developed for VME[1] control system and used for SPring-8 magnet power supply system. The total number of the Storage Ring (SR) magnet power supplies (PS) are more than 1000, and those 480 PS's are floated from the ground level with several hundred volts. From a viewpoint of isolation, noise rejection, reliability, an optical fiber linked Remote I/O) system was made. A large number of beam position monitoring circuits will also take this RIO interfaces. The RIO system consists of the following devices, 1) VME master with a dual port memory, 2) RIO (slave card) which has the following seven types, 3) Star branch for glass fiber cables from the master module to slave cards. VME-RIO test operation with power supplies (B,Q,Sx-PS) was done this year.

1. INTRODUCTION

SPring-8 storage ring consists of 48 cells of Chasman-Green type. Each cell has two Bending Magnets(BM), ten Quadrupole Magnets(QM), seven Sextupole Magnets(SM). Total numbers of Steering magnet PSs (StP) and auxiliary quadrupole PSs (QA) for the SR are 576 and 480, respectively[1][2]. Thirty-eight sets of Skew QM are to be installed. Total number of the all PSs is so large (1112) that power supplies for the magnets are controlled by the VME and remote I/O system. All of the power supplies of BM, QM and SM were completed this March and the interface tests were done.

2. MAGNET POWER SUPPLY

The total numbers of the large PS's for B, Q, Sx is 18. The measured current stabilities of the PSs for BM, QM and SM are within 2~3 x 10^{-5}. A ripple current of the SM must be small because it induces a vertical dipole field at the center of sextupole field in the aluminum vacuum chamber[3].

Some Q-magnets, which are connected in series, are adjusted by auxiliary PS circuits (QA) to correct the modulation of the beta function and phase advance[4]. Forty sets of QAs and ten sets of StPs were also completed and tested. (These forty QAs will be installed for the long straight sections[5] in 1996. The other QAs are to be installed in 1997~8.) These QAs are floated from the ground level with a few hundreds volts. The steering magnets have independent power supplies. B,Q, S, QA and St-PSs are located in PS room-A. PS room-B, C, and D only have 192 sets of StPs and 120 sets of Qa-PSs. The area for St-PS is air-conditioned (26° ±2°C). The other area for BP, QP and SP is only air circulation (10° ~ 30° C).

3. PS CONTROL SYSTEM

3-1) SPring-8 Control System

All the device controller for the SPring-8 takes a VME system basically[6]. The VME system of the Storage Ring with a PA-RISC[2] CPU employs an HP-RT[3]. An FDDI will be adopted as a control network (Figure 1). A UNIX work station (HP755, etc.) will be used as a man-machine I/F, and as a program developing host computer. X-terminals are used for a local control terminal. An Ethernet with 10Base-T Patch-Panel system[4] is employed for a maintenance network. A remote I/O system is taken as a field bus of the VME.

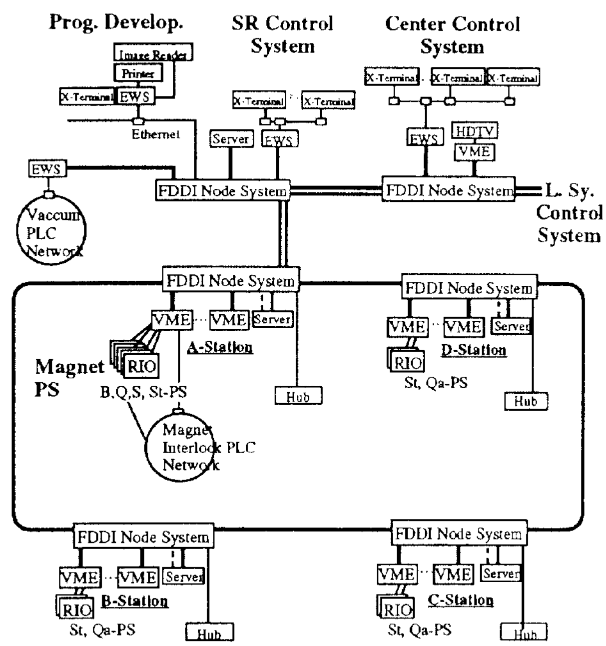

Figure 1. SPring-8 control system architecture. All the magnet PS's are controlled by four VMEs with fiber distributed remote I/O system.

Magnet power supply system and beam monitor system take this RIO field bus system.

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1 Versa Module for European.

2 Hewlett Packered Co.Ltd., CPU tip.: PA-RISC7100.)

3 Hewlett Packered Co.Ltd.: Real -Time Operationg System.: originated by Lynx OS(Real -Time Systems. Inc)

4 PDS: AT&T Premises Distribution System.

3-2) RIO Field Bus for VME

A similar distributed I/O system was developed as a Field Bus for a Nuclear Power plant and for the HIMAC HEBT at the NIRS (National Institute of Radiation Science, Chiba Pref.) with a Multi-Bus system[7]. For the SPring-8 magnet PS control system, especially for an isolation, a master card was modified for the VME bus and the communication link was changed to an optical fiber by the Mitsubishi Electric Corporation.

Figure 2 shows a block diagram of the RIO slave card type-A~G. Type-A, D, and E are a single height of Euro-card size (128 x 172 mm, shown in Fig. 3, left). Type-B, C, F and G are double height (262 x 172 mm, Fig. 3, right) The digital I/O's are all photo isolated, and can be connected to relay circuits, photo-coupler, and TTL level circuits.

The detail specifications of the RIO system are as follows,

1) Master card; VME module (max. 62 slaves),
2) Branch; glass fiber cable star coupler from the master to slave cards with eight ports of optical I/O,
3) RIO (slave card) which has the following seven types,
   - Type-A : 16 bit DAC (AD669, 20 ppm/°C), 16 bit ADC (AD7701) and Amp. (input : 0-1V, 0-10V, ±1V, ±10V), 8 bit digital output, 8 bit digital input,
   - Type-B: 32 bit digital output, 32 bit digital input,
   - Type-C: 32 bit digital output, 32 bit digital input, 16 bit ADC + 16 ch MPX,
   - Type-D: 48 bit digital input,
   - Type-E: 16 bit ADC (< 32 mS) and Amp., 8 bit digital output, 8 bit digital input,
   - Type-F: 12 bit high speed conversion ADC (1μs) & Peak Hold x 4 ch, 1 bit synchronization signal input,
   - Type-G : 64 bit digital output, and 8 bit digital input.
4) Optical fiber cable (Dupont Co. LTD) with a connector: JIS-C 5977 F08.

The RIO master controller, which has a dual port RAM, is a VME module. The interface between the master and slave (RIO card) is an RS485 and HDLC protocol with a transfer speed of 1 Mbps. This communication processor is DN1850[7] which is made by Mitsubishi Cable Inc.

The cyclic data transfer speed of six bytes read write process for one RIO is 0.2 mS, and that for 31 RIOs is 64 mS. From the viewpoint of a material life-time, glass fiber cable is taken.

-- *Beam monitor System RIO* --

Forty-eight sets of beam monitoring circuit for each cell are concentrated to 12 or 24 VMEs by using RIO network. The RIO card type E, F and G will be adopted for them. Type F has four hi-speed conversion ADCs (1μS) for a single pass mode beam position monitor.

3-3) Magnet PS Control System

The each reference voltage for the large PS is given by a 16 bit DAC controlled by the digital output of the RIO type-B. These DAC's for the B, Q, Sx PS's are installed in the PS cubicle's temperature controlled box.

The St and QA PS's are controlled by an analog signal (-10 ~+10 V), using the RIO type-A (Fig. 4-ii, iii). The RIO card -A is attatched to the PS chassis with the same guard level. The RIO operation power source (5V, ±15V) is supplied by those floated PS. The RIO type-A also has a double integration ADC, which monitors a actual current using a shunt resistance output. A double integration type ADC of the RIO type-A has an accuracy of 1 x 10^{-5} [8].

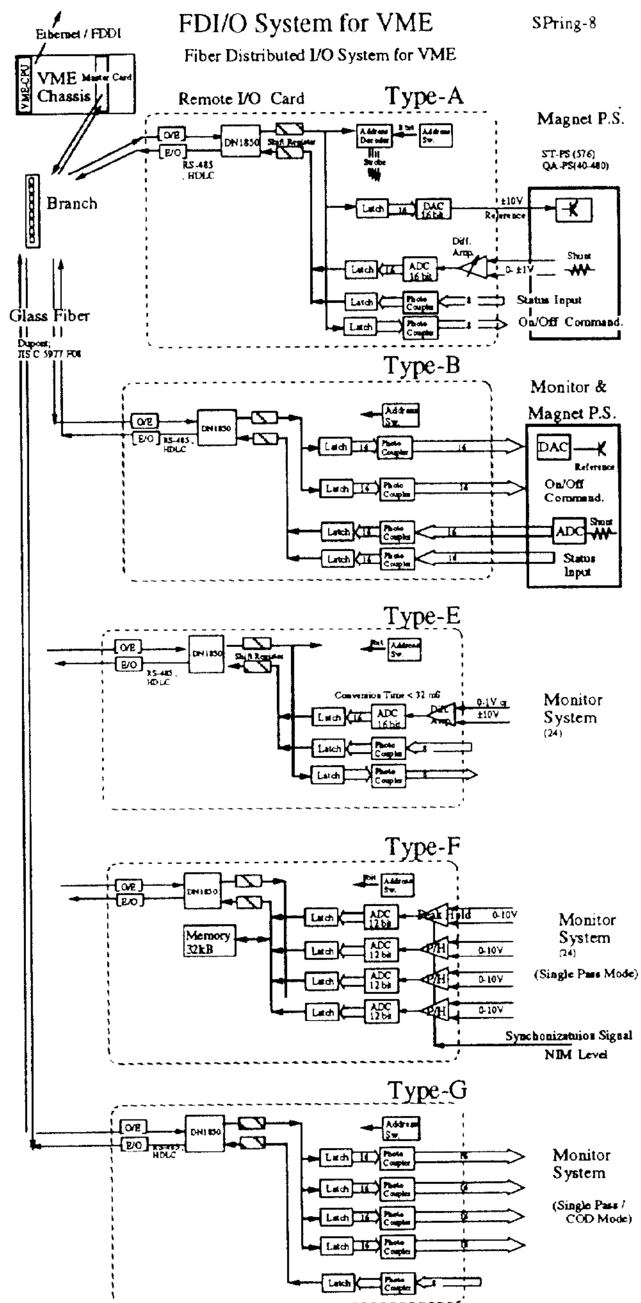

Figure 2. Remote I/O cards (type-A ~ G). VME master controller sends data and address to register (Latch) for the ADC, DAC, DIO through a glass fiber cable and a star coupler.

Thirty-six steering magnet power supplies (or 30 QA-PS's) are 250~300V DC-DC converters (specially developed by IDX: Tokyo Densi, f=100 kHz) and enclosed in one power supply cubicle. This cubicle has a DC Bus power source and send 16 bit status (power on/off, fuse, transistor break down, temperatures, oven, ext-interlocks, etc.) to the RIO type-B.

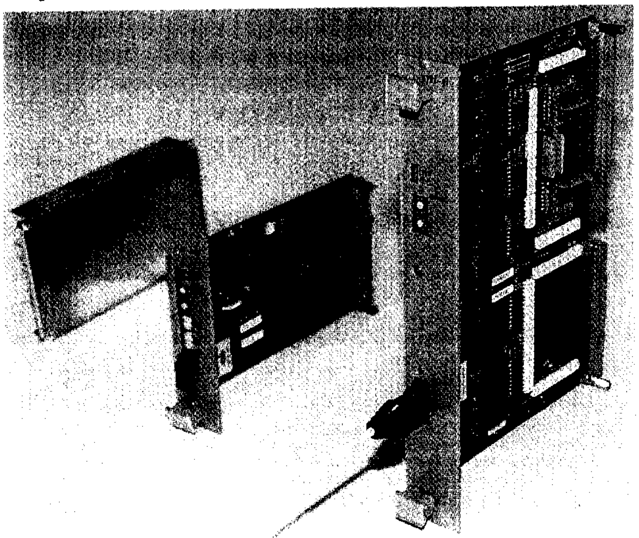

Figure 3. RIO slave card type-B (right), A (middle) and case (left) for type-A.

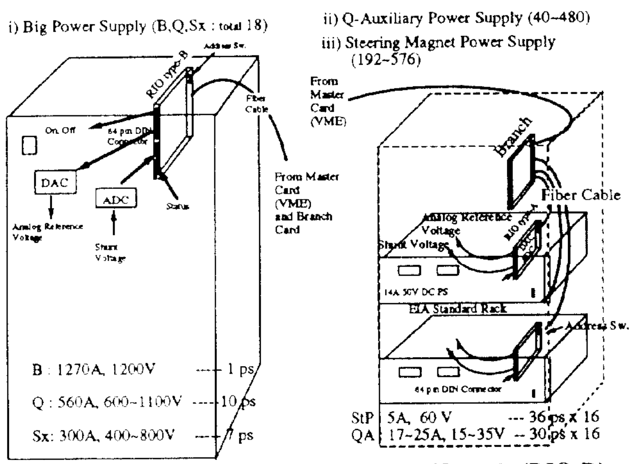

Figure 4. (i) Installation of the Remote I/O cards (RIO-B) and power supply (BP,QP,SP). The DAC is isolated from the RIO-digital output. (ii, iii) Steering PS and QA-PS units mount the RIO card type-A, and is controlled by the analog signal.

The currents of the multiple PS's must be changed simultaneously for an orbit correction. Therefore, one VME CPU controls any combination of four St-PS's in any PS rooms (digital feedback system). Also, if a fast feedback for this correction is necessary, an analog signal can be added to the DAC's reference voltage.

A programmable logic controller (PLC) is used for the PS interlock system. Water flow and temperature switches of each magnets are connected to a distributed I/O units of the PCL.

4. VME AND RIO NETWORK

All the RIOs for all the magnet PSs are controlled by only four VMEs by using Branch cards for the RIOs. A SPring-8 control system adopted a FDDI interface for WS and VME communication. Machine setup and tuning the beam will be done through this FDDI (100 Mbps). Currents for the Storage Ring's Lattice magnets can be set in a few minutes. For a COD correction, multiple sets of steering magnet power supplies (StP) must be set isochronously (local bump orbit). So, that a timing signal (< 10 mS) must be installed for the magnet control system. Figure 5 shows the VME and RIO network for the magnet PS. The RIO's master to master communication (data transfer time is less than 0.8 mS).system will be taken, if the FDDI traffic is so large.

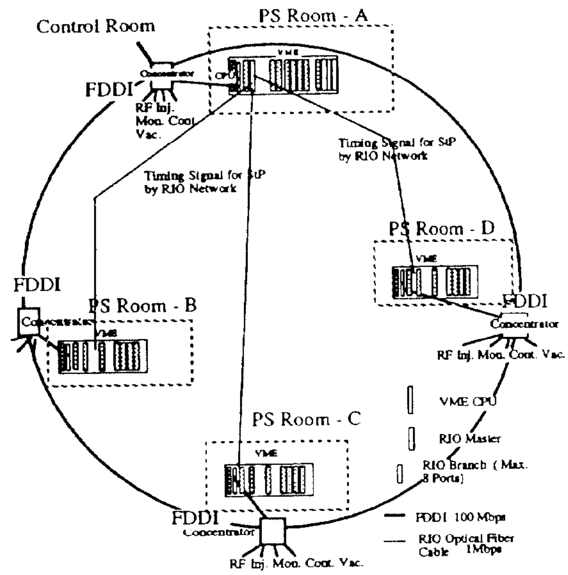

Figure 5. FDDI and RIO network for magnet PSs. Steering magnets are set in a same time for local bump orbit correction. So, the timing signal must be distributed in the four VME controllers using RIO network.

5. REFERENCES

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