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HIGH STABILITY, HIGH CURRENT DC-POWER SUPPLIES

K. Hosono, K. Hatanaka, T. Itahashi, I. Miura, K. Sato, T. Saito, A. Shimizu, K. Takahisa, K. Tamura, T.Yamazaki, S. Ano, M. Kibayashi, H. Tamura, M. Uraki

Research Center for Nuclear Physics, Osaka University, 10-1 Mihogaoka, Ibaraki, Osaka 567, Japan

Abstract

Improvements of the power supplies and the control system of the AVF cyclotron which is used as an injector to the ring cyclotron and of the transport system to the ring cyclotron were done in order to get more high quality and more stable beam. The power supply of the main coil of the AVF cyclotron was exchanged to new one. The old DCCTs used for the power supplies of the trim coils of the AVF cyclotron were changed to new DCCTs to get more stability. The potentiometers used for the reference voltages in the other power supplies of the AVF cyclotron and the transport system were changed to the temperature controlled DAC method for numerical-value settings. This paper presents the results of the improvements.

1. Introduction

The K=140 AVF cyclotron is a three sector, 180° single-dee, variable energy machine. Any necessary isochronous field can be produced by a main coil and sixteen trim coils. The power supplies of these coils have been used for more than 20 years. The AVF cyclotron is now mainly used as an injector of the ring cyclotron. In order to obtain more high quality and more high stable beams in acceleration of ring cyclotron, the quality of the beam from the injector is essential. Accordingly, more high stability of current is required for these power supplies. Improvements of all power supplies of the injector have been made to achieve more high stability.

2. Power Supply for the Main Coil of the Injector

The maximum rating currents of the power supply is 1,430 A and the output voltage is 350 V. The old power supply of the main coil was pre-regulated by a motor generator and the DC current was regulated by series transistors. The stability was about $3x10^{-5}/8h$. The stability was not so good to get high quality beam. So, the power supply of the main coil has been changed to a new one.

The new power supply is pre-regulated by a saturable reactor in stead of a motor generator and is current regulated by series transistors. A current sensor to achieve high stability is performed with a high precision shunt resistance made of germanium manganese copper alloy(ZERAMIN) with a temperature coefficient less than 3 ppm/°C between 15°C and 40°C. The shunt resistance is cooled by temperature controlled water in ±0.1 °C. The feedback amplifier and the DAC for the current control are placed in the thermostatic oven.

The stability and ripple were examined. The current stability of $4x10^{-6}$ for 8 hrs was achieved at the currents between 1300 A and 400 A. The stability was measured with a zero-flux current transformer(DCCT) put in the cubic for a current monitor. Figure 1 shows a result of the measured current stability. Figure 2 shows a photograph of the voltage ripple of the output. The results are very similar to the stability of the power supply for the main coil of the ring cyclotron.

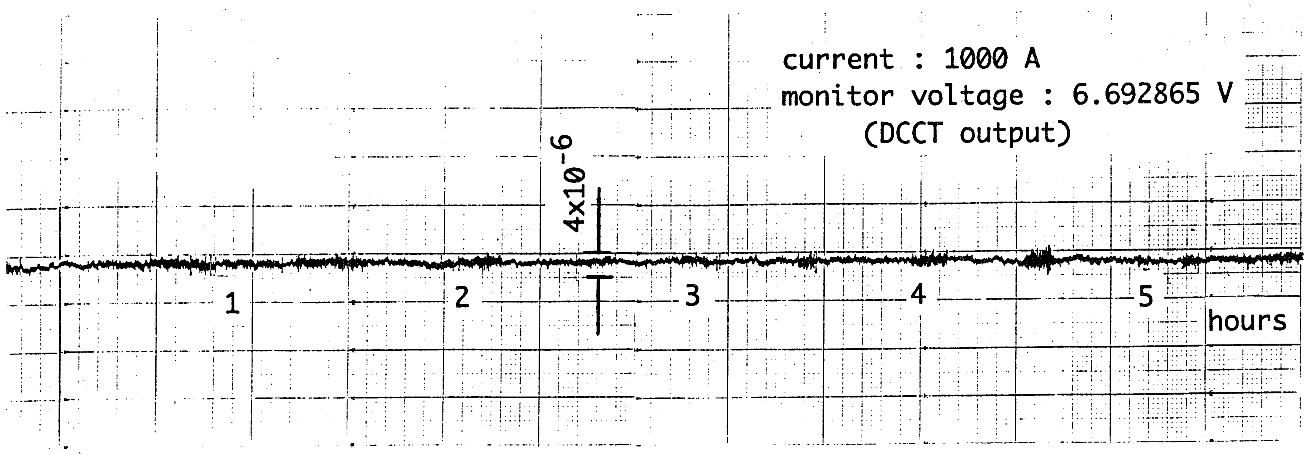

Fig. 1 A result of stabilty measurement of main coil power supply for the injector.

3. Zero-flux Current Transformers

Zero-flux current transformers(DCCT) have been used as current sensors for trim coil power supplies of the injector. However, these DCCTs are old and are not satisfactory in accuracy, reliability and in thermal stability. the current stabilities of the power supplies were $1x10^{-4}$. In order to exchange the old DCCTs used for the trim coil power supplies to more high precision ones, we have carried out performance tests of a few type of the DCCTs. Figure 3 shows a schematic block diagram for the measurements. Figure 4 shows the results of measurements of the temperature coefficients and Figure 5 shows the sensibility(resolution) by a current change of 1ppm for the two kinds of DCCTs made by A company and B company, respectively. The temperature coefficient of A is less than 0.04ppm/°C and that of B is about 0.25ppm/°C. The DCCT made by A company has better quality in both temperature coefficient and sensibility than one made by B company, but is easily affected by a small noise from the outside and stops to work. The DCCT made by B company is not so influenced by a noise. We have adopted the DCCTs made by B company as the current sensors of trim coil power supplies because we have to consider a counterplan for a noise.

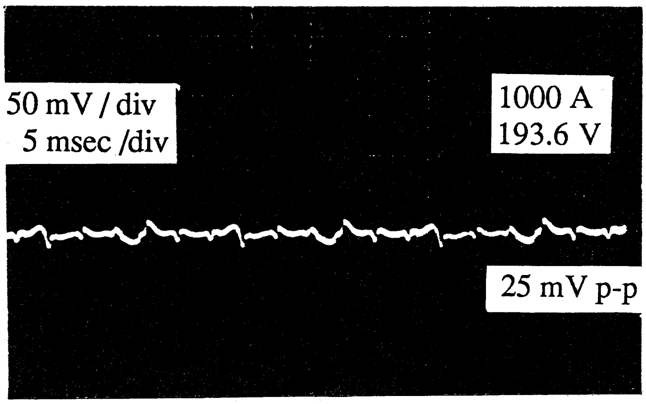

Fig. 2. A photograph of the voltage ripple.

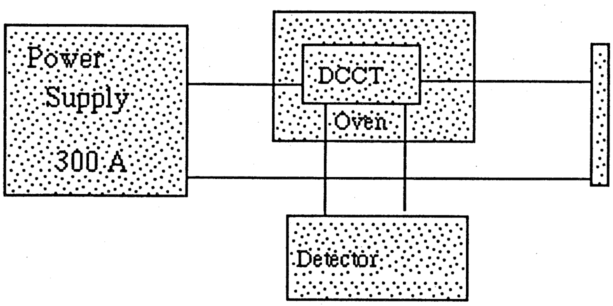

Fig. 3. Schematic block diagram for the measurement of DCCTs.

4. Power Supplies of the Trim Coil for the Injector

A new DCCT has been included as a current sensor of the trim coil power supply. The maximum current of the power supply is 1500 A. The DCCT feedback signal is 10 V for the current of 1500 A. The feedback amplifier and the DAC are placed in a oven. We have measured the current stability of the power supply. Figure 6 shows a result of the measurement of the current stability. We have obtained the current stability of less than $1x10^{-5}$. The current stability has been improved by about 10 times in comparison with the current stability of the power supply. We are going to change the old DCCTs used as current sensors in other many power supplies to the new ones of high precision.

5. Improvement of Power Supplies for the Injector

An improvement has been made to the water cooling system of the injector to ensure better beam stability, because the current stabilities of power supplies are severely dependent on the temperature of the cooling water. So, the temperature control devices of the

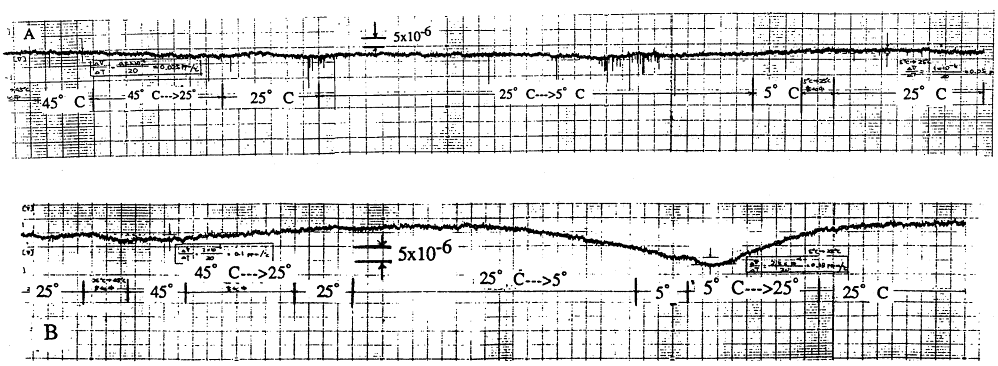

Fig. 4 Results of the measurements of the temperature coefficients.

cooling water have added to the cooling system.

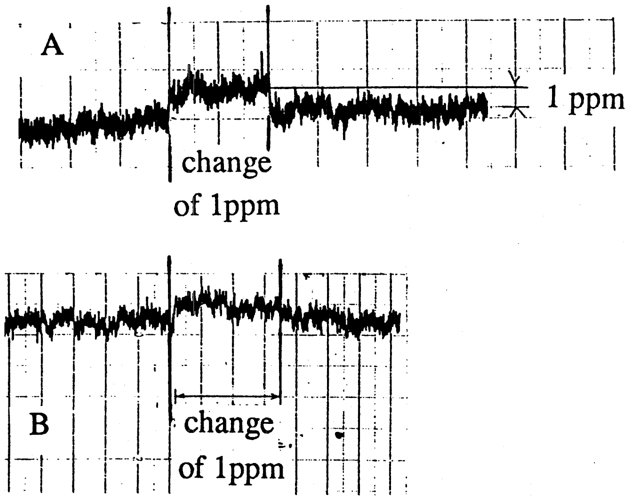

Fig. 5. Sensibility of DCCTs by a current change of 1ppm.

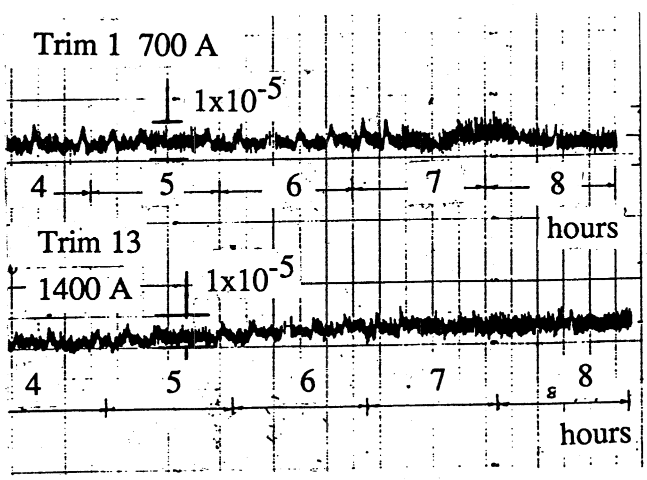

Fig. 6. Results of the current stabilities of trim coil power supplies.

The potentiometers used as the reference voltages in the all power supplies of the injector and the beam transport system have been changed to the temperature controlled DAC method for numerical value settings. Due to the DAC method, the old type control system for the injector and the beam transport system has been replaced to the computer control system and has been included in the control system of the ring cyclotron.

The beam stability for a long time has been become better due to the these improvements.

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