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IMPROVEMENT THE BENDING MAGNET POWER SUPPLY PERFORMANCE FOR TPS STORAGE RING

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Abstract

In the TPS (Taiwan Photon Source) facility, current stability of the electron beam depends on the bending magnet power supply and an orbit FOFB system to compensate the magnetic field. Due to the output current stability of the bending magnet power supply drifts with temperature so the orbit FOFB system should be applied to fine tune magnetic field and the photon beam should circulate in storage ring. In this paper, to stabilize the temperature of regulation circuit's temperature box of the bending magnet power supply, the long-term output current stability is improve from ± 50ppm to ± 10ppm, and orbit FOFB system substantially reduce the tune X of beam position, effectively increasing the beam current stability and quality.

INTRODUCTION

The booster ring had been successfully commissioned and the electron beam was accelerated efficiently from 150MeV to 3 GeV with 3Hz repetition rate on December 16 2014. At the end of 2015, the TPS stored beam current had been pushed to 521mA, which is beyond the designed 500mA goal. For the requirement of beam position stability should be less than 1/10 beam size. FOFB has been implemented to achieve submicron orbit stability. The orbit stability had been effectively improved with FOFB that the suppression bandwidth could achieve 250 Hz in both horizontal and vertical plane. [1-2]

The relation between bending magnet current and the tune X of beam position in a week is shown in Fig. 1, the orbit FOFB system should apply to compensate the magnet filed due to the unstable Bending current that effectively to stabilize the beam particle position. In addition, the bending current spectrum pattern interferes the tune-X behaviour of an orbit FOFB system. This paper mainly studies output current instability issue of bending magnet power supply.

To understand the influence of the bending current variation on beam particle position, under the top-up mode operation condition the bending current was increased 100mA and close the orbit FOFB system to observe the position variation of beam size. The experiment result was shown in Figure 2. Under the condition of bending current variation 100mA, the beam particle x position is shifted from -56.5μm to -57.5μm with 1μm variation. Obviously, instability of output current of bending magnet power supply will directly affect the position of beam particles.

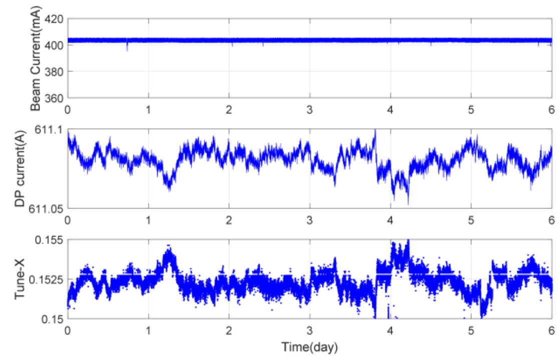

Figure 1: The beam particle position, bending magnet current, and tune-X relationship without adjusting the temperature setting.

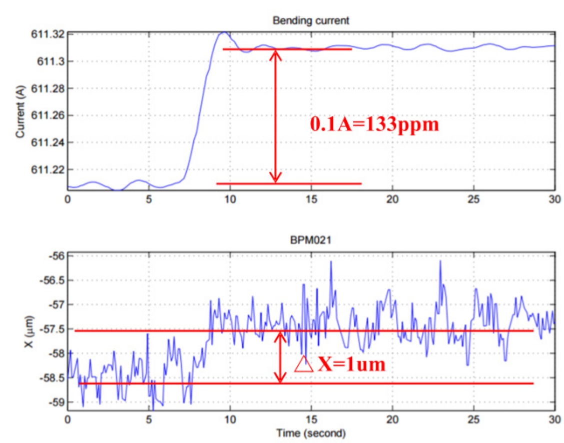

Figure 2: Influence of the bending magnet current variation on beam particle position.

TPS STORAGE RING BENDING POWER SUPPLY

This uni-polar power supply is specially designed for TPS storage ring bending magnets. The converter can deliver 750 Amperes up to 850 Voltage. Figure 3 shows the technology circuit diagram of the bending magnet power converters, which is buck converter employing one Intelligent SkiiP IGBT as switches and a high precision DCCT as feedback element. Control rack mainly has the following functions, digital regulation controller, temperature regulation box, basic control, communication protocol, digital interlock, analogy interlock and external interlock protection. The output current long term stability within 8 hours is well below 10ppm. The specification of the bending magnet power converter is listed in Table 1. [3-4]

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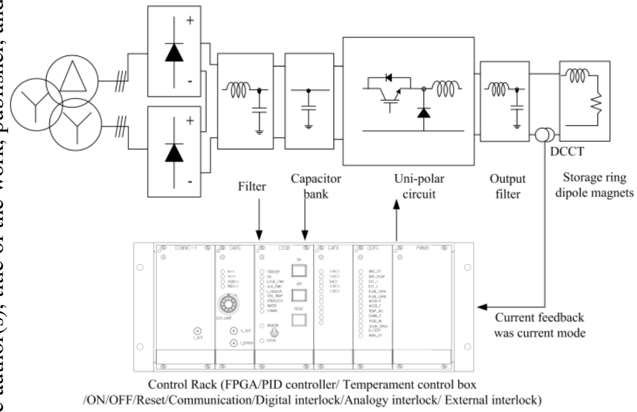

Figure 3: The technology circuit diagram of the bending magnet power converters.

Table 1: Specification of Storage Ring Bending Power Supply

Output(A/V)	750A/850V
Short term stability	±5ppm /± 3.75mA
Long term stability	±10ppm /± 7.5mA
Switch frequency	2kHz
Resolution	18bits
Accuracy	±50ppm

TEMPERATURE REGULATION BOX ISSUE

In this section, the causes of the instability output current of the bending magnet power supply is discussed. The current feedback component is DCCT with output current mode that is primarily to avoid signal interference during transmission. In control loop, feedback current signals are converted to voltage signals with high precision and low temperature coefficient resistors. The regulation temperature box of the COMMC card is used, which could be reduce drift of the resistance value with temperature. Figure 4 and Figure 5 show temperature regulation box of the COMMC card, including a heat sink, the copper box, thermoelectric modules and a precision temperature sensor.

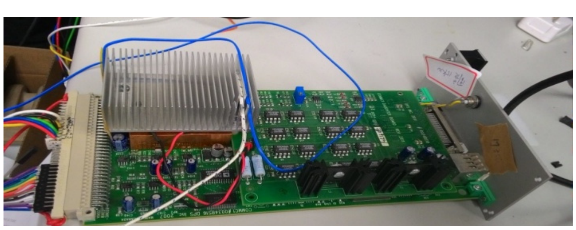

Figure 4: Temperature regulation box of a COMMC card.

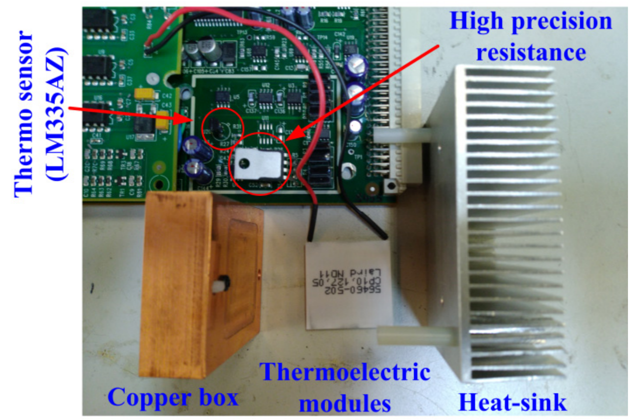

Figure 5: Component of the temperature regulation box.

At the default, the temperature regulation box setting is 27°C, the Figure 5 shows components of the temperature regulation box, and the temperature variation between the heat-sink and copper box is shown at the Figure 6. The Heat-sink does not function properly as the temperature setting value, the heat energy accumulates to heat-sink and the heat is transmitted to the copper box, which increases the temperature of the copper box from 27°C to 41°C. Thus, default setting of the temperature regulation box is instability, immediately affect the accuracy of the feedback resistance, and the bending magnet power supply output current drifts. The Figure 7 shows the thermal image of the temperature regulation box with default setting, that can be discover heat sink temperature is too high, the maximum temperature is 75°C.

The new temperature setting of temperature regulation box was adjusted to 38 °C, the thermal image is shown at Figure 8. Heats-sink temperature was dropped from 75°C to 30°C that the copper box temperature was regulated more stable.

The copper box temperature is stabilized around 38°C, a temperature drift less than 0.5°C during a week, the results are shown in Figure 9.

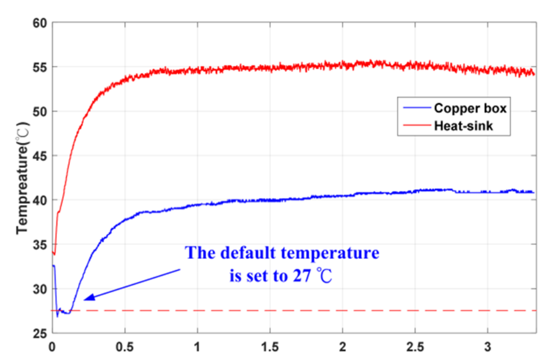

Figure 6: Default temperature regulation box setting.

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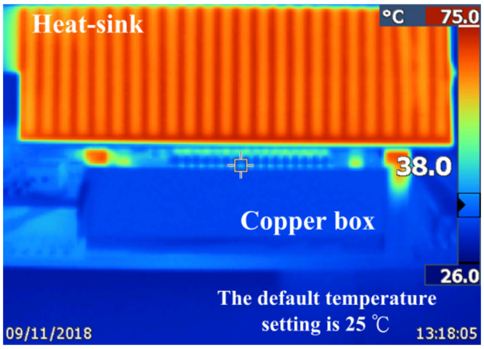

Figure 7: Thermal image of the temperature regulation box with default setting.

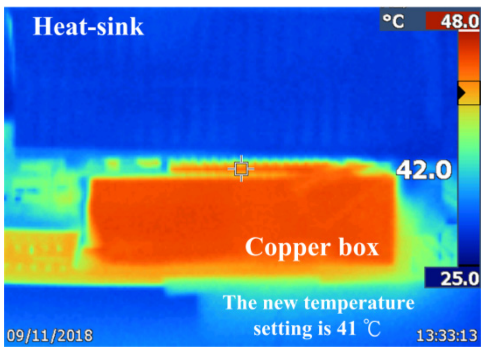

Figure 8: Thermal image of the temperature regulation box with new setting.

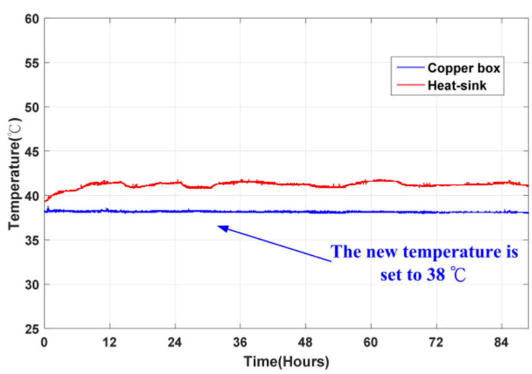

Figure 9: The 38°C regulation box setting.

MESUREMENT RESULT

After adjusting the temperature regulation box setting, the top-up mode 400mA is operated, the relationship of the beam particle position, bending magnet current, and Tune-X is observed in a week, the result is shown in Figure 10. It is obvious, that the bending magnet current became more stable, which reduces tune-X and improve beam quality for user.

The performance difference of output current between default and new adjusted setting of the temperature regulation box is shown at Fig. 11, the output current stability of bending magnet power supply is improved from ±50ppm to ±10ppm during a week.

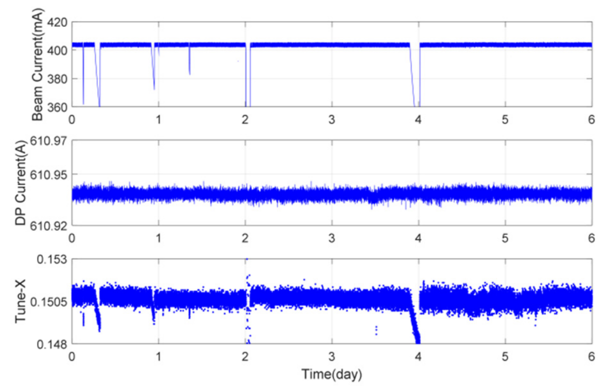

Figure 10: The beam particle position, bending magnet current, and tune-X relationship with adjusting the temperature setting.

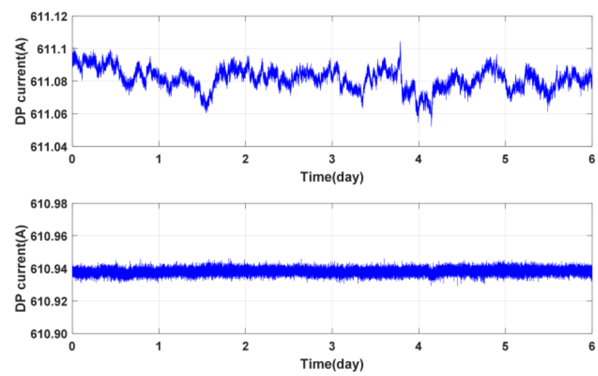

Figure 11: The relationship between temperature regulation box setting and bending magnet current.

CONCLUSION

The output current stability is directly affected by the temperature of regulation box, with a temperature higher than room temperature, the performance of bending power supply is improved obviously, the long-term stability of bending magnet current is improved from ±50ppm to ±10ppm. In the future, the short-term stability and ripple of bending magnet current is an important issue worth for studying. [5]

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