UPGRADE OF A LOW-LEVEL CONTROLLER OF MAGNET POWER SUPPLY

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Abstract

The experimental equipment, magnets or power supplies, have long lifetimes. In order to effectively use them, it is necessary to update the control system. It thus provides not only efficiency, but also an effective environment for maintaining or improving the work. In the KEK counter experimental hall, the low-level magnet power supply controller consists of a CPU board, IO boards, and ADC/DAC boards. The CPU board has been used for more than ten years, which is equipped with a Z-80 8-bit CPU. In order to improve the controller performance, a CPU board equipped with 32-bit CPU SH2 (HITACHI, SH2-7045) was designed according to the STD-bus and under testing. Many of the older STD-bus boards have been refreshed. By using a SH2 high speed CPU, the power supply controller has an additional function of current control of the magnet power supply. This paper presents the features of the CPU board and the result of current control.

INTRODUCTION

In general, an accelerator or a beam line in the physics experimental facility takes much money and time to construct and maintain. In the 12-GeV physics experimental halls, there are about 200 magnet power supplies of the beam lines; one forth of those are almost 30 years old. These are expected to have longer lifetime, and to maintain smooth operation at low cost. The remote control system has been improved since those power supplies were introduced. The system now has an interface device equipped with analogue circuit boards, exclusively developed for the magnet power supply. Fig.1 shows schematic configuration of the control system of the KEK north experimental hall and the neutrino beam line [1] [2]. The power supply controller (PSC) consists of a CPU (Z80) board, a GPIB interface, a 22-bit ADC, a 16 differential channel multiplexer, eight 16-bit DAC boards, and some IO boards. Those analogue circuit boards were , designed as a part of the magnet power supply. Also, those circuit boards have confirmed the performance, stability, isolation, CMR, and reliability through actual long-term operation. However, their costs and time are easily overlooked. Fig. 2 shows connection of PSC and power supplies.

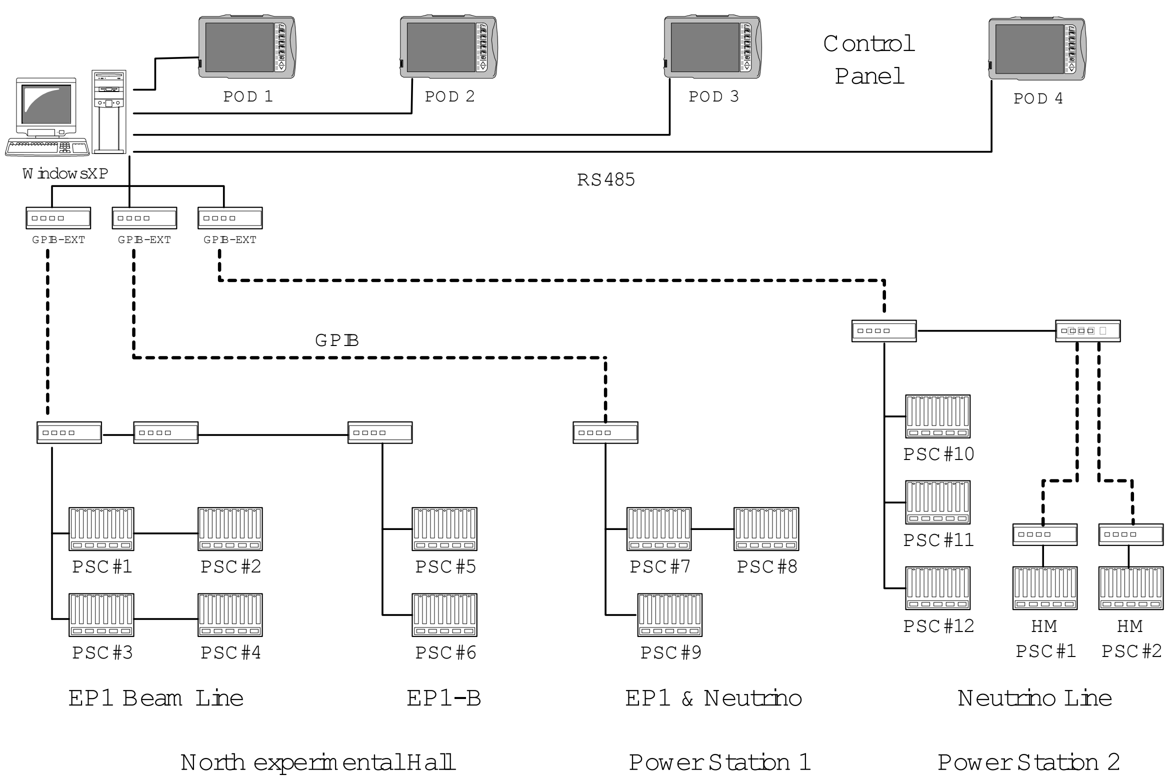

Figure 1: Control system of the beam line magnet power supplies.

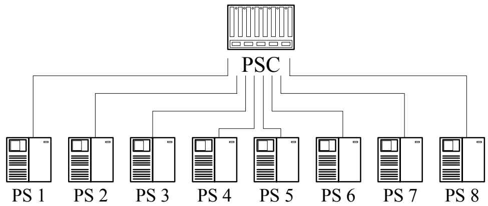

Figure 2: Connection of PSC and power supplies

From the viewpoint of improving of the magnet power supply controller PSC, there are two methods. One is that the PSC be replaced with a PLC, which is popular recently. In this selection, it is especially necessary to select, check or carefully test that the PLC's analogue module does not spoil the performance of the magnet power supply. Another point is development of a CPU board with a high-performance CPU, which reuses the peripheral IO interface boards, as before. It is not necessary to change any hard wiring. It seems to be economical on the whole. This paper reports on the development of an experimental STD CPU board using SH-7045 (Hitachi 32-bit CPU, 37MIPS) and the test result of the current feedback control by the CPU board of the magnet power supply.

UPGRADE OF PSC

STD CPU board of PSC

For improving the CPU board of the PSC, some CPUs were considered. Kawasaki KC80, KC160, Hitachi HD64180 are 16-bit architecture CPUs, and are binary-compatible with Z80. Those CPUs are needed to be equipped with an external EPROM. Concerning the development (programming) work, the EPROM is necessary to move from the UV eraser to the EPROM writer, and finally to the CPU board. At present, it seems that EPROM handling takes much time and is inefficient.

A Hitachi SH/ 7045 CPU with an on-chip flash memory (32-bit, 4kB-RAM, 256kB flash PROM) was considered. The future is that PROM programming is available on a chip. A test STD CPU board was constructed with a small semi-finished CPU board (80mm, 65mm, additional RAM memory 256kB, and clock 28MHs). The small board and some TTL bus driver ICs were mounted on a blank STD board. The wire connection between the STD bus and the SH/7045 is shown in table 1.

Table 1: Connection between the STD bus and SH7045

[STD-bus]	[SH/7045]
Address 0-7	PC0/A0 –PC7/A7
Data 0-7	PD0/D0-PD7/D7
Interrupt _INT	IRQ0
Io-request	PA6/TCLCA/_CS2
Read _RD	_RD
Write _WR	_WRL
Reset	_RES
Clock (7MHz)	28MHz

The development of a software program was carried out IDE of Windows PC.

It was confirmed that all cards of GPIB, DAC, ADC, IO used PSC, could be operated normally. Fig. 3 shows the bus timing of the IO write-cycle. Fig. 4 shows a photograph of the STD CPU board.

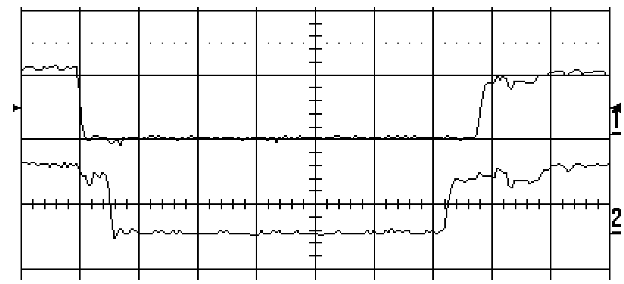

Figure 3: IO-write cycle timing. Ch1, CS (IO request); Ch2, write signal, 100n-sec/div

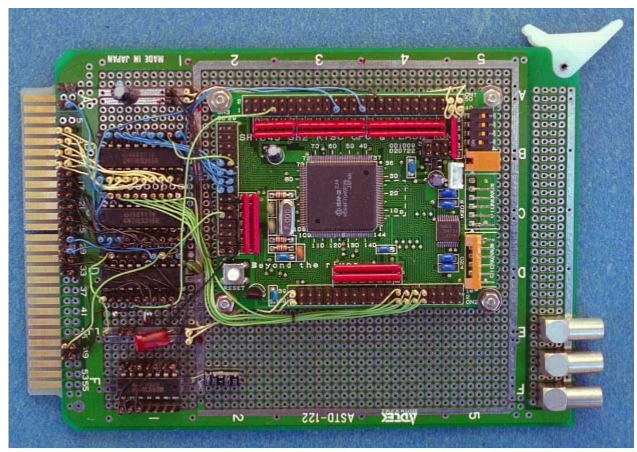

Figure 4: STD CPU board using SH7045

A future to be noticed is the function of serial ports of SH 7045. Each serial port deals with 9-bit signals. The 1 bit indicates whether the other 8 bits are data or an address (command). Using this serial port function, many devices can be easily connected to one controller with a multi-drop serial communication line (see Fig. 5), as usually used by PLCs.

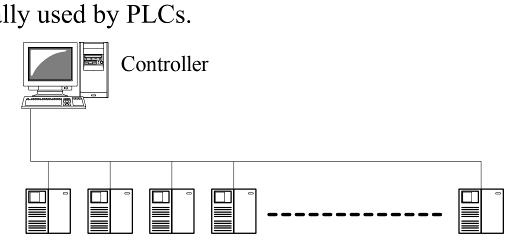

Figure 5: Multi-drop serial connection of controller and power supplies

Current control

Current control of the magnet power supply is usually performed by an analogue feedback loop. The digital current control of the magnet power supply has been studied since 1988 [3]. There are some advantages of digital current control. The adjustment or maintenance of the circuit is easier than the analogue one. There is no offset error in the current setting. The error is detected in a minimum time. It is possible to report on the condition as an accurate value to the engineer for maintenance through the serial line.

This time, the digital current control by SH7045 has been tested. A block diagram is shown in Fig. 6. The magnet is operated at 1000 amperes 72 volts. The time constant is 1.7 seconds. The power supply is a 12-pulse thyristor converter, which has a minor voltage-feedback regurator (MVR). The DCCT is a product of Hitec power protection, and has a rating of 1000 amperes, 10 volts. The ADC board uses Analog Device AD1170 22-bit ADC. The conversion time of ADC is set at 100 milliseconds. The DAC board uses a B.B. DAC701KH 16-bit DAC. The current control program is executed in 104 millisecond intervals.

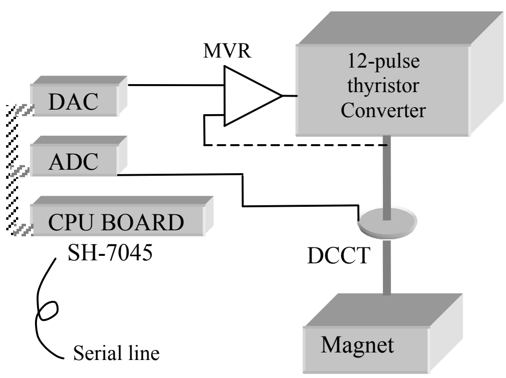

Figure 6: Digital current control loop

A typical procedure of the current control is as follows:

Loop procedure:
{
Set: desired value
Adc: monitor value
Cv: compensation voltage of inductance component
error = Set – Adc
Cv = error * 6: (selection value 4, 5, 6, 7, 8)
dac_base = dac_base + error * 1: (1/2, 1, 2)
dac_set = dac_base + Cv
out dac_set value to DAC
}

The current stability is measured at the differential voltmeter mode of the FLUKE 335A voltage standard. The measured current stability is shown in Fig. 7. Fig. 8 shows the stability of 50 Hz operation without MVR. The conversion time of ADC is 20 milliseconds. Each of results is sufficiently satisfied for a stability of 100 ppm.

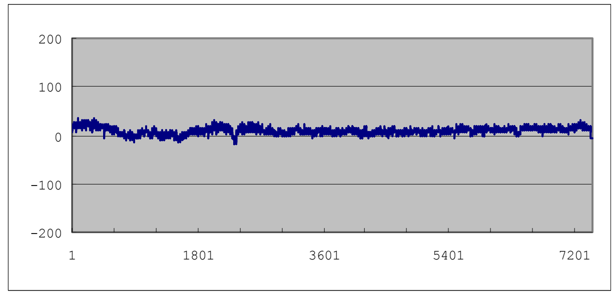

Figure 7: Current stability (x: second, y: ppm)

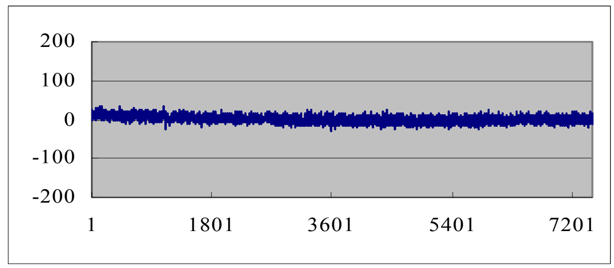

Figure 8: Without MVR 50Hz operation

CONCLUSION

An STD CPU board using SH7045 has been completed, and its performance has been confirmed. By using STD CPU board (SH7045), the development work of PSC becomes easy. Thus, the current control program was developed in a short time. Good results were obtained. As a future plan, it can easily be expected that the controller, which has a function of current control, is included in the magnet power supply. The controller reports detailed information to the maintenance staff through a serial line. The machine reliability can be improved by careful maintenance based on detailed information.

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