THE CONSTRUCTION OF THE SUPERKEKB MAGNET CONTROL SYSTEM

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Abstract

There were more than 2500 magnet power supplies for KEKB storage rings and injection beam transport lines. For the remote control of such a large number of power supplies, we have developed the Power Supply Interface Controller Module (PSICM), which is plugged into each power supply. It has a microprocessor, ARCNET interface, trigger signal input interface, and parallel interface to the power supply. The PSICM is not only an interface card but also controls synchronous operation of the multiple power supplies with an arbitrary tracking curve. For SuperKEKB we have developed the upgraded version of the PSICM. It has the fully backward compatible interface to the power supply. The enhanced features includes high speed ARCNET communication and redundant trigger signals. Towards the Phase 1 commissioning of SuperKEKB, the construction of the magnet control system is ongoing. First mass production of 1000 PSICMs has been completed and their installation for Phase 1 configuration has been done. The construction status of the magnet control system is presented in this report.

INTRODUCTION

KEKB is the asymmetric energy electron-positron collider, which is dedicated to the B-meson physics. Its operation started in December 1998 and finished in June 2010. The KEKB accelerator control system has been constructed based on EPICS (Experimental Physics and Industrial Control System) tool kit. EPICS provides core mechanism for the distributed control system. EPICS runtime database is running on a local control computer called IOC (Input/Output Controller). More than 100 VME/VxWorks computers have been installed as IOC in the KEKB accelerator control system.

SuperKEKB is the upgrade of KEKB. It aims at 40-times higher luminosity than the world record by KEKB. Its operation is going to be performed in three phases. The Phase 1 is the operation without QCS (final focusing superconducting magnets) nor BelleII detector. Start of the Phase 1 is scheduled in Feb. 2016. Phase 2 follows after installation of QCS and BelleII,.

In the KEKB storage rings and the injection beam transport lines, about 2500 magnet power supplies were installed [1] and controlled by 11 IOCs. To connect such a large number of power supplies to the IOCs, we adopted ARCNET as the field bus and developed the PSICM (Power Supply Interface Controller Module) [2]. The PSICM is the ARCNET interface board for the power
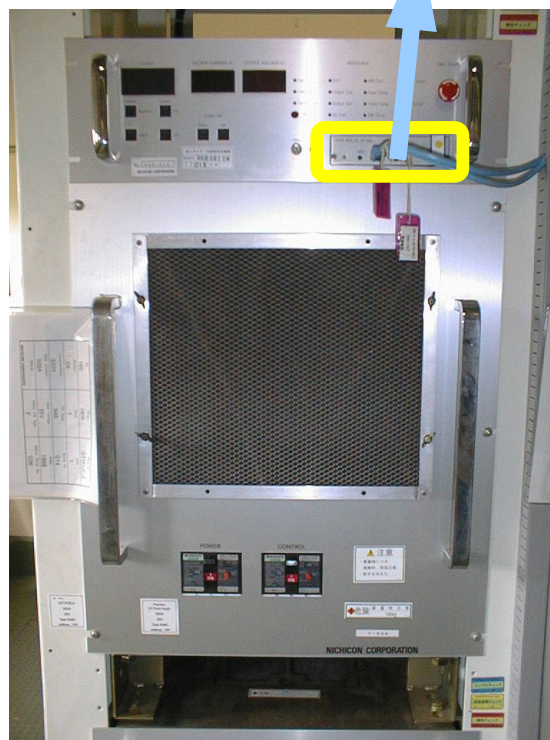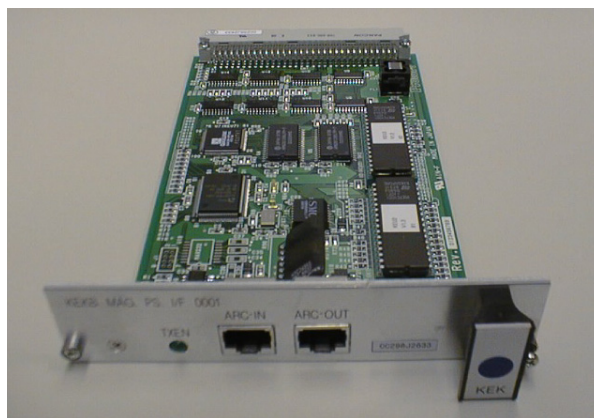
supply. The PSICM has the shape of 3U Euro-card format (100mm × 160mm) with a DIN 64-pin connector and can be plugged into the power supply. Figure 1 shows the photo picture of the PSICM and the magnet power supply with PSICM. Figure 2 shows the details of the interface between the PSICM and the power supply.

Figure 1: Whole shape of the PSICM (above) and the PSICM plugged in a magnet power supply (below).

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The ARCNET allows using several kinds of media. We adopted shielded twisted-pair (STP) cable as the media and HYC2485 as the media driver. This configuration allows up to 20 ARCNET nodes to be connected on single segment in the daisy chain manner. The STP cable includes an auxiliary twisted-pair for the external trigger signal together with the ARCNET. Figure 3 shows typical configuration of ARCNET used in the KEKB magnet power supply control system.
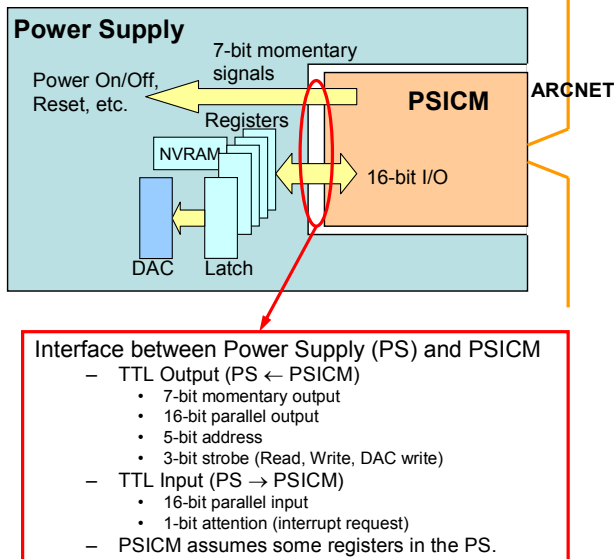

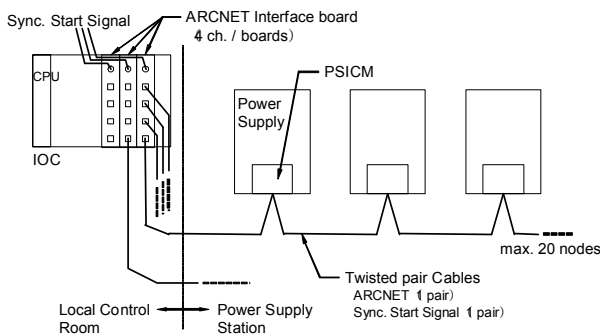Figure 2: The interface to the magnet power supply.

Figure 3: Typical configuration of ARCNET in KEKB.

The PSICM is designed to control the output current of the power supply according to the arbitrary tracking curve. The tracking data are sent from the IOC to the PSICM as an array of the output current values. After receiving the data the PSICM start tracking by a start command or an external trigger signal. Figure 4 shows the schematic diagram of this sequence. Using the external trigger signal all magnets in the storage ring can be synchronously operated. The sequence control of the synchronous operation is performed by the IOCs with the arbitration by the server process on the central workstation [3].

The magnet power supplies of the Photon Factory Advanced Ring (PF-AR) in KEK are also controlled in the similar manner using the PSICM.
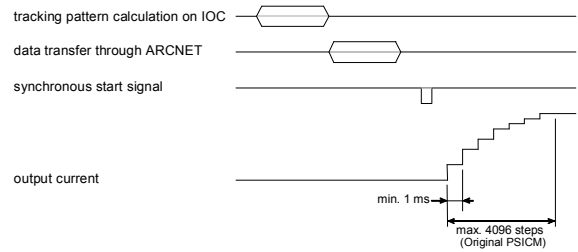

Figure 4: Schematic diagram of synchronous operation.

NEW VERSION OF THE PSICM

For the SuperKEKB, significant numbers of power supplies are newly manufactured. The PSICMs have worked in KEKB for 12 years. During these years some of the parts have been discontinued and it becomes much harder to reproduce the PSICM. Thus we have developed the new version of the PSICM [4]. Table 1 shows the hardware specifications of the new PSICM together with the original one. Figure 5 shows the photo picture of the new PSICM.

Table 1: Hardware Specifications

	Original PSICM	New PSICM
Microprocessor	AM186	MPC8306
Clock frequency	20MHz	133MHz
Data memory	256kB SRAM	128MB DDR2 SDRAM
Program memory	256kB EPROM	64MBit NOR FLASH
ARCNET interface	2.5Mbps Backplane mode	2.5/5/10Mbps Backplane mode
Controller	COM2002	COM20022
Media driver	HYC2485	HYC5000
Power required	5V 0.4A	5V 1A

Figure 5: The upgraded PSICM.

Compatibility is the most important issue for the design of the new PSICM. The specifications of the interface to the power supply are fully backward compatible to the original PSICM. The new PSICM can be plugged into any existing power supplies.

The application-level communication protocol between the IOC and the new PSICM is also backward compatible to the original PSICM. All of the command messages defined for the original PSICM can be accepted also by the new PSICM.

In addition following extensions are introduced.

(1) The high speed ARCNET communication is supported. 10Mbps, 5Mbps and 2.5Mbps are supported for the new PSICM while the original PSICM supports 2.5Mbps only.

(2) 32-bit data handling of the tracking data array is available in order to support high resolution DAC (24-bit, 20-bit and 18-bit). The original PSICM supports 16-bit DAC only. (Later special version for 18-bit DAC was developed based on the original PSICM. But this version was ad hoc and limited.)

(3) Dual trigger inputs for synchronous start signals are available. This feature enables trigger signals redundant. More reliable synchronous operation is expected.

(4) More reliable RJ-45 connectors which have optional protectors against dust are adopted.

INSTALLATION OF THE NEW PSICM AND THE CONSTRUCTION STATUS

First mass production of 1000 modules have been completed in March 2014. We finally need 3000 modules for all magnet power supplies of the main storage rings, the damping ring and the beam transport lines. The schedule of the second mass production of 2000 modules has not yet fixed due to the budget limitation. Thus we have decided to use both old and new PSICM at least at the beginning of the commissioning of SuperKEKB. For the Phase 1 operation of the main storage rings, 426 New PSICM (out of 2162 magnet power supplies) have been installed. The remote operation test of the power supplies with PSICM and IOC is now in progress. Figure 6 shows the example of the combination of the old and new PSICM.

We also upgrade the VME-based IOC for the magnet power supply control. The CPU board has been upgraded from PowerCore6750 to MVME5500. VxWorks has been updated from Ver. 5.3.1 to Ver. 6.8.3. EPICS on the IOC has been updated from R3.13.1 to R3.14.12.3. VME board of the 4-channel ARCNET interface have been also upgraded. Figure 7 shows the renewal of the IOC.
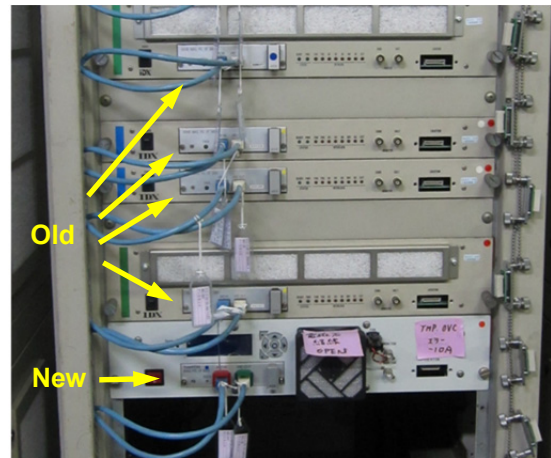

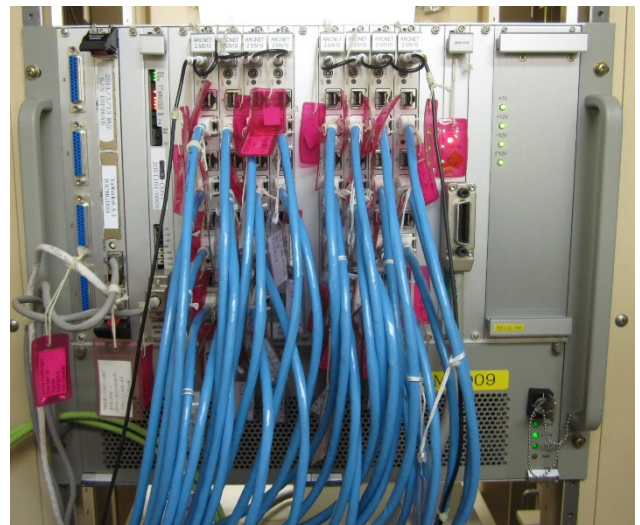Figure 6: The combination of the old and new PSICM.

Figure 7: The setup of the IOC for SuperKEKB.

INTERFACE TO THE MAGNET INTERLOCK SYSTEM

We have completely changed the interface to the magnet interlock system. In KEKB, Modbus-plus was used as the interface between the interlock system and the IOC located in the D8 local control room. In SuperKEKB, the interlock system has been completely replaced with new one, which use Yokogawa FA-M3 PLC. In the PLC, We have installed F3RP61 CPU module, on which EPICS running. Thus the EPICS IOC is embedded in the interlock system. Figure 8 shows the PLC in the D8 power station.
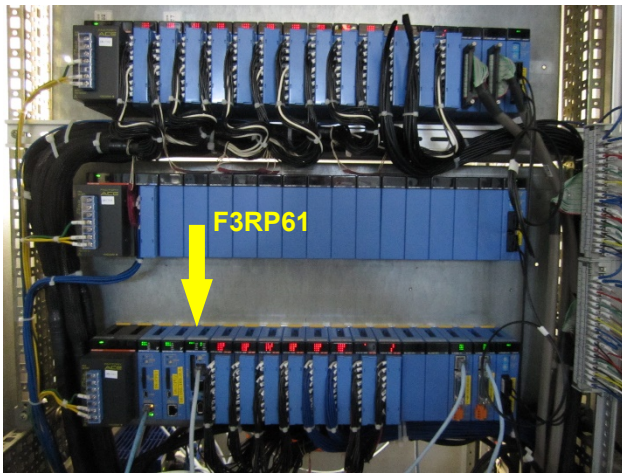
Figure 8: The PLC for the magnet interlock system. The photograph is taken at the D8 power station. F3RP61 CPU module is mounted (yellow arrow).

CONCLUSION

We have developed the new PSICM for SuperKEKB. It is backward compatible to the original PSICM. Several enhancements are introduced. The high speed ARCNET communication is expected to enable more efficient operation of the magnet power supplies. Wide variety of the high resolution DAC can be supported by 32-bit data handling. Dual trigger input for the synchronous start signals, together with the dust protectors of the RJ-45 connectors, is expected to enable more reliable and stable operation of the magnet power supplies. We have completed the first mass production of 1000 modules of the new PSICM and installed for the Phase 1 operation. We are going to start with the combination of the old and new PSICM because of the budget limitation. The compatible design of the new PSICM enables such a flexible configuration.

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