THE DEGRADATION EFFECT ON OUTPUT CURRENT STABILITY OF QUADRUPOLE POWER SUPPLY BY AC LINE VARIATION

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Abstract

The output current of quadrupole power supply used at storage ring of Synchrotron Radiation Research Center (SRRC) is an analog-controlled unit, and the performance of such unit is degraded by operating at EMI noisy core area of storage ring but still within 100 ppm specification. The variation of output current of quadrupole power supply is strongly correlated with AC line voltage variation, and correlation seems include two modes, one mode is direct proportional and the other mode is inverse proportional. The influence of inverse proportional mode on output current of quadrupole power supply is dependent on the location of power supply on the rack, and direct proportional mode influence is very small so it only would be measured when inverse proportional mode influence is become smaller or disappear.

1 INTRODUCTION

The original quadrupole power supply used at storage ring of SRRC is a 12-pulse SCR type power supply[1] and it supplies ±100 ppm stability current to 12 in-series quadrupole magnets. Based on operation requirement, there are several insertion devices (ID) are installed at straight sections (there are six straight sections at storage ring). After then two quadrupole magnets symmetrically beside every insertion device must be in-series supplied current by one power supply, so there are six power supplies for one type quadrupole magnet.

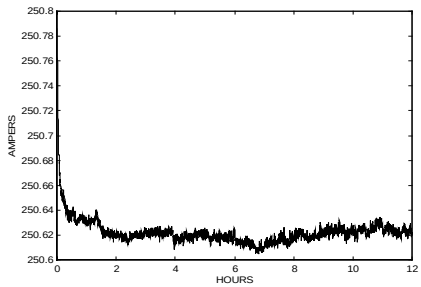


Fig. 1 : Output current longterm stability of power supply

The power supplies[2] used to supply current to quadrupole magnets after installing insertion devices are switched mode power supplies with AIAO and DIDO control interface, and output current stability of this kind of power supply is about 500 ppm (figure 1). With extra homemade control circuitry, these power supplies could be controlled by GPIB (compatible with original control strategy) and output more stable (about 100 ppm) current.

Power supply with GPIB control interface is easy to control but the degauss process of magnets before re-injection will take too much time because there are lots of power supplies. With AIAO and DIDO control interface, the time of degauss process could be shortened. Since output current stability of original power supply can not reach the ±100 ppm requirement, some optimization are proceeded and stability is under 30 ppm (figure 2)[3].

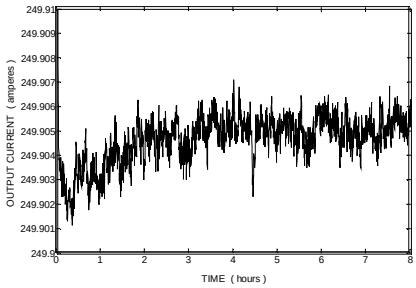
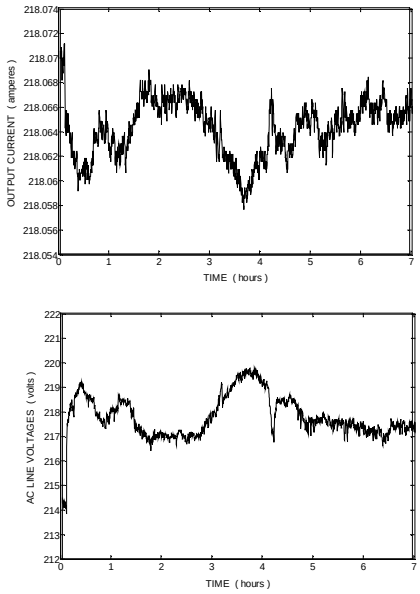


Fig. 2 : Optimized output current longterm stability of power supply

2 RELATIONSHIP BETWEEN OUTPUT CURRENT AND AC LINE VOLTAGE

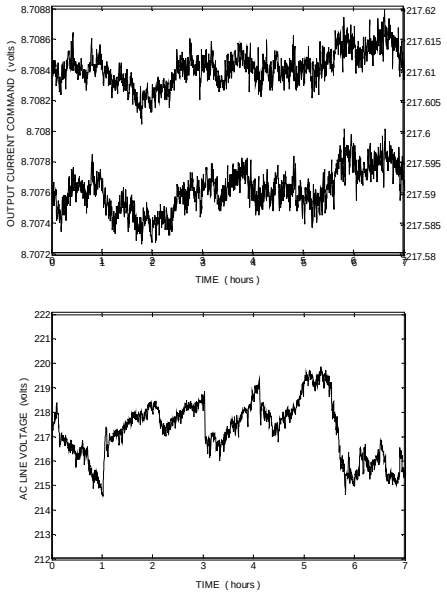


(a)

(b)

Fig. 3(a) : Output current stability V.S.
3(b) : AC line voltage waveform

The performance shows on figure 2 is measured at laboratory of power supply group and it seems quite good. But frequently the behavior of output current of quadrupole power supply is degraded (figure 3(a)) that is measured at core area of storage ring when storage ring is on normal operation; figure 3(b) shows AC line RMS voltage variation at the same interval of output current was measured. Comparing figure 3(a) and 3(b), it is very obvious that there is very strong correlation between output current stability and AC line variation, and the correlation is inverse proportional.



(a)

(b)

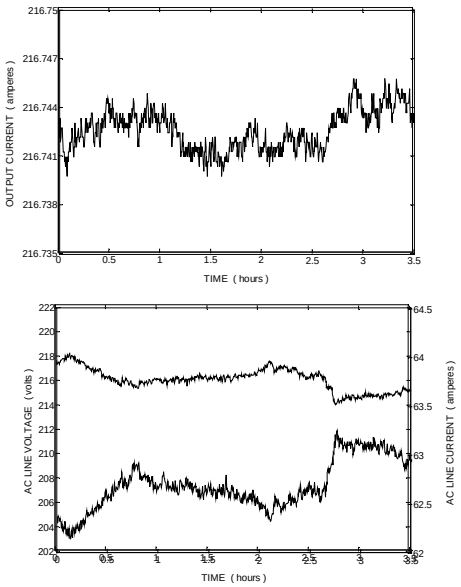
Fig. 4(a) : Output current (dotted line and right Y axe) V.S. output current command (10V⇔250A, left Y axe)
4(b) : AC line voltage waveform

Based on figure 3, it is hard to imagine how does the variation of AC line voltage influence stability of output current; but another measurement (figure 4) shows some information. Figure 4(a) shows behavior of output current and output current command during one user's shift, it was very clear that output current faithfully followed output current command and we were convinced output current stability getting worse was caused by output current command was interfered by something.

Comparing figure 4(a) and 4(b), the relation is not very obvious between stability of output current and AC line voltage variation likes that figure 3 shows. The correlation might include two modes, because at some interval the relation seems inverse proportional but another interval seems direct proportional.

3 RELATIONSHIP BETWEEN OUTPUT CURRENT AND AC LINE CURRENT

During normal operation of storage ring output current of every power supply is constant (and constant power), so every change on AC line voltage will cause variation of input AC line current and relation between them must be inverse proportional.



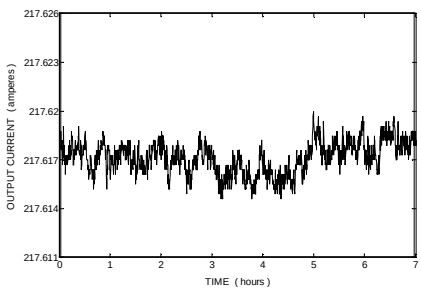
(a)

(b)

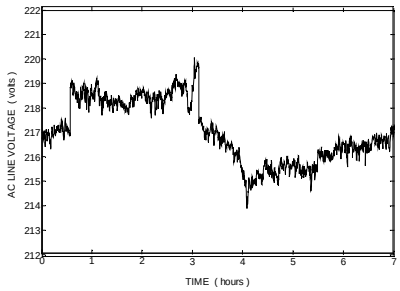
Fig. 5(a) : Output current waveform
5(b) : AC line voltage waveform (dotted line and left Y axe) V.S. AC line current waveform (solid line and right Y axe)

Variations of AC line voltage and AC line current are inverse proportional related (figure 5(b)) to keep constant power output of power supply as what was described before. It is an interesting phenomenon the correlation between output current stability and AC line voltage is inverse proportional but when comparing output current stability and AC line current the correlation becomes direct proportional. It seems the electromagnetic field built by AC line current to interfere output current command and variation of output current follows after output current command.

Quadrupole power supplies installed at core area of storage ring are six power supplies per group assembled in one rack. The AC line current measured above is the total input AC line current of QPS2 group and output current of power supply measured above is the power supply just beside the AC line input panel the interference from AC line current must be the strongest in the rack.



(a)



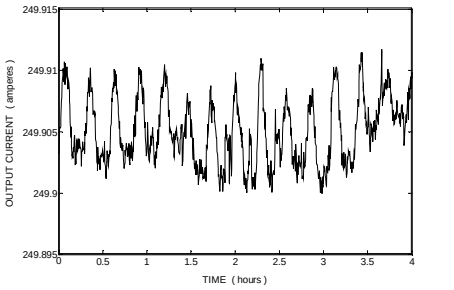
(b)

Fig. 6(a) : Output current stability V.S.
6(b) : AC line voltage waveform

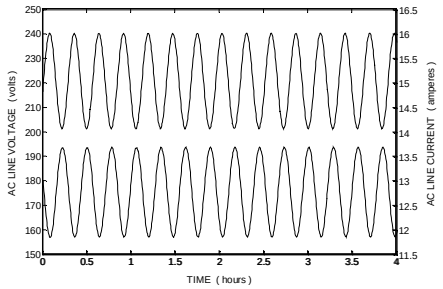
It is hard to relate the correlation between AC line voltage and Output current stability of power supply that is located farthest from AC line input panel (figure 6). Assumption above seems correct the electromagnetic field built by AC line current is much weak when location is far away from AC line input panel. Output current stability of that power supply is almost the same as figure 2 that is measured at laboratory with single power supply located far away from AC line panel.

4 RELATIONSHIP BETWEEN OUTPUT CURRENT AND AC LINE VOLTAGE SUPPLIED BY AC VOLTAGE SOURCE

Although output current stability shows at figure 2 is good enough for normal operation of SRRC, but the stability plot still shows some pattern that is not easy to recognize what is going on.



(a)



(b)

Fig. 7(a) : Output current waveform
7(b) : AC line voltage waveform (dotted line and left Y axe) V.S. AC line current waveform (solid line and right Y axe)
(AC input voltage is supplies by ac source)

In order to exclude interference from external source, figure 7 shows a test held at laboratory of power supply group and the AC input voltage of power supply is supplies with CROMA 6490[4] three phase programmable ac source. In this test intentional AC input voltage variation of ± 20 volts (rms) is ridden on 220 volts (rms) that cause about 2 amperes variation of AC input variation. At this condition the variation of output current is about 0.01 amperes (40 ppm), it is not very much and the variation is inverse proportional to variation of AC input current but direct proportional to variation of AC input voltage.

5 CONCLUSION

At most time variation of AC line voltage at core area is about 5 volts that may induce about ± 80 ppm variation of output current (figure 3) and that is inverse proportional correlated with variation of AC line voltage. The direct proportional correlation between variation of AC line voltage and output current could be clearly observed without inverse proportional interference (related to AC line voltage) and large variation of AC input voltage. Because large variation of AC input voltage at normal operation is hardly happened, so inverse proportional interference would dominate the variation of output current. When power supply is located away from interference source, inverse proportional and direct proportional interference should become competitive to each other and variation of output current is hard to match variation pattern of AC line voltage.

6 REFERENCES

[1] Manual of 250A/220V, RMP-Q/24 MAGNET POWER SUPPLY, INVERPOWER CONTROLS Ltd., Canada.

[2] Manual of 250A/30V, SWITCHMODE MAGNET POWER SUPPLY, INVERPOWER CONTROLS Ltd., Canada.

[3] “Improvement of Long-term Stability of Output Current of Quadrupole Power Supply”, technical report of power supply group of SRRC, SRRC/PS/IM/99-04, October, 1999.

[4] Manual of CROMA 6490 three phase programmable ac source.