MAGNET POWER SUPPLY SYSTEM FOR KEKB ACCELERATOR

A. Akiyama, T. Katoh, Ta. Kubo, S. Kurokawa, T. T. Nakamura, M. Yoshida, KEK, Japan

Abstract

A number of magnet power supplies will be operated for KEKB accelerator. The control systems are composed of current setting, current monitor and interlock systems. New current setting system has been introduced to control the current of power supply. Current setting and monitor systems have high speed response, high accuracy and high stability. The interlock system has high reliability.

1 INTRODUCTION

The number of magnets (including auxiliary coil) and magnet power supplies for KEKB accelerator are 4,589 and 2,245 respectively. Seven of all power supplies are recycled from TRISTAN and thyristor regulated type. Twenty are high-power power supplies that are thyristor plus transistor dropper regulated types. The others are switched mode power supplies. Much more power supplies must be installed in the existent 8 power supply rooms than those required for TRISTAN accelerator. For magnet power supplies, required current stability is very severe. Especially, for bending (B) and quadruple (Q), current stability is 100 ppm (p-p) / year and magnetic field ripple content rate is 10 ppm (p-p) (> 0.2 Hz) [1]. What is more, magnetic fields of correction (St) magnets must be controlled quickly and synchronized with the other magnetic fields [2].

Except for high voltage and high-power power supplies, switching mode power supplies have been introduced to make its size smaller and to reduce the heating loss. After many R&D studies to satisfy the requirement for current stability for yearlong operation, we have decided to introduce a very small temperature compensator which contains important parts to realize the high stability [3]. For the interface, ARCNET (Attached Resource Computer NETwork) [4] consisting of serial bus has been introduced instead of CAMAC to reduce the cost and to satisfy the requirements of the high speed operation for the St magnet. GPIB digital voltmeter and scanner system have been introduced for the magnet's current monitor. As an important means to prevent magnet breakdown and accidents resulting in injuries, a sequence controller has been introduced for interlock system.

In the next section, the whole power supply systems are described.

2 CONTROL SYSTEM OF POWER SUPPLY

2. 1 Current Setting System

Fig. 1 shows a block diagram of the KEKB magnet power supply system. There is a power supply interface controller module (PSICM) [4] as a communication controller. The size of the PSICM is 3U Euro-card, and it has a CPU to control the current setting. It is installed through the front panel of the power supply. A port of VME-ARCNET interface can drive up to 20 power supplies. Synchronized start trigger pulses for all power supplies are distributed to the PSICM from VME-ARCNET interface through the same ARCNET cable by using remaining wires. The cable is shielded category 5 cable that contains 4 twisted pair wires. ARCNET and start trigger pulse signals are connected to interfaces by pulse transformer and photo-coupler respectively, and 8 St magnets can be controlled synchronously within a second as to the data transfer and current setting.

There are two ways to control the current of power supply. One is a way of using start trigger pulse, and the other is a way of using start command. And there are two ways of data creation for these current settings. One is a way of using the linear data calculated by CPU from present set value to target value. We call it constant slewing rate mode. The other is a way of using the data that is sent from a VME-bus based computer called IOC (Input / Output Controller) [5] and stored in the memory on the PSICM. The data consists of setting values like stairs from present set value to target value. Therefore the data can be formed into non-linear setting data. The current of St magnet will be controlled by using the start trigger pulse and the data stored in the memory in a beam feedback operation. We call it wave-generator mode. The current setting data is down-loaded to the PSICM from the IOC through the VME-ARCNET interface. There are 8 IOCs in the power supply control system in 8 local control rooms near power supply rooms.

We have decided to use no trimmer such as variable resistor for adjusting the gain and offset of the power supply to prevent the trouble for adjustment and to reduce the long-term drift. To adjust the gain and offset, we have introduced digital adjustment that we call it double buffer method. Fig. 2 shows a block diagram of current setting. DAC (Digital to Analog Converter), error amplifier, buffer amplifier and burden resistor are important parts to set the current of the power supply accurately. Total errors of gain and offset of these parts are a few percent. However we can reduce its error to less than ± 50 ppm as compared with a standard current monitor by using the double buffer method. The method is that the CPU of the PSICM in power supply calculates the corrected set value (on register 2) for DAC from the down-loaded one (on register 1) by using the correction coefficients stored in non-volatile memory in the power supply. In addition, the parts that have characteristic of less long-term drift are used for power supplies. For B and Q magnet power supplies, we introduce small temperature compensators to suppress the current drift caused by difference of air temperature [3]. Therefore the current setting of B and Q magnets' power supplies are perfect in accuracy and stability.

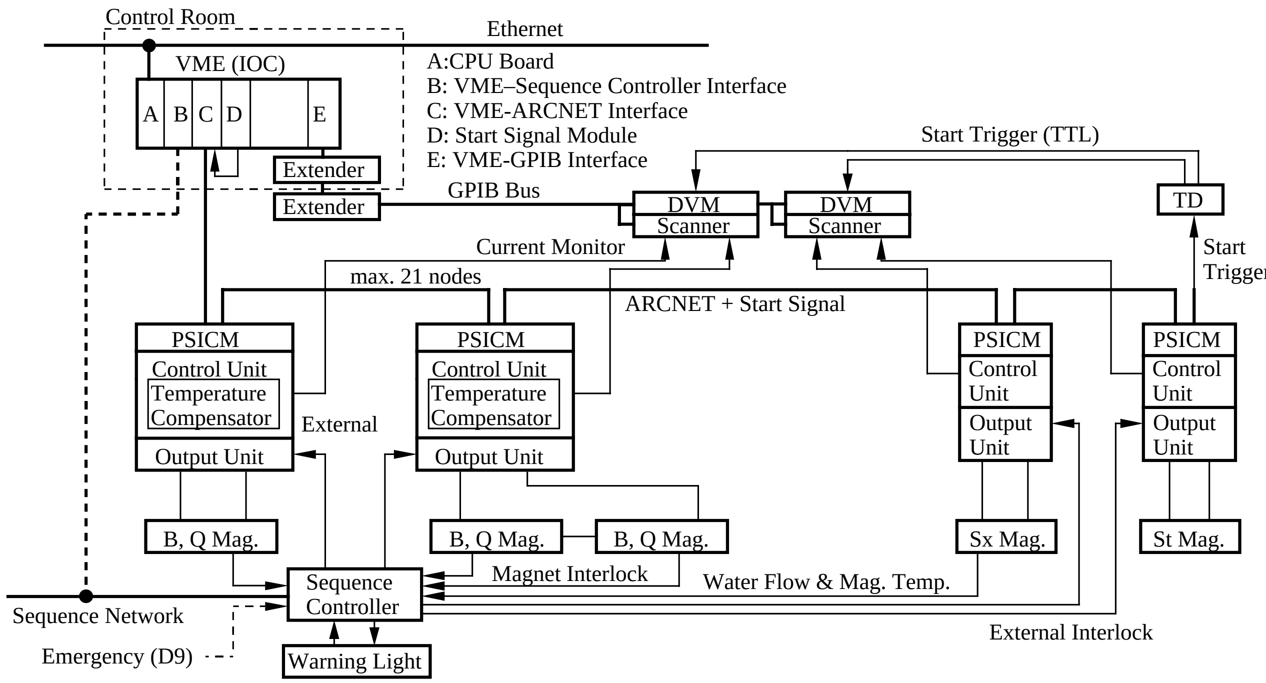

Figure 1: Block diagram of the KEKB magnet power supply system.

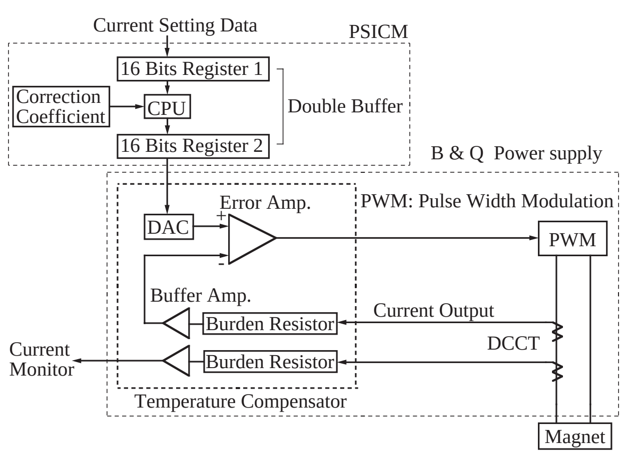

Figure 2: Block diagram of current setting of the power supply.

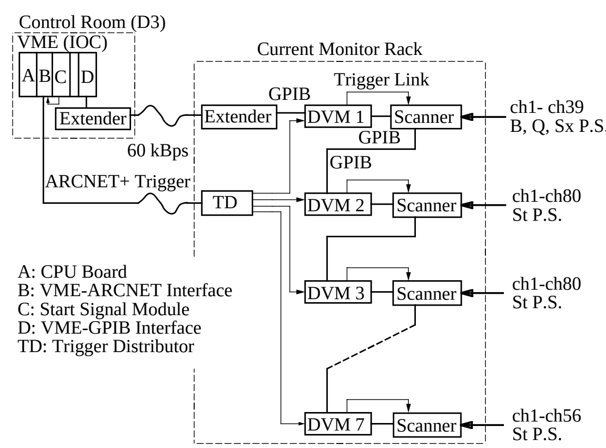

Figure 3: Block diagram of current monitor system of the power supply.

2.2 Current Monitor System

The current of the magnet is detected by a current monitor such as a DCCT (Direct Current Current Transformer) shown in Fig. 2 or a shunt resistor. The shunt resistor is used for St magnet power supply and the DCCTs are used for the other power supplies. For KEKB, the power supplies have two current detectors. One is for the current feedback circuit and the other is for the current monitor. Therefore we can find out early indications of malfunctioning by comparing the set current value with current monitor value.

Fig. 3 shows a block diagram of current monitor system for the power supplies. This block diagram is for the power supply room that has the largest number of power supplies. A set of a digital voltmeter (DVM) and a scanner can measure up to 80 current values of power supplies within a second. The measurements of 7 sets are started by a start trigger pulse or software command. The block diagrams of other power supply rooms are the same as Fig. 3 except for the number of sets. Therefore measurements of all power supplies are finished within a second. Then the data transfer from DVM to each IOC is finished within a second, and so whole measurement (for 2,245 power supplies) is completed within two seconds.

The accuracy of measurement depends on the current monitor of the power supply and the DVM. For the DVM, th resolution and accuracy are very good, and the drifts caused by long-term use and temperature are very small. For the current monitor of power supply, its accuracy is not good except for the linearity because it has no adjusting trimmer for the gain and offset. But the accurate current value can be obtained in the manner like the double buffer method of the current setting. The correction coefficients of the gain and offset for the current monitor are stored in the memory in the power supply. Therefore the accurate current value is obtained on the IOC by using correction coefficients read from the memory of the power supply. The total error of current monitor system is less than ± 50 ppm as compared with the standard current monitor in highest accuracy mode. In standard monitor every 10 seconds, the accuracy of the DVM is less than ± 200 ppm because the integrating time is short in order to measure all data within a second.

We can measure a delay of the constant slewing rate of the current setting of St power supply by using this current monitor system. A delay of magnetic field of St magnet against the current setting is caused by the delay of the constant slewing rate and a delay of the copper chamber used for KEKB accelerator. Therefore the delays should be measured to set the magnetic field of St magnet synchronously. For the delay of current setting, there are various values in relation to the kinds of power supplies and the load (St magnet and cable). So the delays of all St magnet system (1,841 power supplies) have to be measured, but it takes much time if it is measured by using a measuring device individually. Therefore we introduce the current monitor system to measure the delay automatically. DVM can start the measurement that depends on time by start trigger pulse and can measure the wave form of the current of a target St with time-stamp at regular intervals (for example, 10 ms). Supposing that the current of the St magnet is increased with a constant slewing rate after the start trigger, the delay can be measured in condition that St magnet power supply is started by the same start trigger as one for DVM. As a result of the test, it is found that the performance of the DVM is enough to measure the delays.

2.3 Interlock System

There are two types of interlocks to switch off the power supply. One is the internal interlock of the power supply such as over current. The other is the external interlock such as abnormal magnet temperature. There are many external interlocks if a power supply drives many magnets. One of the power supplies drives 112 magnets distributed along the accelerator ring really. Therefore many long interlock cables are needed and also the information of interlocks of the power supply are increased if the interlock cable between a magnet and the power supply is connected directly. To avoid this, we introduced a programmable logic controller (we call it sequence controller).

Fig. 4 shows a block diagram of the interlock system of power supplies. This system has a CPU in D8 power supply room and two fiber-optic networks to communicate with the other systems located in the power supply rooms. Through the VME-sequence controller interface, the information of interlocks is read, and IOC can reset the interlock and control the ON/OFF of warning lights (mentioned later). The interlock information can be also observed by personal computer (a display in Fig. 4) located in all power supply rooms. The emergency stop signal is set by a safety control system in D9 control room, and it is distributed to all power supplies.

The warning light system is controlled on the interlock system because it is important system to avoid accident caused by electric shock. After warning lights in the power supply rooms and accelerator tunnel are switched on, the power supply can be switched on if other interlocks are not active. The warning lights are controlled by the IOC and local control devices located in all power supply rooms. The local control devices are given priority over IOC to keep safety.

The reliability of this system is very high because it is much the same as one for a petrochemical plant. The fiber-optic network is self-healing type. As the measures for trouble of a power supply for CPU, there are double power supplies for it.

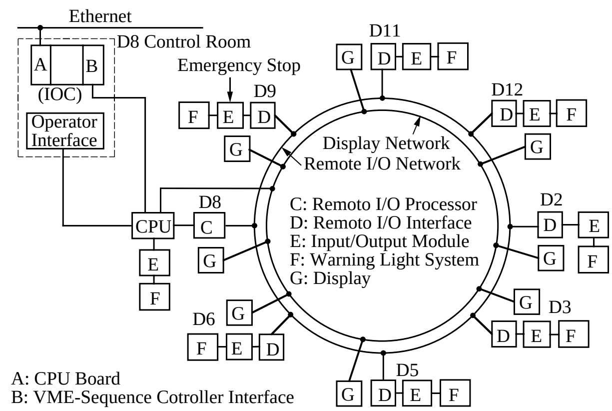

Figure 4: Block diagram of interlocks system of the power supplies.

3 SUMMARY

The current setting, current monitor and interlock systems will be ready until July 1998. From then, a part of power supplies will be set up and adjusted. The delay data of the copper chamber and St power supply system will be measured before the KEKB accelerator operation. The measurement set up is now being prepared.

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