PERFORMANCE OF THE RHIC MAIN POWER SUPPLY SYSTEM*

C. Schultheiss#, BNL, Upton, NY

Abstract

Each of the main power supply systems for the Relativistic Heavy Ion Collider (RHIC) consists of a power module, a digital regulator and an output circuit compartment. The sextant test provided an opportunity to test the prototype main power supply system. This test indicated areas where improvements could be made in the system. Changes were incorporated into the design. Testing of the system, using the actual ring as a load, is expected to be complete by March 1999. The performance of this completed system is presented and discussed.

1 INTRODUCTION

The actual ring has not been available for testing; the results presented are from tests of the subsystems that make up the main power supplies.

2 CURRENT SIGNAL CONDITIONER

The Current Signal Conditioner (CSC) printed circuit board develops an error signal based on the difference between the Direct Current Current Transducer (DCCT) and a DAC that receives the commanded current. The error signal is amplified by a factor of 16 and then digitized by a 16 ADC, this provides the equivalent of 20 bits of resolution in the current loop. Figure 1 shows a block diagram of the test configuration of the CSC.

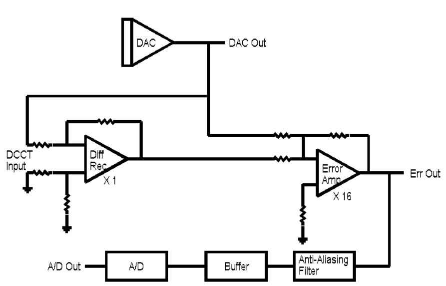

Figure 1 Test Configuration for Current Signal Conditioner

*Work performed under Contract No. DE-AC02-76CH00016 with the U.S. Department of Energy.

Email: carls@bnl.gov

2.1 DAC Linearity

The DAC Out signal was used to measure the linearity of the DAC. Figure 2 presents the results. The numbers at the edge of the graph indicate the extreme values.

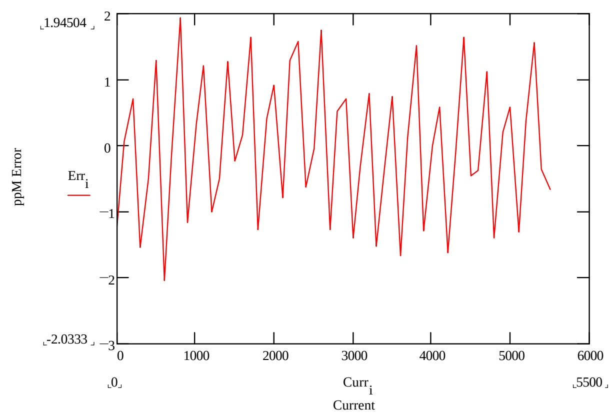

Figure 2 DAC Linearity Error

The linearity error is within the error budget allocated for it. A scheme to improve the linearity is under development; the necessary hardware has been incorporated into the regulator.

2.2 Accuracy and Noise

The Accuracy and Noise was measured at the Err Out signal and at the A/D Out at various currents. Figure 3 shows the typical output at the A/D Out signal in ppM.

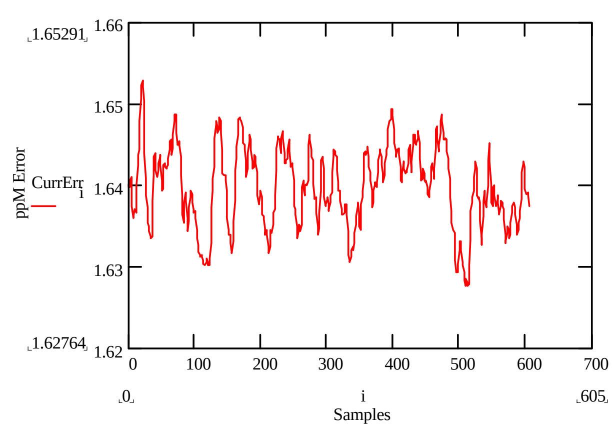

Figure 3 Accuracy and Noise at A/D Out

0-7803-5573-3/99/$10.00@1999 IEEE.

3 SUB-HARMONIC CORRECTION

The power supply uses digital firing circuits to allow a real-time correction of the sub-harmonic frequencies generated by the phase controlled power converter. [1] The sub-harmonic correction algorithm has been improved since the sextant test. [2] Figure 4 shows the sub-harmonic frequencies without correction and with correction at 1000 amps.

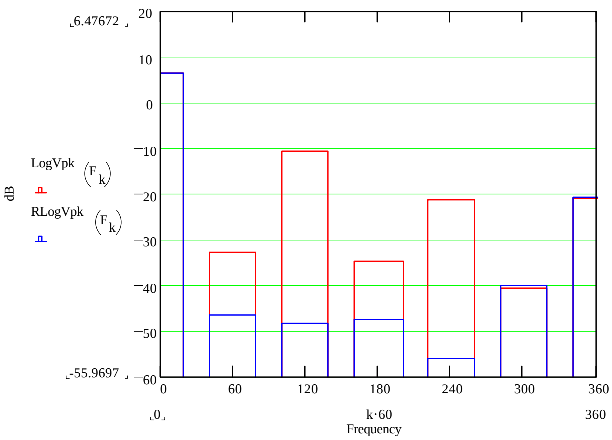

Figure 4 Sub-Harmonic Correction at 1000 Amps

4 QUENCH PROTECTION CIRCUITS

The magnets are super-conducting and require a circuit to extract the energy in the event of a quench. The quench protection circuitry consists of a pair of free-wheeling SCRs that are across the output of the main power supplies. These free-wheeling SCRs will conduct current when the output voltage polarity is the opposite of normal operation. When these SCRs conduct they place energy dump resistors in the circuit as they are triggered. The main SCRs are commutated off by a pulse-forming network (PFN) that back biases them. A quench detection system provides the triggering signal when it detects a quench. The quench protection system also includes self-triggering circuits that will trigger the free-wheeling SCRs if the output voltage rises above the normal operating range.

The quench protection circuits have been tested on a 300 uHenry inductor. The following oscilloscope pictures show the PFN output voltage in the upper trace and the current in the energy dump resistors in the lower trace.

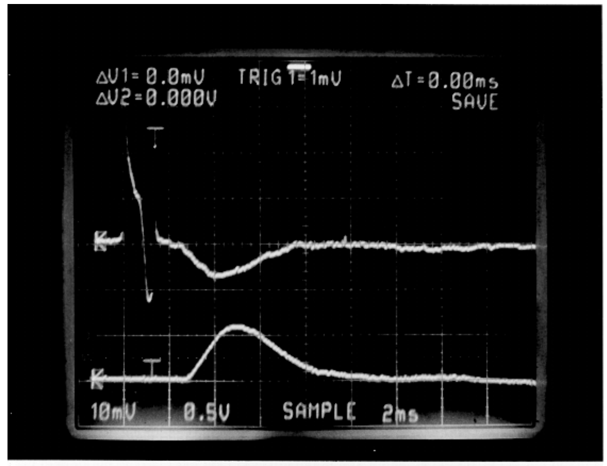

Figure 5 Quench at 500 Amps

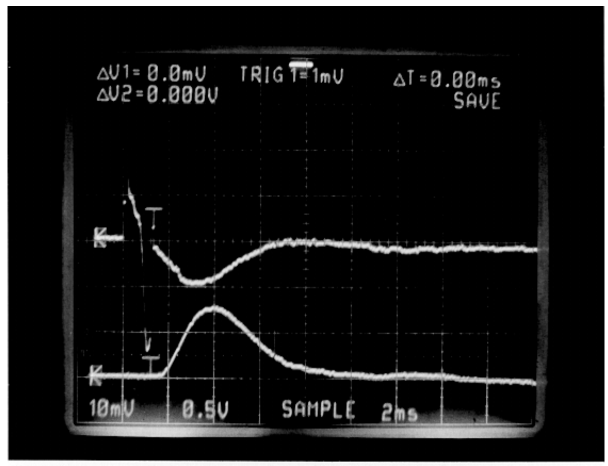

Figure 6 Quench at 3000 Amps

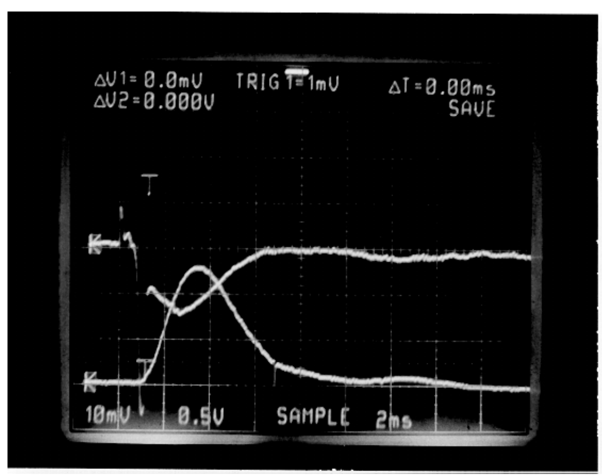

Figure 7 Quench at 5500 Amps

The pictures indicate that the time between the firing of the PFN circuit and the beginning of current flow in the energy dump resistor is dependent on the current in the main circuit. The voltage at the output must reverse polarity before the free-wheeling SCRs can begin to conduct. The output capacitor delays this voltage reversal and is the reason the delay is current dependent. The voltage across the main SCRs is also reduced due to the voltage drop in the resistance of the inductors that form part of the PFN network.

5 CONCLUSIONS

The sub-systems tested in the main power supplies have shown satisfactory performance. When the ring becomes available further testing will be conducted.

6 REFERENCES

[1] C. Schultheiss and T. Haque, “Digital Regulation of a Phase Controlled Power Converter”, Nuclear Science Symposium and Medical Imaging Conference, (1994)

[2] C. Schultheiss, D. Bruno, P. K. Feng, T. Haque, and R.F. Lambiase, “Power Systems for the RHIC First Sextant Test”, Particle Accelerator Conference , (1997)