**PB18**

# VME BASED CONTROL SYSTEM FOR THE TRISTAN CORRECTION DIPOLE POWER SUPPLY

Hitoshi FUKUMA, Kuninori ENDO, Atsushi KABE, Haruyo KOISO
and Tadashi KUBO

National Laboratory for High Energy Physics
Oho, Tsukuba-shi, Ibaraki-ken, 305, Japan

## Abstract

The control system for the TRISTAN correction dipole power supply was improved to cure the beam loss during the energy ramp. The main part of it is based on VME standard. This paper describes the system configuration, the software and the operation with the beam.

## 1.Introduction

The TRISTAN MR has 520 correction dipoles named correctors to control a closed orbit. Their power supplies are placed in four buildings around the ring. Initially the power supplies was controlled by a specially designed Power Supply Control Module(PSCM) with Motorola 68B09 and driver units[1,2]. The module calculates the current of the power supplies $I_i$ according to the formula $I_i=A_i\ I_0+\Delta I_i$, where $A_i$ and $\Delta I_i$ are constants which are indexed by a power supply no. i and $I_0$ is a wave form(i.e. "pattern") in an accelerator cycle. $I_0$ is similar to the current of the main dipole power supply and common to all power supplies. In the energy ramp $I_i$ was uniquely determined from the injection and flat top current because free parameters were two, $A_i$ and $\Delta I_i$. For several years after the commissioning of MR this system functioned enough for the energy ramp. As the beam current increased it was found that the beam life time at injection was very sensitive to the RF voltage, the betatron tunes and the vertical closed orbit. And the beam loss during the energy ramp became troublesome. One of the cause of the beam loss was considered the deviation of the closed orbit from the optimum one at injection. This led to us to develop a new control system of the correction dipole power supply to control the closed orbit more finely.

In the new system the PSCM was replaced with a VME based system while driver units remain unchanged. We employed VME system because of its flexibility in changing a software.

## 2.System Configuration

Fig. 1 shows the schematic diagram of the system. The system consists of three parts, 1)VME system, 2)Control computer Hitachi HIDIC and serial CAMAC system and 3)Driver units.

The VME system is Hitachi Zosen's Portable VME system(HIMV-P254/N) . The system consists of a rack with 7 slot back planes, a CPU board Motrola MVME-147S, a 100MB hard disk drive and a floppy disk drive. The operating system is PDOS from EYRING Co..

The CPU board calculates the current of the power supplies and write it to a digital output(Hitachi Zosen HIMV630). The output-signals are transferred to the driver unit through 21 parallel lines(12 bits data, 7 bits address and 2 timing signals). The data of 72 power supplies are sent sequentially on the lines. The timing sequence of data transfer is emulated by a software so as to fit the driver units. VMEbus interface, KSC 2917-Z1A is used to communicate with the HIDIC through memory modules. The clock interrupt, which is controlled by a HIDIC, initiates a program. The maximum repetition rate of the clock is 50Hz. So the CPU calculates and outputs the data every 20ms. The interrupt is accepted by FORCE SYS68K/IPIO-1.

HIDIC and serial CAMAC system are a part of TRISTAN control system[3]. The 128KB memory modules in the CAMAC crate, which are accessed from both HIDIC and VME CPU, are used for the communication between them.

The driver units are the part of original control system with PSCM. They accept the data from the digital output and distribute the data to each power supply.

## 3.Software

### A.VME system

A device driver was written for VMEbus interface KSC 2917-Z1A. This supports CAMAC 16 bit single transfer and CAMAC 16 bit DMA transfer. The data-transfer-time is about 50 μs/word for the single transfer and 3.5 μs/word for the block transfer. The device drivers of FORCE SYS68K/IPIO-1 and HIMV630 were prepared by Hitachi Zosen.

Two functions are written as application software for 1)Cyclic operation and 2)Current-setting at static states.

#### 1)Cyclic operation

A function is called in cyclic operation of MR such as the energy ramp, the squeezing of the beam and the setting current from flat top to injection. The cycle goes by synchronously with the clock pulse. Whole accelerator cycle is divided into 14 periods by 15 nodal points. The time, which is measured by the number of the clock pulse, and current at each nodal point is stored in a "clock-current table" in the memory module. The current of a power supply I(t) at a clock t is calculated as

$$I(t)=\frac{I_B(t)-I_B(t_N)}{I_B(t_{N+1})-I_B(t_N)}\cdot I_{N+1}-\frac{I_B(t)-I_B(t_{N+1})}{I_B(t_{N+1})-I_B(t_N)}\cdot I_N$$

during the energy ramp and

$$I(t) = \frac{t-t_N}{t_{N+1}-t_N} \cdot I_{N+1} - \frac{t-t_{N+1}}{t_{N+1}-t_N} \cdot I_N$$

in remaining periods, where $t_N$ and $t_{N+1}$ are the clocks at nodal point N and N+1 respectively. The clock t satisfies the condition $t_N < t < t_{N+1}$. $I_B(t)$ is the current of the main dipole power supply at clock t. $I_B$ at each clock is stored in the memory module.

The total processing time, which includes the above calculation, the data transfer from/to the memory module and the output of the data, is 8ms for 130 power supplies.

2)Current-setting at static states

Another function is called at injection and flat top. The current is changed from present set point to new point in the total steps $N_{step}$. This function is initiated $N_{step}$ times by the clock interrupt. At each step the function calculates the current by linear interpolation of present and new set point.

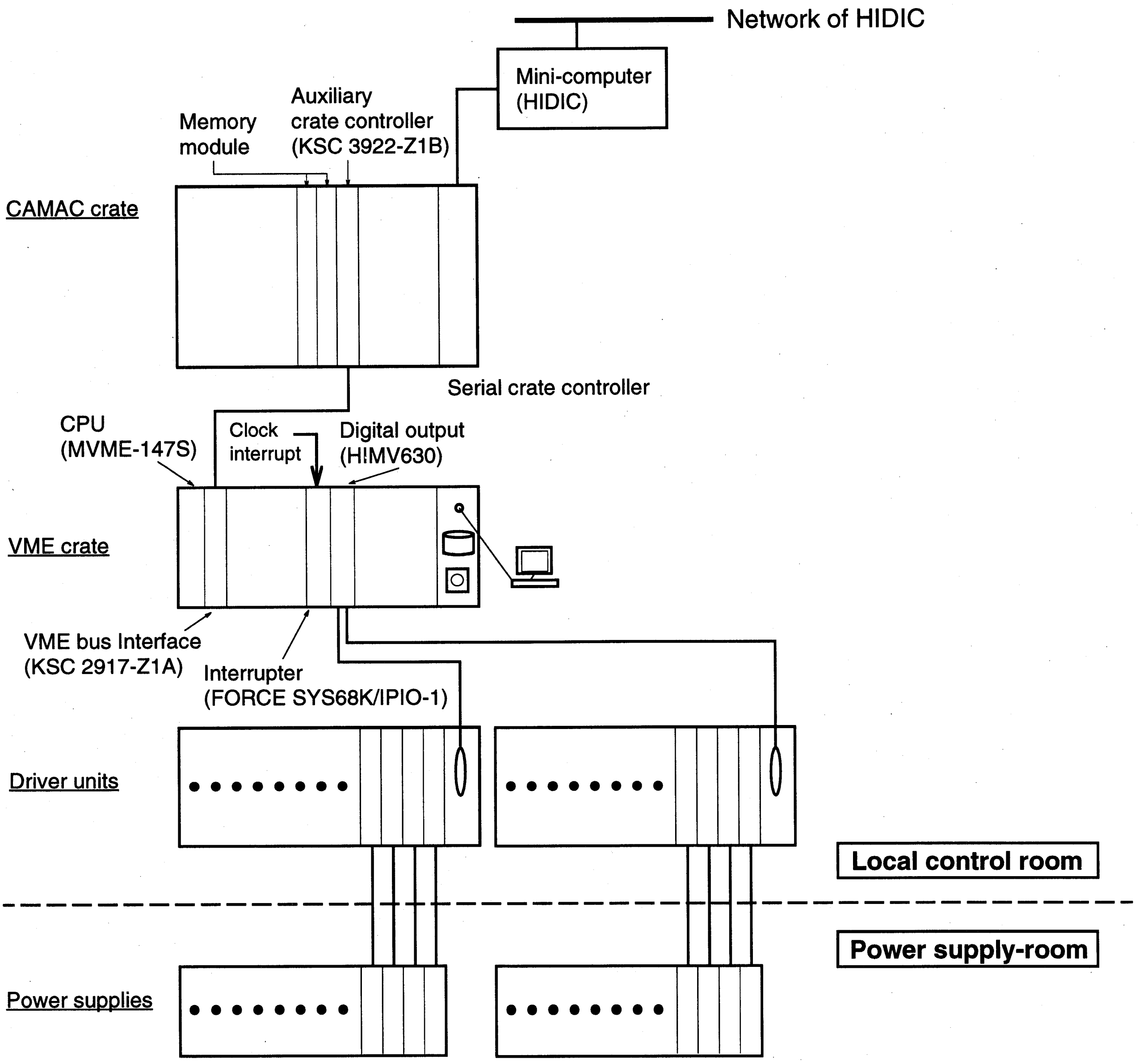

Fig. 1 Schematic diagram of the control system for the TRISTAN correction dipole power supply.

### B.HIDIC

Programs are prepared for 1)Management of the clock-current table and 2)Control of the clock interrupt.

## 4.Operation

In the operation 11 nodal points are used during the energy ramp. The nodal points are denser in low energy region than in high energy region because the beam loss occurred very often below 11GeV. Following procedures are taken in the beam tuning for the energy ramp.

1)The current which corresponds to the kick by the correctors at injection is set to all nodal points.

2)The closed orbit at injection c.o.$_{inj}$ is measured. Then the energy ramp starts.

3)The energy ramp is suspended at the clock corresponding to a nodal point and the closed orbit c.o.$_{nod}$ is measured. This procedure is repeated for all nodal points.

4)An orbit correction program calculates the kick of the correctors $\{\Delta\theta\}$ to correct the difference between c.o.$_{nod}$ and c.o.$_{inj}$, where {...} means the list of the kick by the correctors. The $\{\Delta\theta\}$ at each nodal point is stored in a file.

5)The kick at each nodal point is calculated as $\{\theta_{inj}\}$+ $\{\Delta\theta\}$, where $\{\theta_{inj}\}$ is the kick at the injection. The current corresponding to $\{\theta_{inj}\}$+ $\{\Delta\theta\}$ is set in the clock-current table.

6)The procedure 2) and 3) are repeated to confirm that the closed orbit is really corrected.

Table 1

A result of the closed orbit correction during the energy ramp.

| Nodal no. | Energy (GeV) | $\sqrt{<\Delta y^2>}$ (mm) | |
|---|---|---|---|
| | | before correction | after correction |
| 2 | 8.4 | 0.14 | 0.08 |
| 3 | 9.6 | 0.31 | 0.12 |
| 4 | 11.6 | 0.49 | 0.14 |
| 5 | 14.2 | 0.69 | 0.22 |
| 6 | 16.8 | 0.84 | 0.22 |

Table 1 shows an example of the result of the above correction. $\sqrt{<\Delta y^2>}$ is the r.m.s. of the difference between the vertical closed orbit at injection and that at a nodal point. Average < > was taken over the beam positions around the ring. Nodal no. 1 corresponds to the injection stage.

Actually, the closed orbit in the energy ramp being suspended is different from that in the energy ramp being in progress. But we have no way to measure the instantaneous closed orbit because the measurement takes about a minute in the present beam position monitor system .

We can not state clearly the effect of the correction on the beam loss. On one occasion the beam loss disappeared after that. On another occasion, in addition to the correction, another ways such as the change of RF voltage, the change of the betatron tunes and the optimization of the closed orbit at injection were needed to cure the beam loss.

Above correction is made at the beginning of a long operation period. Once $\{\Delta\theta\}$ is determined the procedure 5) is taken before every energy ramp because the closed orbit at injection is corrected to a standard orbit at every beam fill. Usually the re-determination of $\{\Delta\theta\}$ is not necessary for three to four months despite the change of the closed orbit at injection.

## 5.Acknowledgements

The authors wish to thank to T. Kato and H. Nakagawa for useful advise and discussion about VME system.

## 6.References

[1]Ta. Kubo, To. Ozaki, A. Kabe, H. Fukuma, K. Endo, “MAGNET POWER SUPPLY AND IT’S CONTROL MODULE FOR TRISTAN MR STEERING MAGNET”, Proceedings of the 6th Symposium on Accelerator Science and Technology, Tokyo, Japan, 1987, 161

[2]H. Fukuma, A. Kabe, Ta. Kubo, T. Ozaki and K. Endo, "POWER SUPPLY CONTROL FOR THE TRISTAN MAIN RING AND ACCUMULATION RING", Proceedings of the 1987 IEEE Particle Accelerator Conference, Washington,D.C., 1987, 1529.

[3]Shin-ichi KUROKAWA et al., "THE TRISTAN CONTROL SYSTEM", Nucl. Instr. and Meth., A247(1986), 29.