

TPS FAST CORRECTOR MAGNET POWER CONVERTER

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Abstract

M With the increasing demand of the current output accuracy on the TPS(Taiwan Photon Source) project, the MCOR 30 correction power supplies used in current TLS ring are no longer sufficient to meet the TPS requirement. Therefore, power supply group develops a high-precision low output current corrector magnet power supply with a DCCT as an output current feedback component for the future TPS ring. During the research and development experiment phase, we found the DCCT is more possible damaged than the other components.

The implementation of the fast corrector magnet power converter is with keeping the architecture of the high-precision low output current power supply, but the DCCT output current feedback component is replaced with a current sensing Shunt resistor. This paper will discuss the design methods of utilizing several different types current sensing Shunt resistor to reduce the cost of power supply and the probability of damage, and improve frequency response of power supply.[1]

INTRODUCTION

With the increasing demand of the high speed current output of fast corrector magnet power converter for the TPS(Taiwan Photon Source) project, power supply group of NSRRC construct a new high performance and high speed small current power converter. The goal is not only to provide high performance power converters for correction magnets of the future storage and booster ring of TPS, but also to reduce the maintenance labour and fee due to outsourcing.

This paper focuses on the design of shunt current sensing for the high speed low current corrector magnet power converter. The overall system can be divided into four functional sections: Power regulation and filtering, Error amplifier, offset circuit, PWM control, Fault diagnosis, protection, monitoring and high precision current feedback system. In the current feedback system design, current sensor is use the shunt. As a result, the output current performance of the power converter is greatly enhanced and meets the future need of fast magnets for TPS project.

THE STRUCTURE OF CORRECTOR MAGNET POWER CONVERTER

The corrector magnet power converter could be roughly divided into four functional sections: Power regulation and filtering, Error amplifier, offset circuit, PWM control, Fault diagnosis, protection, monitoring and current feedback system, shows in figure 1.

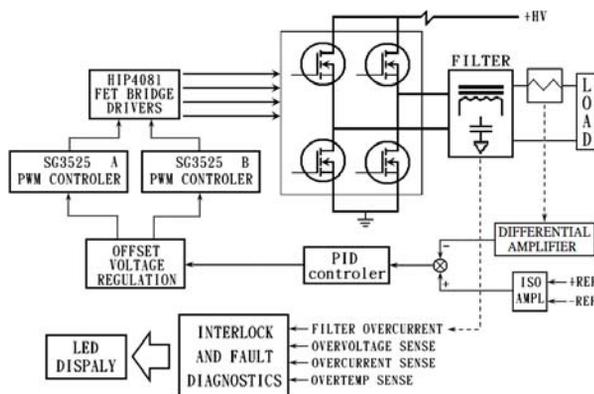


Figure 1: The structure of corrector power converter.

PWM CONTROLLER

To solve the problem of low output current spectrum, an offset circuit between the error amplifier and two PWM controllers is inserted allowing two PWM controllers output constant duty cycle when zero current is demanded [2]. Figure 2 shows this relationship between the switching duty cycles and the output of error amplifier, figure 3 shows the output current spectrum of corrector magnet power converter when two PWM controller with an offset circuit.



Figure 2: The relationship between the switching duty cycles and the output of error amplifier.

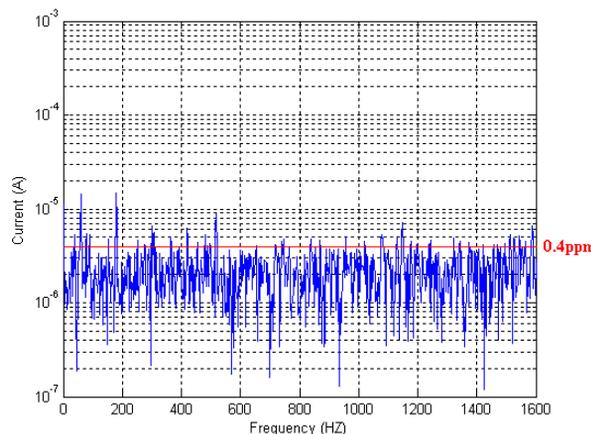


Figure 3: Output current spectrum of power converter.

In Figure 3, output current spectrum of corrector power converter, the total ripple current integrated from 0 Hz~1 kHz is about 20uA that is 2ppm for ±10A maximum current output of corrector magnet power converter.

CURRENT FEEDBACK SYSTEM

Low ripple · high stability · high speed and accuracy output current are the requirements of the fast corrector magnet power converter. The key component of the corrector magnet power converter to meet requirements is the current sensors. Here we adapt the RUG-Z-R01-0.1-TK1[3] as the current feedback element, shown in figure 4. Figure 5 show the power derating curves. If the ambient temperature is higher than 70°C the power dissipation must be reduced to secure that the resistance element will not exceed the limiting temperature, otherwise the element will might be damaged. This must be taken into account while designing a power supply system. Figure 6 show the current feedback circuit for shunt.



Figure 4: RUG-Z-R01-0.1-TK1.

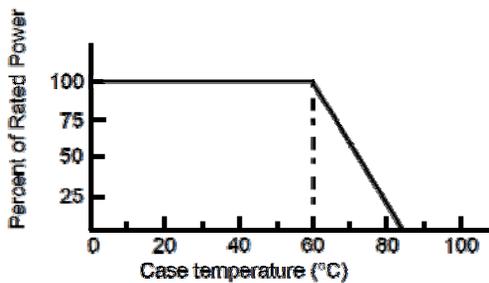


Figure 5: power derating curves.

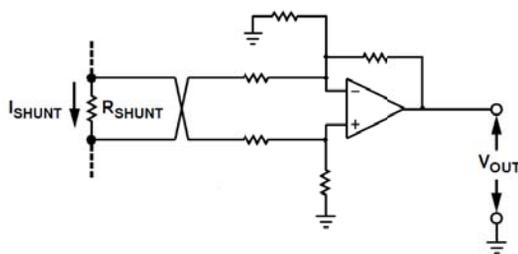


Figure 6: the current feedback circuit for shunt used as a current feedback component.

FAULT DIAGNOSIS, PROTECTION, MONITORING

The fast corrector magnet power converter provides four monitor signals and eight fault protections. Four monitor signals include output current, output voltage, temperature of MOSFET and temperature of power converter module, eight fault protections include output over-current, output over-voltage, input under-voltage, PWM input under-voltage, MOSFET over-temperature, two damping resistors of output filter over-temperature and fault exist.

With these four monitor signals and eight fault protection statuses, the corrector magnet power converter could be easily remote monitoring and fault diagnosis. Figure 7 is the picture of corrector magnet power converter.

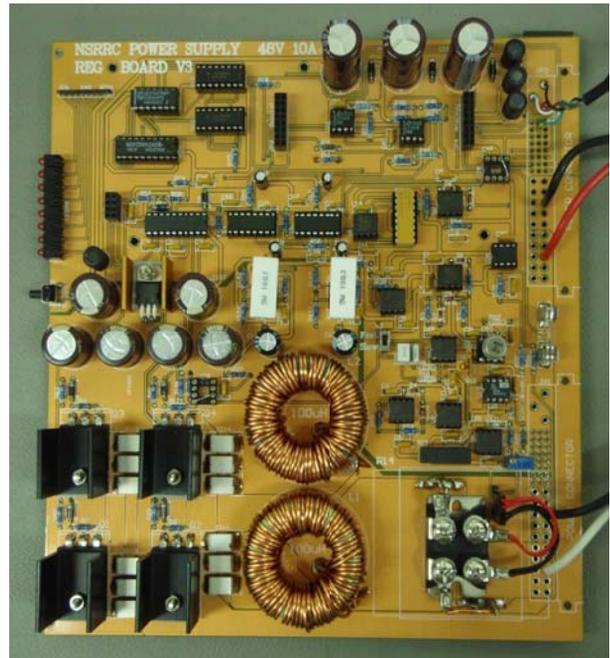


Figure 7: The picture of fast corrector power converter.

CURRENT FEEDBACK SYSTEM

The goal of the corrector magnet power converter is to meet requirements to power booster ring corrector (horizontal & vertical), trim coil of storage ring sextupole (include horizontal dipole, vertical dipole & skew quadrupole) and fast feedback corrector, so exclude high stability and low ripple of output current, the frequency response is another important parameter for the fast corrector magnet power converter. With suitable tuning on PI's value of error amplifier the frequency response of the corrector magnet power converter is about 3.437 kHz, show in figure 8.

Figure 9 shows the output current stability the corrector magnet power converter within 12 hours and the stability is within ±4ppm.

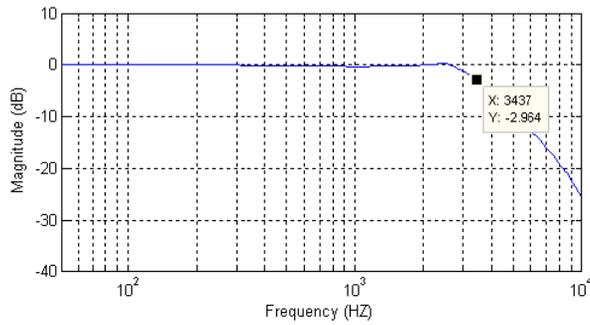


Figure 8: The frequency response of the corrector magnet power converter.

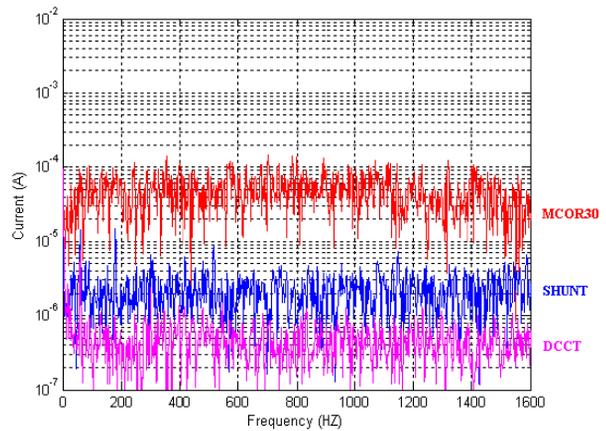


Figure 10: Output current spectrum compare.

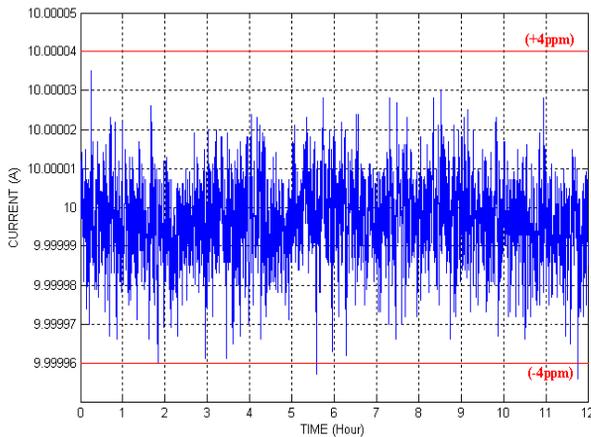


Figure 9: Stability of output current of the corrector magnet power converter within 12 hours.

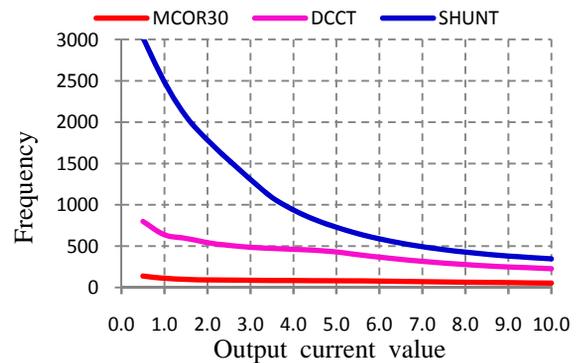


Figure 11: The frequency response comparison.

CONCLUSION

A new high frequency response fast corrector magnet power converter is fulfilled. The output current spectrum of the fast corrector magnet power converter compares with that of other corrector magnet power converter is shown in Figure 10, red curve is for MCOR30, blue one is for fast corrector magnet power converter and pink one is for corrector magnet power converter with a DCCT as current feedback component. Figure 11 is the comparison of frequency response. The frequency response performance of the corrector magnet power converter with a SHUNT as a current feedback component, is better than the other two power converter system, and the output current ripple is still better than the specification required for fast corrector magnet power supply.

This fast corrector magnet power converter could output current with 4ppm stability within 12 hours, 80uA ripple(0~1kHz) and 3.4kHz high frequency response. This corrector magnet power converter is versatile to meet any kind of requirements for magnets to be powered within ± 10 amperes that include booster ring corrector (horizontal & vertical), trim coil of storage ring sextupole (include horizontal dipole, vertical dipole & skew quadrupole) and fast feedback corrector. By using this power converter could save a lot of work in maintenance and quantity of spare parts is minimized.

REFERENCES

- [1] TPS MAGNET POWER SUPPLY SYSTEM: Kuo-Bin Liu, Yi-Da Li, Bao-sheng Wang, Kuo-Tung Hsu (NSRRC, Hsinchu, Taiwan) IPAC10.
- [2] TPS corrector magnet power converter: Kuo-Bin Liu, Yi-Da Li, , Kuo-Tung Hsu Bao-sheng Wang (NSRRC, Hsinchu, Taiwan), Jimmy Chun-ming Hsu (CMS/ITRI, Hsinchu, Taiwan) IPAC10.
- [3] RUG-Z datasheet.
- [4] <http://www.isabellenhuetten.de/de/das-unternehmen/>