INCREASING OUTPUT CURRENT STABILITY OF POWER SUPPLY WITH COMPONENT REPLACEMENT

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Abstract

Quadrupole magnets of storage ring must be served with power supplies (quadrupole power supplies) with +/-100 ppm long-term output current stability in Synchrotron Radiation Research Center (SRRC). Using power supplies with lower long-term output current stability could save money but need another control loop to increase their performance that will increasing the complexity of circuitry of quadrupole power supply. Without adding another control loop, some components of quadrupole power supply are replaced by ones with more precious and insensitive to temperature variation; so that the same circuitry structure of quadrupole power supply is kept without increasing its complexity and could reach +/-25 ppm long-term output current stability.

1 INTRODUCTION

There are four families of quadrupole magnets at storage ring of SRRC, and each family of quadrupole magnets includes twelve quadrupole magnets. In original operation condition of SRRC, each family of quadrupole magnet is served with one SCR-type power supply that with +/-100 ppm long-term output current stability and these four power supplies were operated well in the operation period. After insertion devices were installed at the straight section of storage ring, there are there families of quadrupole magnets must be separate into six groups due to there are six sections in storage ring so that the quantity of power supplies should increase six times but with six times lower power.

The specification of these eighteen power supplies is +/-1000 ppm long-term output current stability instead of the original +/-100 ppm long-term output current stability because of the shortage of budget, so there must be some procedure to improve the stability of these eighteen power supplies to be ±100 ppm to meet the specification and let electron beam to be stored stably at storage ring.

Adding extra control loop formed by personal computer, HP 36601A DVM, Danfysik ULTRASTAB 866 DCCT[1], VISHAY 5 Ω burden resister[2] with 5ppm/℃ temperature coefficient and computing algorithm could meet the +/-100 ppm long-term output current stability. These eighteen power supplies are controlled with AIAO and DIDO interface that is different to the original interface and this problem could be solved with installing IEEE-488 interface card into PC to communicate with main computer.

Due to communicating speed concern, finally, default AIAO and DIDO interface is the better way for Instrument & Control group to integrate and speed up their control environment so the added control loop with IEEE-488 based must be removed and +/-1000 ppm long-term output current stability should be improved to be +/-100 ppm by another method.

In this experiment, the method used to achieve higher long-term stability of output current of quadrupole power supply is to replace original devices of control circuitry of quadrupole power supply with lower temperature coefficient components.

There were several devices of control circuitry replaced and each one of them makes obvious contribution on long-term output current stability of quadrupole power supply, so measurement will be demonstrated for any replacement of device.

2 IMPROVEMENT OF STABILITY BY ADDING EXTRA CONTROL LOOP

The specification of long-term output current stability of these eighteen power supplies with AIAO & DIDO control interface is +/-1000 ppm and figure 1 shows the actual performance is about 600 ppm that is a little bit better than the specification.

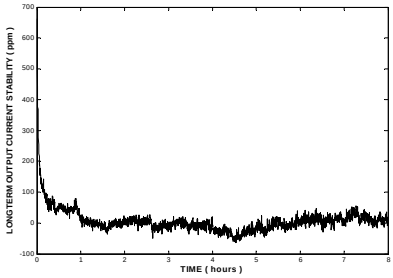

Figure 1: Original long-term output current stability

But from the stable operational point of view of storage ring, 600 ppm long-term output current stability is too high compared with +/-100 ppm requirement.

After adding extra control loop formed by personal computer, HP 36601A DVM, Danfysik ULTRASTAB 866 DCCT, VISHAY 5 Ω burden resister with 5ppm/℃ temperature coefficient and computing algorithm, the improvement is obvious and figure 2 shows it's about 100

ppm that is good enough.

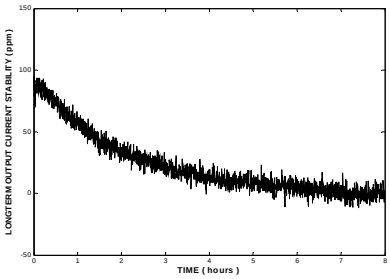

Figure 2 : Long-term stability of output current after adding extra control loop

3 IMPROVEMENT OF STABILITY BY REPLACEING REFERENCE INPUT STAGE OP AMPLIFIER

Increasing over all control environment speed, Instrument & Control group requires more fast control interface for every subsystem, based on this requirement the control interface of quadrupole power supply is changed from IEEE-488 to AIAO and DIDO interface, and this change is just return the control interface of quadrupole power supply to default one.

With AIAO and DIDO control interface, current control and read-back are analog signals and there is a long distance between current control crate and quadrupole power supply so that ground loop between these two systems exists. Ground loop at times can be a source of noise, if the magnitude of noise is too large such that control circuit of power supply will be affected and the performance of power supply degrade. The effect of ground loop can be eliminated or at least minimized by isolating these two circuitry and isolation can be achieved by transformer, common mode choke, optical coupler, balanced circuitry, frequency selective grounding or isolation amplifier.

There are two current control reference input stages for quadrupole power supply, remote control state and local control state. In normal remote control state the only concern is the long-term output current stability of power supply. The circuitry used as remote current control analog input stage is an isolation amplifier BURR-BROWN ISO120BG[3]. The performance of isolation of BURR-BROWN ISO120BG is undoubted, but temperature coefficient of some parameters (include gain, input offset voltage, …etc.) seems too large so that better long-term output current stability is impossible.

Instead of an isolation amplifier, the local reference input stage of quadrupole power supply is a differential amplifier composed of four resistors and an AD708[4] operation amplifier. As stated above, a differential amplifier is also able to eliminate or minimize the effect of ground loop. Furthermore, the temperature coefficient of AD708 is much lower than that of BURR-BROWN ISO120BG and the differential amplifier could be used in the reference input stage of quadrupole power supply by changing some wiring. Long-term output current stability quadrupole power supply is improved as figure 3 after AD708 was introduced. Within 200ppm long-term output current stability is achieved and improvement is obvious compared with figure 1.

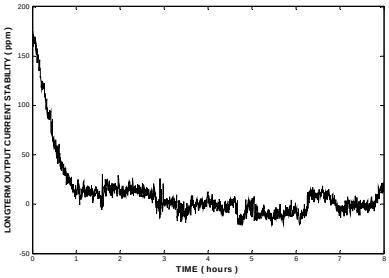

Figure 3 : Long-term output current stability after modification of reference input stage

4 IMPROVEMENT OF STABILITY BY REPLACEING DIRECT CURRENT CURRENT TRANSDUCER

The original direct current current transducer(DCCT) is LEM LT 300 – S/SP 9[5], the accuracy of nominal analog output current is about 500 ppm and this parameter seems not good enough for power supply to get very good long-term output current stability because the temperature inside power supply should rise when power is delivered to magnet.

The temperature coefficient of secondary compensation current of Danfysik ULTRASTAB 866 DCCT is 1 ppm/℃ better than that of nominal analog output current of LEM LT 300 – S/SP 9, there is so much difference on temperature coefficient and the replacement of these two transducers is not difficult that make us believed this replacement could benefit long-term output current stability of quadrupole power supply. Figure 4 shows the result after Danfysik ULTRASTAB 866 DCCT is installed.

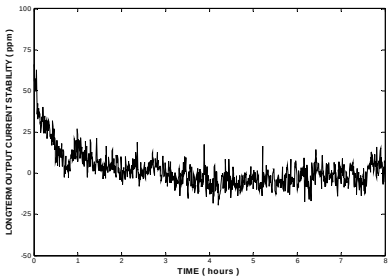

Figure 4 : Long-term output current stability after replacement of DCCT

Long-term output current stability is improved obviously and under 75 ppm that is better than the

specification we need.

5 IMPROVEMENT OF STABILITY BY REPLACEING BURDEN RESISTER

No matter what DCCT we used for the feedback loop of quadrupole power supply, there still need a burden resistor to be a load for DCCT that output secondary compensation current in ratio to measured current to get a voltage value.

The original burden resister is a metal film 1% 10 ohm resister and it's temperature coefficient is unknown but it's a trial for this resister to be replaced with a VISHAY 5 ohm resister with 5ppm/℃ temperature coefficient.

Long-term output current stability is under ±50 ppm as shown in figure 5 after VISHAY 5 ohm resister with 5ppm/℃ temperature coefficient is installed and even more after about 10 minutes warm-up time ±25 ppm is achieved.

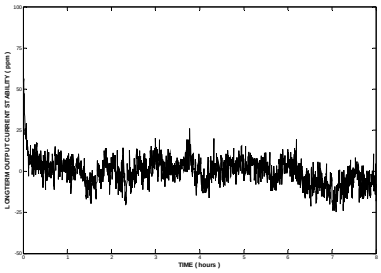

Figure 5 : Long-term output current stability after burden resistor is replaced

6 CONCLUSION

The long-term output current stability of quadrupole power supply used at SRRC is improved by utilizing lower temperature coefficient components to replace original ones that include reference input stage OP amplifier, direct current current transducer for current feedback and burden resister.

All experiments are proceed at full power output of maximum 250 amperes output current of quadrupole power supply, this should be the worst case because at this operational condition temperature inside quadrupole power supply should rise higher than other lower output current. There are obvious results show every replacement of component could contribute improvement on long-term output current stability and it's could be said performance of quadrupole power supply is less sensitive to temperature variation.

All of improvement procedures are just to replace some components and do not change the circuitry of quadrupole power supply that could simplify the maintenance work.

7 REFERENCES

[1] Manual of Danfysik ULTRASTAB 866 DCCT

[2] Data book of VISHAY resister

[3] Data book of BURR-BROWN, LINEAR PRODUCTS, 1995.

[4] Data book of ANALOG DEVICE, LINEAR DATABOOK, 1992.

[5] Manual of LEM current transducer