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MAGNET POWER SUPPLY AND IT'S CONTROL MODULE FOR TRISTAN MR STEERING MAGNET

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ABSTRACT

The Steering Magnets - ST Magnets (including the Backleg Coils - BK Coils wound on Bending Magnets), the number of which are 520, are prepared for the TRISTAN MR Accelerator for the purpose of COD correction. To excite these magnets the unipolar power supplies (ps's) are used as bipolar ones by means of changing the polarity of the DC output with mechanical relay. But, various protection circuits should be considered to prevent the ps's from the failure caused by many reasons.

The Micro-CPU Control Module (Power Supply Control Module - PSCM) has been developed to control these many ps's[1]. In this report the summary of the total system will be described.

INTRODUCTION

The MR has 4 Experimental halls and the tunnel is divided into 4 super-period sections. The 1192 various types of magnets have been installed along the beam orbit. The 8 ps buildings have been constructed in consideration of these configurations. The 4 ps buildings neighboring the Experimental Hall are used for main magnet ps's and the residual 4 auxiliary buildings which are situated at the symmetry point of the curved section of the tunnel are mainly used for 130 ST Magnet PS's. Two types of the ps's are prepared to excite 64 ST Magnets and 66 BK Coils. The allowance of the field tracking error of the steering to the bending is estimated as 10^{-3} at full excitation, and the non-linear effect of the magnet excitation may be negligible. So it is enough for the magnet current that the accuracy is 10^{-3} and each magnet current is proportional to a certain standard current. Then, the simple method described later had been adopted for generating the reference pattern.

The control room for the ps's is situated at the next door of the ps room. The all control signals of these ps's are connected with the CAMAC system by the signal wires, and the ps's are controlled remotely from the Center Control Room through the Computer Network.[2]

STEERING MAGNET POWER SUPPLY

The ST Magnet PS has been paid attention to design work so as to have high reliability and save the maintenance labor and repairing time, because of its large number and widely distributed buildings. For the MR System the unipolar ps has been used to get rid of the failure caused by the noise signals which come from the tunnel through the loading DC cables. The characteristics of the magnet and the specification of the PS has been written in Table 1 and 2 respectively. Fig. 1 shows the ST PS installed. 10 ps's are inserted in one rack and 13 racks are set like a photograph. The control and relay circuits are also inserted under the PS in the rack.

The reference current patterns are transferred at every 20 ms by the external clock signal to the ps's as 12 bits two's complement bipolar data which are produced by the PSCM in the CAMAC Crate and are converted to analog signals by 12 bits D/A converter in the ps.

	resistance	inductance
ST Magnet	33 Ω	20.0 H
BK Coil	2.81 Ω	0.075 H

Table 1 Magnet Parameters

	rated current	rated voltage
ST Magnet PS	± 3 A	± 110 V
Backleg Coil PS	± 10 A	± 55 V

Table 2 Power Supply Parameters

Fig. 1 ST Magnet PS installed in the Building

Fig. 2 shows a block diagram of the PS system. The unipolar ps has been based on same design as could be got at the market. To protect the PS from the failure the surge absorber and the shortening relay have been inserted after the switching relay and the particular logic sequence which inhibits the polarity change soon after polarity change of the reference signal had been taken into account. The polarity would be changed after that the magnet current or voltage decays and becomes below the settled limit. As the ST Magnet has a large inductance or a time constant of a few seconds, a large voltage spike will be induced even if the step width of the reference signal change is not so large. This is a matter of course and measured data is shown in Fig. 3. So the voltage detection method is not suitable for the ST Magnet PS. On the other hand the time constant of BK Coil is less than 25 ms. As a result the current and the voltage detection methods for the protection have been adopted for the ST Magnet PS and BK Coil PS respectively. The fly-wheel diode in Fig. 2 is used for the protection of ST Magnet PS.

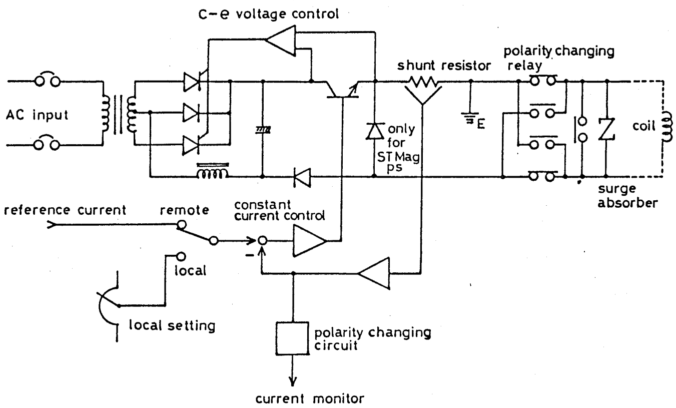

Fig. 2 Block Diagram of the PS System

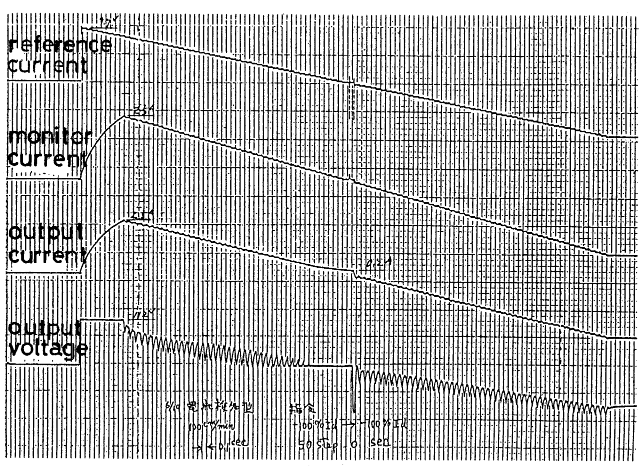

Fig. 3 Measured Data for the ST Magnet PS

Fig. 4 shows the chart of a logic sequence in case of polarity changing. As can be seen the flow branches to two directions. At first the direction would be decided by the changing step width of the reference current pattern. Secondly the real polarity would be changed by judging the value of the detected voltage or current. Fig. 5 shows the timing chart of the polarity change for the ST Magnet PS. For the normal operation the dead time is 100 msec, and this will not affect to the real accelerator operation.

DC output power had been connected to the magnet by Non-halogen cable whose cross section - 2 mm^2, 3.5 mm^2, 5.5 mm^2 or 8 mm^2 was chosen in accordance with the cable length. By this way the design and construction of the ST Magnet PS have been completed.

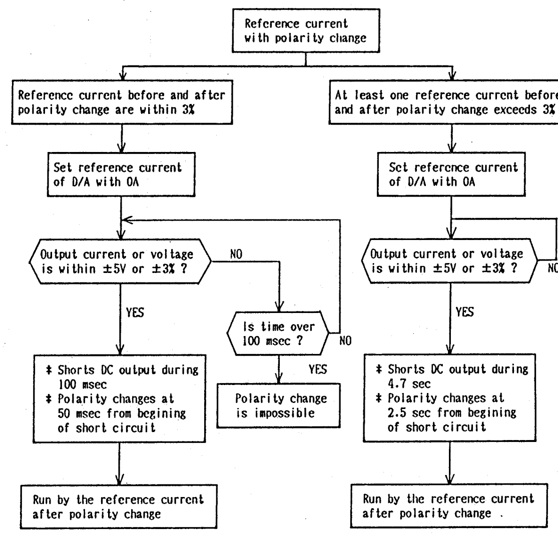

Fig. 4 Flow Chart of the Logic Sequence

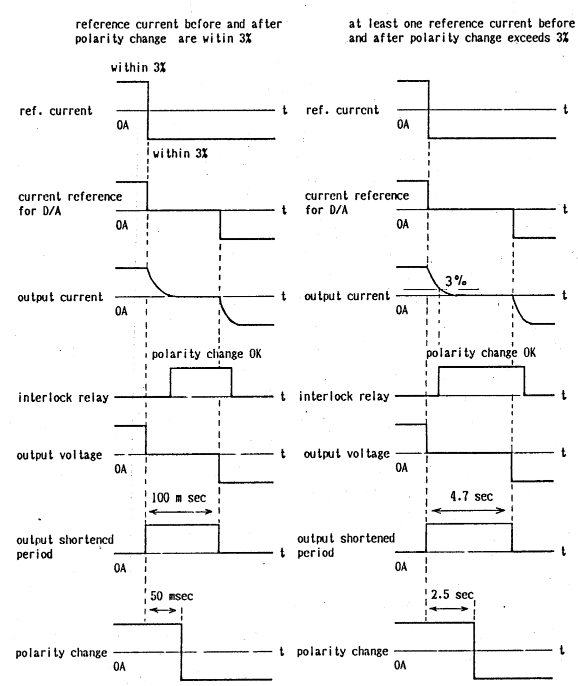

Fig. 5 Timing Chart of the Polarity Change

PSCM

The reference current patterns are generated and transmitted to the memory modules in the CAMAC Crate trough the serial highway of the local computer beforehand the accelerator operation. The memory module having 20 bits - 16KW's, had been developed at the beginning of the construction of the magnet ps control system. For the main ps's one memory module is assigned to each ps. On the other hand for the ST Magnet PS's only one standard pattern which is written in the memory module is prepared in one ps house and the various reference patterns are calculated with simple algorism from this standard pattern and are delivered to each ps through the driver unit. The system configuration is shown in Fig. 6. As in the figure, the PSCM consists of a Micro CPU Module in camac crate and a Driver Unit in standard rack.

The 8 bit micro-processor, Motorola's 68B09 whose cpu clock is 2 MHz, had been adopted for the CPU Module, because the cpu has 8 bit multiplication command. One CPU Module calculates 72 reference patterns. The time spent by calculation is about 13 ms. This is short enough for the actual accelerator operation. As a result two sets of PSCM are used at each ps house. Fig. 7 shows a schematic diagram of the CPU Module. The mathematical expression of the calculation is as follows:

$I_i = A_i \times I + \Delta I_i \quad (i = 1 - 72)$

I : standard current pattern (16 bit)

A_i : correction coefficient (16 bit)

ΔI_i : offset current (16 bit)

I_i : current pattern for i-th ps (12 bit).

The calculated reference patterns are transmitted to each ps in the form of 12 bits digital data and a strobe signal. The RS-422 standard is used for the data transmission and the signal isolation is performed with the photo-coupler in the ps.

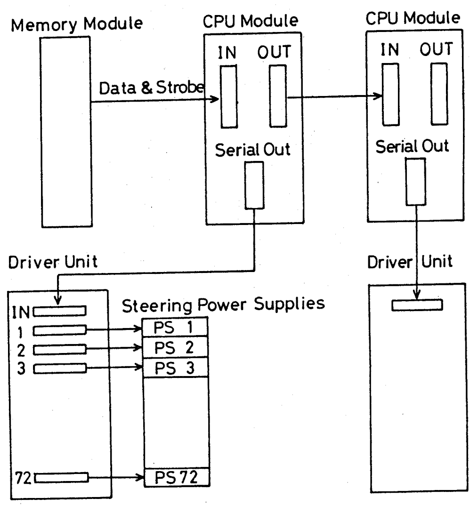

Fig. 6 Block Diagram of the PSCM System

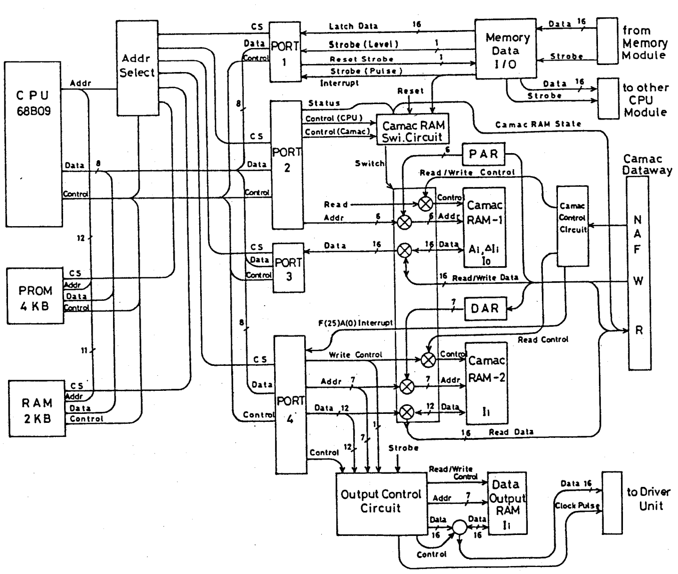

Fig. 7 Intelligent CAMAC Module

SYSTEM OPERATION

The ST Magnet PS and the PSCM system had been constructed in the manner described above and has been operating well during 8 months from the start of beam acceleration of the MR except for a few initial troubles on the ps. All the operation for the ps can be executed from the touch panel of Center Control Room. The monitored currents of the ps's are indicated on the graphic display above the touch panel of the control desk.

REFERENCES

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2. H. Fukuma, A. Kabe, Ta. Kubo, To. Ozaki, and K. Endo, "Power supply control for the TRISTAN Main Ring and Accumulation Ring", the 1987 Particle Acc. Conf., Washington, D.C.,U.S.A., 16-19, 1987, to be published.