PROTOTYPE OF THE ETHERNET-BASED POWER SUPPLY INTERFACE CONTROLLER MODULE FOR KEKB

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Abstract

Most of the magnet power supplies of the KEKB rings and beam transport lines are connected to the local control computers through ARCNET. For this purpose we have developed the Power Supply Interface Controller Module (PSICM), which is designed to be plugged into the power supply. It has a 16-bit microprocessor, ARCNET interface, trigger pulse input interface, and parallel interface to the power supply. According to the upgrade plan of the KEKB accelerators, more power supplies are expected to be installed. Although the PSICMs have worked without serious problem for 11 years, it seems too hard to keep maintenance for the next decade because some of the parts have been discontinued. Thus we decided to develop the next generation of the PSICM. Its major change is the use of the Ethernet instead of the ARCNET. On the other hand the specifications of the interface to the power supply are not changed at all. The new PSICM is named ePSICM (Ethernet-based Power Supply Interface Controller Module). The design of the ePSICM and the development of the prototype modules are in progress.

INTRODUCTION

KEKB is an asymmetric electron-positron collider at 8 × 3.5 GeV/c, which is dedicated to B-meson physics. Its operation was started in December 1998. 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 are installed as IOC in the KEKB accelerator control system. The workstations of 4 kinds of platform (PA-RISC/HP-UX, Alpha/OSF1, PC-AT/Linux and Macintosh/OSX) are also installed. Most of the high level application programs run in these workstations. The runtime database is downloaded from the central server workstation when the IOC starts up.

In the KEKB storage rings and the injection beam transport lines, about 2500 magnet power supplies are 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], which 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. The hardware specification of the PSICM is listed in Table 1.

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 other than the ARCNET use.

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. Using the external trigger signal all magnets in the storage ring can be synchronously operated. The sequence 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.

NEW GENERATION OF THE PSICM

For the Super-KEKB, the upgrade plan of the KEKB, significant numbers of power supplies are expected to be newly manufactured. The PSICMs have worked in KEKB for 11 years. During these years some of the parts have been discontinued and it becomes much harder to reproduce the PSICM. At this moment we decided to develop the next new generation of the PSICM.

Although ARCNET is still available in the market, we have decided to adopt Ethernet as the field bus for the new PSICM. In this decade the Ethernet becomes much popular and wide variety of the inexpensive commercial products become available. We think the Ethernet is the most probably surviving technology in the next decade. We call the new PSICM "ePSICM", which means Ethernet-based PSICM.

REQUIREMENTS OF THE COMPATIBILITY

We define the requirements of the compatibility between the ePSICM and the original PSICM as followings.

Compatibility for the power supply

The specification of the interface to the power supply must be fully compatible to the original PSICM. The ePSICM must be able to be plugged into any existing power supplies.

Compatibility for the control software on IOC

Although the lower level drivers are completely different, the higher level protocol of the communication between the IOC and the ePSICM should be compatible to the original PSICM. This requirement minimizes the modification cost of the control software. We consider the option of the partial replacement of the PSICM. In such case the common control software for both generations is desirable.

HARDWARE CONFIGURATION OF THE PROTOTYPE MODULES

Although the detailed design of the ePSICM has not yet fixed, we have started developing prototype modules for the study of the feasibility. We have developed 2 types of the prototype modules, in which ready-made small board computers, SUZAKU and Armadillo, are used for the rapid prototyping. Both are the commercial products of Atmark Techno, Inc.

Prototype using SUZAKU

The first prototype module (ePSICM Prototype-1) uses SUZAKU, which is the small board computer with FPGA. Table 1 shows the specification of the module. We choose SUZAKU-V, which has Virtex-4 FX FPGA with hardcore PowerPC and also has the Ethernet interface with RJ-45 connector. Thus the hardware design of the module has been very simplified because few additional chips are required to build the complete module. Fig. 1 shows the board layout of this prototype module. SUZAKU-V supports Linux Kernel 2.6. It provides rich software environment for rapid prototyping.

SUZAKU is powerful for prototyping but somewhat expensive. We have also developed another type of prototype module using cheaper board computer, Armadillo.

Prototype using Armadillo

The second prototype module (ePSICM Prototype-2) uses Armadillo, which is the small simple board computer. The specification of the module is listed in Table 1. Fig. 2 shows the board layout of the Prototype-2. Some additional chips, CPLD, SRAM and the Ethernet interface are also mounted on the board. Armadillo-500 also supports Linux Kernel 2.6.

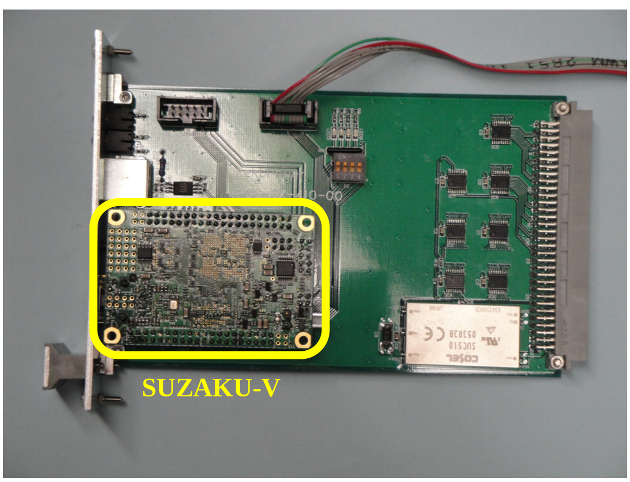

Figure 1: Board layout of the ePSICM Prototype-1.

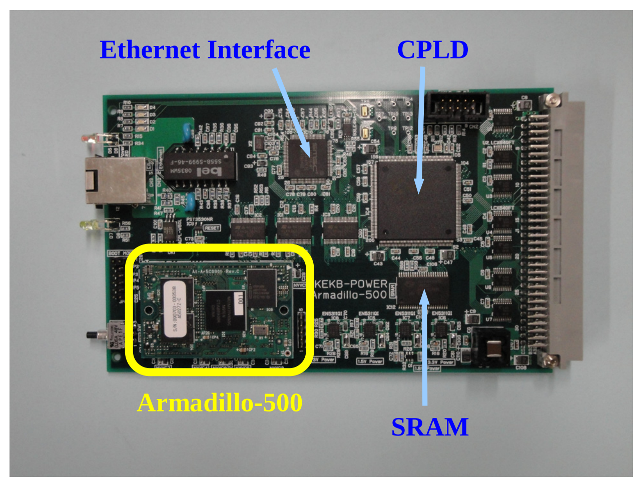

Figure 2: Board layout of the ePSICM Prototype-2.

Table 1: The Specification of the PSICM and the ePSICM Prototypes

	Original PSICM	ePSICM Prototype-1 (Using SUZAKU)	ePSICM Prototype-2 (Using Armadillo)
Board computer		SUZAKU-V SZ410-U00	Armadillo-500 A5027-U00Z
Microprocessor (CPU core)	AM186	(PowerPC405)	i.MX31 (ARM11)
Clock frequency	20MHz	350MHz	400MHz
Data memory	256kB SRAM	32MB DDR2 SDRAM × 2	128MB DDR SDRAM
Program memory	256kB EPROM	8MB SPI FLASH	32MB NOR FLASH
Buffer memory			256k × 16bits SRAM
Network interface	2.5Mbps ARCNET Backplane mode	Ethernet 10BASE-T/100BASE-TX	Ethernet 10BASE-T/100BASE-TX
Programmable logic device		FPGA: Xilinx Virtex-4 FX XC4VFX12-SF363	CPLD: Xilinx CoolRunner-II xc2c256

SOFTWARE ON THE PROTOTYPES

The firmware on the original PSICM consists of two parts. One part governs the power supply control. Another part handles ARCNET communication. Porting the former part to the prototype modules has already done. The latter part should be completely rewritten for the Ethernet but it has not yet completed. At this moment we have not yet fixed the lower level communication protocols. We are considering 3 candidates, which are UDP/IP, TCP/IP and EPICS-CA. Evaluation of them is in progress.

For the test purpose, we have installed EPICS in the both prototypes and have successfully run EPICS IOC core program. It provides us powerful environment for the self test. At this moment for the ePSICM Prototype-1 the external file server through NFS or additional SD memory card mounted on board is necessary to install EPICS because the SUZAKU-V has not enough flash memory.

We are considering the use of the ePSICM not only for the power supply control but also for other purposes. The ePSICM has the potential to be the general purpose embedded I/O controller.

NEXT STEP OF THE DEVELOPMENT

We have only finished making the hardware of the prototypes and partially software. Next step is designing and implementing the lower level communication protocol. We also have to design the handling of the external trigger signal. In the view of the whole system, not only ePSICM but also the design of the network configuration and cabling has to be done.

REFERENCES

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