PROGRAM FOR CONTROLLING MAGNET POWER SUPPLIES OF THE RIKEN RING CYCLOTRON

M. Nagase, H. Takebe, T. Wada, and K. Shimizu

The Institute of Physical and Chemical Research, Wako-shi, Saitama, 351-01 JAPAN

SUMMARY

New micro-computer program of Device Interface Module (DIM) is developed to control quickly magnet currents in the RIKEN ring cyclotron. When a mini-computer controlled sixty eight kinds of magnet power supplies through the CIMs and DIMs, it took more than 20 minutes to set all magnet currents to determined values.

The new program, which is written with assembler language and firmwared into DIM, enabled the DIM to control all the power supplies in less than 3 minutes. Therefore, the load of the mini-computer culd be decreased effectively.

1) INTRODUCTION

The control system of the RIKEN ring cyclotron[1)] uses CAMAC equipment and two types of intelligent interface modules (CIM and DIM) to link between a control computer and controlled instruments. These modules consist mainly of a micro-processor (CPU Intel 8031), a random access memory (RAM) and a read only memory (ROM). The CPU has such functions as a timer interruption and communication in addition to data processing. The RAM is used for storing a block data, while the ROM is used for firmwaring a system program and sequential control programs. Instructions are provided for operating the CIM/DIM system. The instructions are classified into five types: 1) instructions for initializing 2) and for checking the CIM/DIM system, 3) for sending out/fetching a single data from/to the control computer to/from the CIM/DIM system, 4) for transferring a block data from/to the control computer to/from a CIM's memory or a DIM's memory, 5) for sending out/fetching a message from/to the control computer to/from the CIM/DIM system. Details of these modules were described[2)]

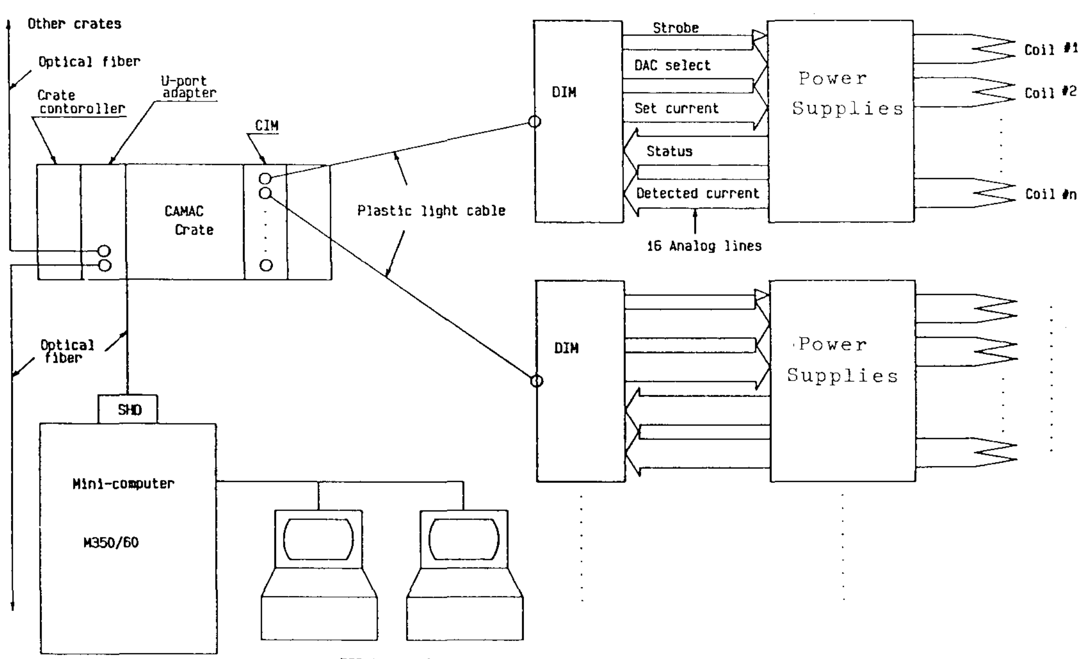

Fig. 1. Block diagram of magnet current control system.

There are many power supplies for exciting electrical magnets in the instruments. It is required to vary tens kinds of magnet currents as a linear function or its jump function with respect to time. Although such a current control can be performed by the control computer[3], it is not effective in the control system because it increases the load of the control computer. On the other hand, the DIM can perform many sorts of sequential controls independently of the control computer by firmwaring respective programs into it.

Therefore, we decided to make the DIM perform the control and developed a program for it.

2) SYSTEM CONSTITUTION FOR MAGNET CURRENT CONTROL

Fig. 1 shows a block diagram of a magnet current control system. There are a mini-computer (M350/50, made by MITSUBISHI ELECTRIC Co., as the control computer. The computer communicates with each CAMAC crate through a serial high way made of optical fiber. A communication interface module (CIM) is mounted in a CAMAC crate, while a DIM is set in a group of power supplies: a pair of plastic cables are used for connecting between them. The DIM gives information such as DAC select and set current to each power supply, and fetches the status information and current of each coil.

Fig. 2 shows the configuration of a main coil power supply. It consists mainly of a pre-regulator and a main current regulator. The pre-regulator is used for decreasing the power dissipation of control elements in the main current regulater. It detects a voltage drop across the elements and helds the drop

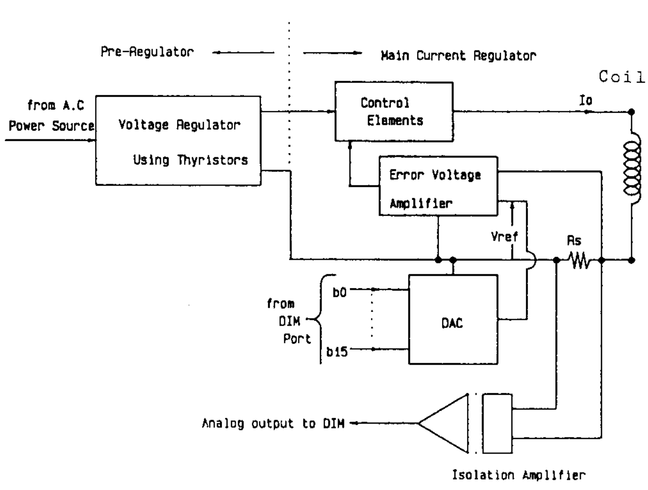

Fig. 2. Configuration of main coil power supply.

constant even if a change on A.C. power source or coil registor arises. But a power supply used for each trim coil consists only of a main current regulator, has not a pre-regulator, because the power dissipation of it is not so large as that of the main coil power supply. The main current regulator consists of control elements, an error voltage amplifier, a standard registor and a 16 bit (b_0 - b_{15}) digital to analogue converter (DAC) for accepting a reference Vref digitally. The error voltage amplifier is very high gain. Assuming the amplifier has not an offset voltage, and the value of the standard registance is, independently of a surrounding temperature, constant. The output current I_0 of the power supply depends on information coming from the DIM. It becomes nearly

$$I_0 = K \sum_{n=0}^{15} 2^n b_n$$

where b_n is the value of each digital input (0 or 1) of the DAC and K is a constant. Therefore, all the power supplies can be controlled sequentially by the information from the DIM.

3) PROGRAM

The algorithm of a newly developed program will be explained below. Parameters used for the current control are as follows.

1. The number of controlled power supplies: NT
2. A repetition time on varing all references as a jump function based on a linear function: ΔT
3. A power supply number: ND
4. A reference for obtaining an initial output current of each power supply: II
5. A reference for obtaining a final output current of each power supply: IF
6. A reference step on the incremet of each reference: ΔI
7. Allowable deviation, which is an upper limit of the difference between each reference and an output current borne by it.

These parameters are stored into a predetermined RAM area with instructions for transferring a block data. After storing the parameters, the current control is performed if an instruction for sending out a message is sent to the DIM.

Fig. 3 shows the operation flow diagram of initial current settings. In fig. 3, the number of controlled power supplies NT is checked firstly. When NT is more than 1, a variable n corresponding to the number is defined. The DIM reads out each reference for obtaining an initial output current II(n) and each power supply number ND(n) from the RAM area, and sends them to each power supply sequentially (n = 1 to NT). In this case, a reference IOt(n) for setting each output current is equal to the II(n).

Flags depending on the number NT are provided in the DIM. When the output of a power supply reaches its final value, a flag F(n) being related to the power supply is set. After the initial current settings, all the flags are reset. Then, the DIM loads a repetition time ΔT into the timer counter of its CPU and enables a timer interruption.

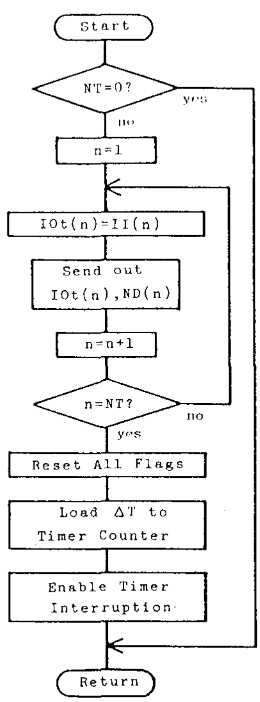

Fig. 3. Operation flow diagram of initial current settings.

Fig. 4 shows the operation flow diagram of the current control. When a timer interruption depending on the repetition time happens, the following procedures are performed. The DIM detects each output current IAt(n) through analogue inputs, converts it into digital contents and stores the converted contents into predetermined data area sequential (n = 1 to NT). The DIM checks whether all the flags are set, or not. If they are set, it means that the current control is completed. Therefore, the DIM sets an end flag, disables the timer interruption and finishes the current control(Return).

When they are not set, the following steps performed sequentially (n = 1 to NT+1). Each flag F(n) is checked. If a flag F(n) = 0, which is not set, is found out, the difference between the setting reference IOt(n) and the detected current IAt(n) is calculated. If the difference exceeds the upper limit IL(n), the DIM sets an error flag, disables the time interruption, and finishes the current control(Return). When the difference is less than the upper limit, the DIM adds

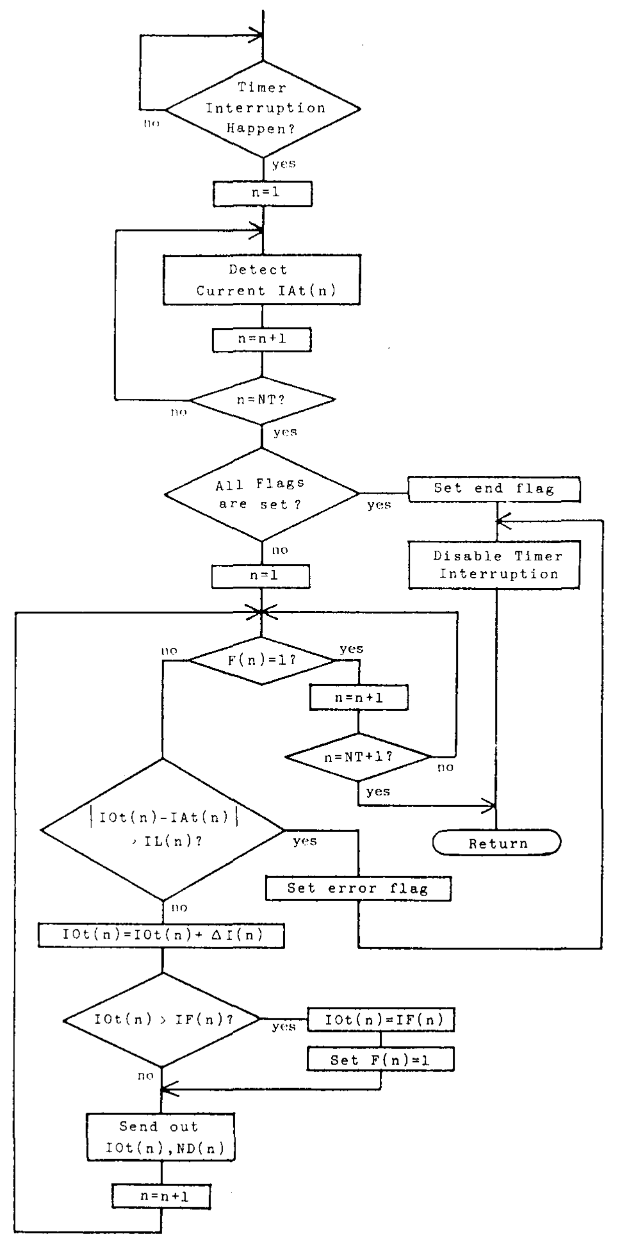

Fig. 4. Operation flow diagram of current control.

each setting reference IOt(n) to its reference step ΔI(n) and checks the amount of the added reference IOt(n). When the amount exceeds its final value IF(n), it is replaced by IF(n) and a flag F(n) is set. The setting reference IOt(n) decided in this way and a power supply number ND(n) are sent out each power supply.

The above mentioned procedures are repeated every when the time interruption happens. When the DIM finishes the current control(Return), it checks the end flag and the error falg. When these flags are not set, the DIM waits for an instruction coming from the control computer. If one of them is set, the DIM sends information to the DIM. As a result, the CIM sets its LAM flag. After searching each LAM signal, the cause of the generation of the LAM signal can be found out by fetching a message from the DIM.

4) RESULT

Some kinds of current controls were carried out by using the program. The normalized output current characteristics of six power supplies are shown in Fig. 5 as an example. In this current control, one DIM was used. Since the repetition time was constant for all the power supplies, it will be found that a power supply ND(2) controlled at a wide reference step reached its final value in a short time, while the case of ND(6) at a narrow reference step took for a long time. In the same manner, the current control of sixty eight power supplies could be made in less than three minutes with fifteen DIMs.

As the application of the current control to main coil power supplies, resetting parameter was repeated to swing their output current levels. A reproducible and fast stabilizing field distribution was obtained.

5) CONCLUSION

The DIM reduced the load of the control computer because it was used not only for interfacing between the control computer and instruments but also for controlling those instruments sequentially. Furthermore, the DIM could respond to request from the control computer even during it performed the current control. Such a function of the DIM is superior that of a general purpose sequential controller. The function made the control system more flexible and powerful.

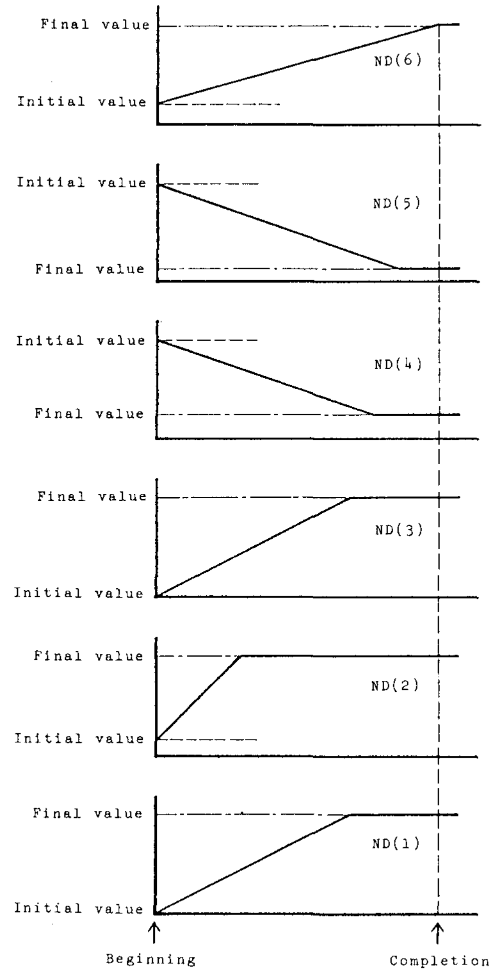

Fig. 5. Normalized output current characteristics.

REFERENCES

1) K. Shimizu, J. Fujita, T. Wada and I. Yokoyama: RIKEN Accel. Rep. 17, 141 (1983).

2) K. Shimizu: Nucl. Instrum. Methods Phys. Res. A 236, 109 (1985).

3) H. Takebe, S. Motonaga and T. Wada: RIKEN Accel. Rep. 19, 174 (1985).