

CONSTRUCTION OF RIKEN SSC SECTOR MAGNETS

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ABSTRACT

Four sector magnets of the Riken SSC Facility were installed in the SSC vault completed in the end of this March. Power supplies for the main and trim coils were delivered and being tested in August 1984. Final stage measurements of the magnetic field of the four sectors without a vacuum chamber are scheduled until Autumn of 1985.

INTRODUCTION

A separated sector cyclotron (SSC) project started in 1980. Manufacture of the sector magnets started in 1981 at the factory of Sumitomo Heavy Industries Ltd.(SHI). Table 1 shows a fundamental characteristics of the sector magnet. In April and July of 1982, excitation characteristics and magnetic field distributions induced by the two sector magnets were measured at the factory in Niihama.¹ The results of the measurements were quite satisfactory.²

TABLE 1. Characteristics of RIKEN SSC magnets

Number of sector magnet	4
Sector angle	50
Gap width	8 cm
Height of magnet	5.24 m
Total weight	2105 ton (526 ton/sector)
Maximum field	1.58 T
Maximum magnetomotive force	1.38×10^5 AT
Maximum current	1050 A
Maximum power	480 kW
Number of trim coils	29 x 4 pairs
Maximum current	590 A
Total trim coil power	216 kW

FABRICATION OF THE MAGNETS

The building of the SSC vault was completed in March 1984. A transportation of the poles and coils, by 37 tons trailer trucks and ferry boat (from Kohchi city to Tokyo bay) and that of yokes and the other parts, by 20 tons trailers (from Kobe to Tokyo and Wako city), started at April. The trim coils were brought fixed on the pole face. The fabrication of yokes and poles at the Institute accomplished in June. Figure 1 shows the assembled four sectors and cables in the SSC vault. Two sets of 3.75 kW dehumidifier (6.5 l/h) were set beside of the magnets to reduce humidity of over 95% to less than 70%.

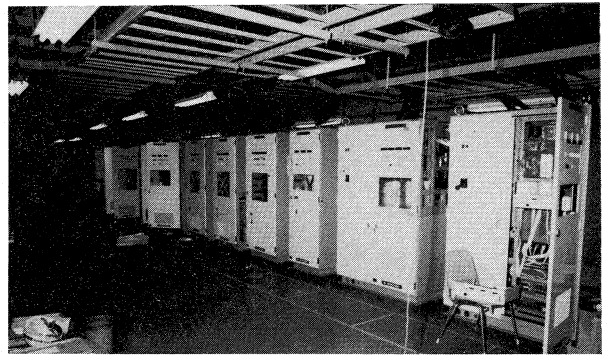


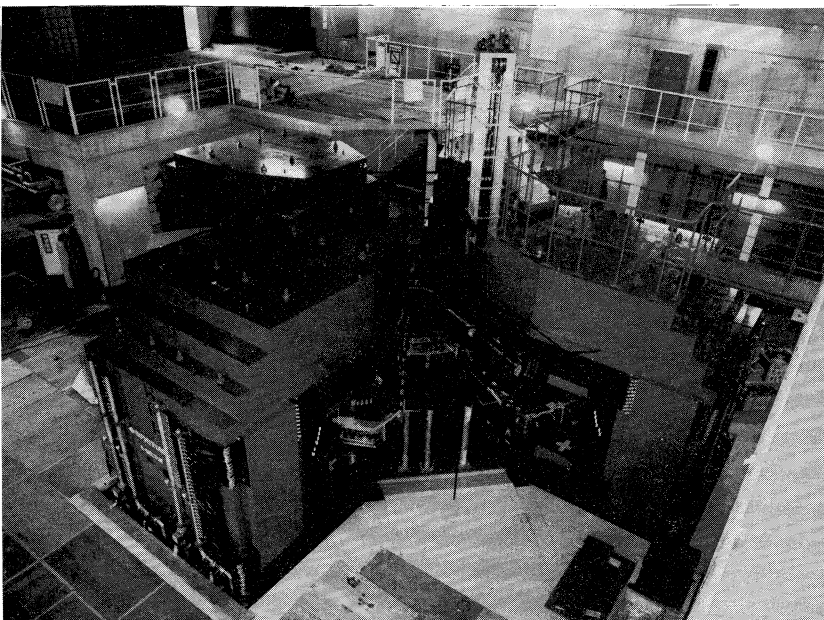
Fig.2. Power supplies for the SSC sector magnets on the 1st stage floor in the SSC vault.

POWER SUPPLIES

Power supplies (PS) for the main and trim coils were ordered to SHI at November 1982. Manufacture of the PSs started at February 1983 at a factory in Sano city, Tochigi. They were delivered the PSs at the end of July 1984 into the 1st stage floor in the accelerator room (Fig.2) and a final adjustment and testing is now under going. The stability check will be done until end of this September.

MAIN COIL POWER SUPPLY

The maximum current of the main coil's PS is decided to 1050 A according to the previous excitation measurement in 1982 to get the maximum field 15.8kG. To reduce the output voltage over 400 V of the Main-PS, it is divided into two sets (M1 and M2). Maximum currents of both M1 and M2 PS are 1050 A, but maximum voltage of the M1 is 353 V and that of M2 is 136 V, respectively. The M2 PS has bypass circuits to adjust field strengths of the four sectors. The maximum bypass current is 100 A. The input power of M1 and M2 are 505KVA max and 218KVA max, respectively. These high-power supplies are of thyristor pre-regulated type, so that save the size of the cubicle, power and cost. Then, a noise cut type transformer from 6.6kV into 415V AC-line is placed just upside of the PS, using a shielded type connection cables (CV-S) between them.



TRIM COIL POWER SUPPLY

The final design of the trim coil power supplies is achieved according to the last measurements, being modified of the previous calculation with the 1/4 scale model measurements. Trim coil PS are divided into following four types:

- TA, four sectors series connection,
- TB, four sectors series with bypass circuits,
- TC, independent connection,
- TD, independent connection with a polarity switch.

Table 2 shows the trim coil names, coil resistances, minimum and maximum currents, coil and cable resistances and power supply types and names. Type TD1, TD2, and TD3 PSs provides to making harmonic fields, so that they need large currents in positive and negative.

Some of the PSs are enclosed in the same cubicle and total number of the cubicles is eleven. Type TD4 is ordered after measurement of the field perturbed by injection or extraction elements. Figure 3 shows the main and the trim coil PSs cubicles, their input/output powers and connection to input transformers.

CONTROL OF THE POWER SUPPLIES

All the power supplies are controlled by the control computer: M60 (Mitsubishi M350-60/500) through a CIM and DIM modules.^{3,4} Figure 4 shows a control linkage of the magnet power supplies with CIM, DIM and M60. Figure 5 shows a block diagram of the PS control modules and DIM interfaces. The DIM is enclosed in a cubicle of the power supply.

The necessary stability of the M1 and M2 for 24 hours is better than 5×10^{-6} (guarantee is 1×10^{-5}) and that of the trim coil PS is 1×10^{-4} . A shunt resistance for the M1 and M2 is made of a ZERANIN⁵ ($b=0.8-3\text{ppm}/^\circ\text{C}$) with temperature controlled water ($30 \pm 0.5^\circ\text{C}$). All of the PSs have 16 bits D/A converters. In the 71 sets of the D/A converters, we selected the best ones for M1 and M2 main currents controlling.

Name	INPUT/OUTPUT(KVA)	Curr.	Type	Transformer
M1	505 370	1050A	Thyrister	NCT (500KVA)
M2	214 143	1050A	Thyrister	NCT (500KVA)
BM1,2	273	3000A	Thyrister	
TB12	29 8	420, 230A	Transister	415V Line 6.6kV Line
TA3	48 25	490A	Thyrister	
TB3	64 32	530A	Thyrister	
TB45	66 30	590A	Transister	
EBM1,2	226		Thyrister	NCT (500KVA)
MDC1,2	100		Thyrister	
MIC1,2	18		Thyrister	
TD12	122 20	400A	Transister	NORMAL TRANS (500KVA)
TD3-1	94 20	550A	Transister	
TD3-2	97 23	550A	Transister	
TC1,2	41 9.8	500A	Transister	
TA1245	101 49	560A	Transister	
EIC, EDC	8		Transister	

Fig.3. Connection of the power supplies and input transformers. Power supply M1 and M2 is for main coil. TA1, TA1245, TB12, TB3, TB45, ... and TD3 are for the trim coils. The other power supplies (BM1,2,...), for injection and extraction elements, are not designed yet.

Table 2. Resistances, Maximum and Minimum currents and types of the power supplies for the trim coils.

COIL NO.	NO.	RESISTANCE (mΩ)	MIN. (A)	MAX. (A)	S	SECTOR W	N	E	MainDC
1		7.8	0	0		Coil and TD4			
2		7.5	0	0	TD4	TD4			
3	1	7.85	-399	-47	TC2-2 12.5	TC2-1 9.8	TC1----- 21.4		
4 -H	2	7.6	-476	-144	TD3-31 12.3	TD3-11 9.6	TD3-23 10.5	TD3-35 13.4	
5 H(74A)	3	7.9	-404	-17	TD3-32 12.6	TD3-12 9.9	TD3-24 10.8	TD3-36 13.7	
6 H(74A)	4	7.8	-223	82	TD2-33 12.5	TD2-14 9.8	TD2-21 10.7	TD2-4 13.6	
7	5	7.5	-29	203	TB1-4	TB1-1 41.6	TB1-2	TB1-3	TB1-0
8	6	9.4	-48	297		TA1 43.4			
9	7	10.2	50	370		TA2 45.6			
10-11	8	15.2	47	471	TB3-4	TB3-1 66.6	TB3-2	TB3-3	TB3-0
12-13	9	14.5	29	481		TA4 63.8			
14-15	10	13.9	40	504	TB4-4	TB4-1 61.4	TB4-2	TB4-3	TB4-0
16-17-20-21	11	12.4+11.9	9	440		TA3 103.0			
18-19	12	12.1	19	486	TB3-8	TB3-5 54.2	TB3-6	TB3-7	
22	13	6.4	22	541	TB5-4	TB5-1 31.4	TB5-2	TB5-3	TB5-0
23-24	14	6.7+6.6	12	515		TA5 58.2			
25	15	6.6	9	380	TB2-4	TB2-1 32.2	TB2-2	TB2-3	TB2-0
26H(400A)	16	7.5	5	176	TD2-31 12.2	TD2-12 9.5	TD3-21 10.4	TD3-33 13.3	
27H(400A)	17	7.5	5	176	TD2-32 12.2	TD2-13 9.5	TD3-22 10.4	TD3-34 13.3	
28 -H	18	5.9	0	0	TD1-2 15.2	TD1-1 9.9	TD2-11 8.8	TD2-22 11.7	
29		5.8	0	0			TD4-	TD4-	

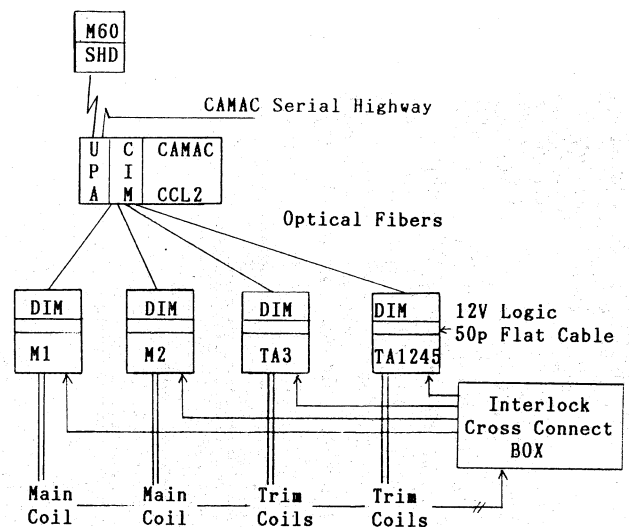


Fig.4. Control linkage of the magnet power supplies with CIM, DIM and M60 computer.

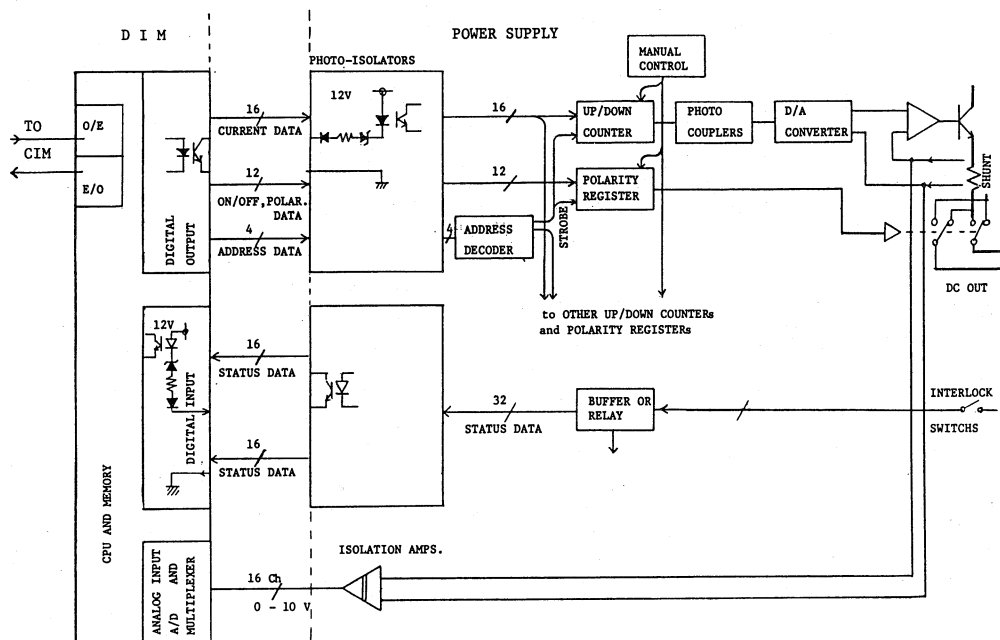


Fig.5. Block diagram of control sequence of the power supply and DIM interface.

FIELD MEASURING SYTEM

A pneumatic driven field mapping system was constructed and used two years ago. This system was worked very well in the two sector magnets excited at the factory in Niihama. That was controlled by DEC LSI-11 micro-computer, and the obtained data was transferred to a computer FACOM 380.

At this time, M60 (Mitsubishi M350/60) super mini-computer is prepared for processing the obtained data, not only control the measuring system instead of the LSI-11. Figure 6 shows aluminum guide rings for the measuring system on the magnet poles.

An NMR gaussmeter (SENTEC) with four probe heads and multiplexer is introduced to our system. A probe selection and auto search reference voltage of this NMR meter are controlled and read out by CAMAC system. We ordered the special probe range of 6 -18 kG to match our magnets, modified from a probe range of 7 - 21 kG.

In order to turn the Hall assembly for 360 degree, an automatic cable handling system was equipped (called a loop tower) at this time.

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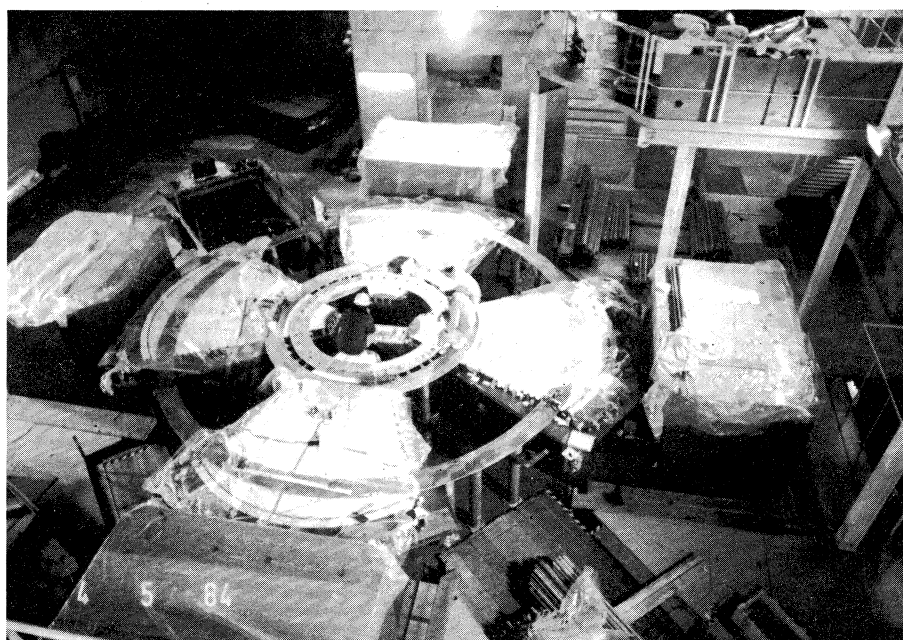


Fig.6. Magnetic field measuring system's guide rings on the pole faces and trim coils(white ones) of the sector magnets.