PA33

Design of Magnet Power Supplies for KEKB Accelerator

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Abstract

A number of magnet power supplies (for Bending, Quadrupole, Sextupole and Wiggler magnet) and about 1800 Steering magnet power supplies will be prepared for KEKB Accelerator. The required specifications for these power supplies, especially the specification for the current stability is very severe. Various measurements have been carried out and in progress at present to try to realize these specifications. In consideration with the results of the measurements the design of power supplies has also been going on.

1. Introduction

There are 4 small and 4 large power supply stations in TRISTAN. 90 main and 520 steering magnet power supplies have been installed in these stations. These existing power supplies will be recycled as far as possible for KEKB Accelerator. Especially almost all of the main magnet power supplies in 4 large power supply stations will be utilized again. But the number of power supplies which have to be prepared for KEKB Accelerator is quite larger than TRISTAN case. Thus 4 new power supply stations for the installation areas of new power supplies will be reserved in the floor of the existing buildings or experimental hall of TRISTAN. The design of power supplies has been put into account in consideration with the room condition of 12 power supply stations which are different with each other.

To investigate the recycling method of the power supplies we altered a power supply of TRISTAN last year which is not in use. We are going to fabricate typical R&D magnet power supplies as well. One is for the 20kW class and the other is for the steering magnet power supplies. We will adopt the switching mode power supplies in both cases.

In this report the design process and its plan will be discussed taking into account the results from the various measured data.

2. Required Specifications for the Power Supplies

Table 1. shows the required current stability and magnetic field ripple content rate of the power supplies. In the Cu vacuum chamber actual magnetic field ripples will be smaller than current ripples because the magnet field ripples will be reduced by eddy current effect of vacuum chamber.

Thus how to realize such high current stability is a most important problem for the design of magnet power supplies.

Table 1.
Required Current Stability and Field Ripple Content(P-P).

Magnet Power Supplies for	Current Stability	Magnetic Field Ripple Content Rate(P-P)
QCS (Superconducting Quadrupole Mag.)	1×10^{-4}/year	1×10^{-5}
Quadrupole Mag. (Curved Section)	1×10^{-4}/year	1×10^{-5}
Bending Mag.	1×10^{-4}/year	1×10^{-5}
Sextupole Mag.	5×10^{-4}/year	5×10^{-4}
Correction Mag.	5×10^{-4}/year	5×10^{-5}

To estimate the power supply design parameters many kind of measurements have been carried out to attain these current stability and . Later these problems will be discussed in detail.

Table 2 shows the list of power supplies to prepare.

Table 2.
The list of magnet power supplies required at KEKB.

Ring	Magnet Type	Voltage (V)	Current (A)	Number of Units	Total Units
LER	Dipole	1400	1250	1	
		250	1100	2	
		130	1100	2	
		120	1250	2	
		70	1250	2	
		70	1100	2	
		40	1100	2	
		30	1250	2	
			1250	5	
			550	2	
	Wiggler	400	1100	8	30

	Quadrupole	700	500	3	
		600	500	2	
		400	500	2	
		130	500	1	
		100	500	3	
		80	500	2	
		70	500	2	
		50	500	12	
		40	500	35	
		30	500	56	
				2	120
	Sextupole	50	425	4	
		40	425	48	
			425	2	54
	Steering			886	886
HER	Dipole	1400	840	1	
		40	840	4	
		20	840	3	
			840	9	17
	Quadrupole	900	500	1	
		500	500	1	
		400	500	6	
		300	500	3	
		100	500	10	
		60	500	12	
		30	500	46	
		20	500	29	
			500	1	109
	Sextupole	60	425	24	
		50	425	28	52
	Steering		886	886	

3. Measurement of the Room Condition of the Power Supply Station

The room temperature of the existing 8 power supply stations have not been controlled. But the existing magnet power supplies satisfy the specification of TRISTAN because the control circuits of the power supply have been kept in constant temperature box. We are planning to install all new Sextupole, Steering and several Quadrupole magnet power supplies in 4 existing small power supply stations, and the other new Bending, Quadrupole and Wiggler magnet power supplies in 4 new power supply stations. But in both cases the constant temperature box will not be used by reason of the cost performance. Therefore we measured the room temperature variation at the time of power supply operation. Fig.1 shows the measured data on this summer. As can be seen the room temperature is same as the air outside when the ventilation fan has been operating.

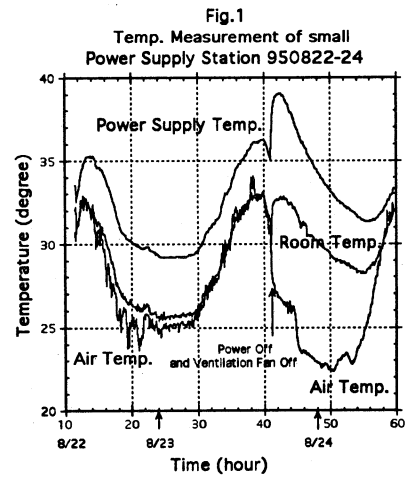


Fig.1

It will be able to keep the room temperature in the range of 20 to 40 degrees in all the year only by on/off control of ventilation fan. Consequently it became clear that to guarantee the specification given in Table 1 the design of KEKB magnet power supplies must be carried out by taking account of the room temperature change of 20 degrees .

4. Configuration Plan of KEKB Magnet Power Supplies

The KEKB magnet power supplies will be separated into two parts because of the reason mentioned in the previous sections. Namely one is a hardware part not affected by the temperature variation comes from surroundings. The other is a control part which is most important part to satisfy the specification and easily affected by the temperature drift. So the latter part has to be kept in air-conditioned room. Fig.2 shows the configuration plan of the KEKB magnet power supply. All the control units of power supplies will be put together in same air-conditioned room. The temperature coefficient of the head of DCCT will be ignored normally. So it will be installed in hardware part. On the other hand the control circuit of DCCT will be installed in air-conditioned room. In case of steering magnet power supplies the current sensors will be probably kept in air-conditioned room to reduce the cost.

5. Measurement of altered TRISTAN magnet Power Supply

Various measurements have been carried out with the configuration shown in Fig.3 by using altered TRISTAN magnet power supply. DCCT of HOLEC company has been used as the external monitor. 20m length of connection cable between DCCT head and control circuit is guaranteed by the company. So we used it to confirm the specification.

Fig.2
B, Q and Sx Power Supply Plan for B-FActory

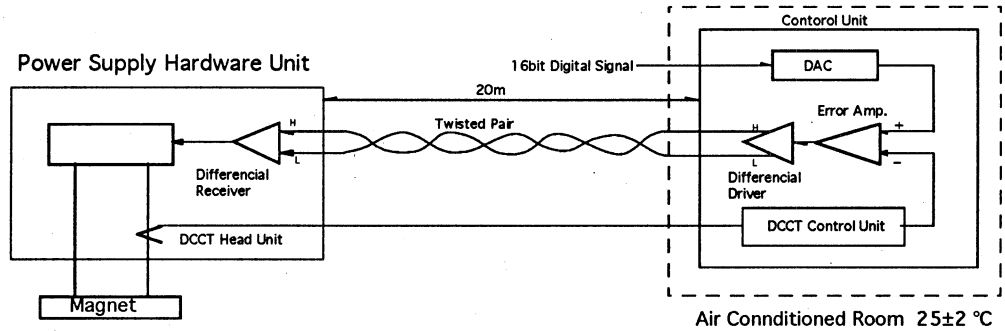


Fig.3
Block Diagram of Current Stability Measurement

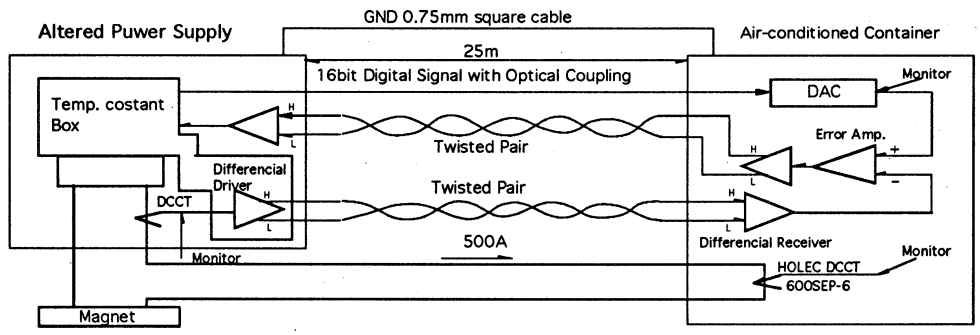
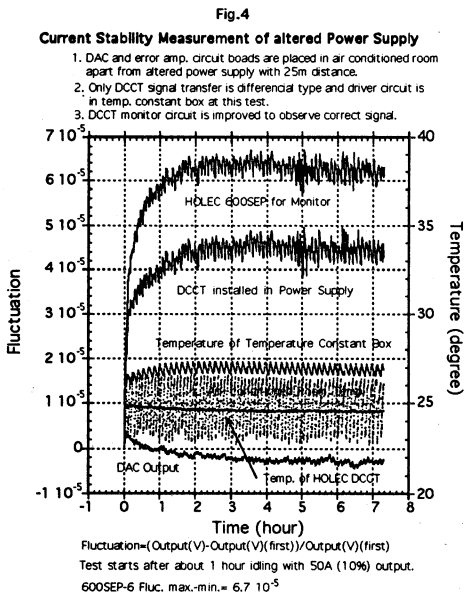


Fig.4 shows a typical measured data. Large drift of DCCT output at warming up was perhaps caused by temp. drift of the resistors which have been used for the differential amplifiers in the current feedback loop. The temp. coefficient of resisters is 100 ppm/ degree.



The current stability of this power supply is within 10 ppm after warming up. This value is enough for the specification of KEKB magnet power supplies.

6. R&D Magnet Power Supplies

It proved to be clear that the configuration shown in Fig.3 has been applicable to KEKB magnet power supplies on the basis of the measurement described in previous sections. Accordingly by this way the fabrication of 20kW class and low power bipolar steering magnet power supplies has been going on as R&D at present. Recently in Europe and USA switching mode power supplies have been introduced for almost all of the power supplies of these classes. For example nowadays it is not difficult to use semiconductor component like IGBT. In Japan switching mode magnet power supplies for accelerator are not so popular. So we would like to adopt switching mode power supplies in both cases which have many merits like very small sizes, high power-factor etc.

7. Magnet Power Supplies for KEKB Accelerator

As pointed out in this report it will be surely possible to fabricate KEKB magnet power supplies which satisfy the given specifications. But here we point out again that how important are the selection of electric parts and the design of electric circuits.

We arenow drawing up a detail construction schedule of the magnet power supplies toward KEKB Accelerator operation.