Development of a new high stability power supply in the superconducting system

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Background

This paper presents newly developed high precision power supply to instead orderly power supply of superconducting system in Taiwan Light Source (TLS). The circuit of proposed converter by using high frequency power switch to combine full bridge structure. In addition, this proposed converter is designed with a good mechanism to emission of heat by air cooling, the previous generation of converter must be water cooling. Therefore, the volume of proposed converter can be significantly reduced and assembled concise, deionized water system is no required. This power supply has high stability, low output current ripple characteristics. Also, the slope slew of raising and failing were be change through the firmware in order to satisfy the operation of the system. The superconducting coil winding has a total length magnetic period of 36.5cm, total magnet length of 478.9cm and vertical (horizontal) magnetic field of 18.7T. The operation principle and steady state analysis of the proposed converter were discussed. Finally, a hardware prototype system with output current of 297 ampere was constructed in a superconducting laboratory of Taiwan Photon Light Source.

Proposal suerconducting magnet power supply

Power supply

A power pack size is 19 inch, The space of dimensions (H*W*D) is 1765mm* 3700mm* 1050mm.

Cooling water system are necessary (Deionized water system).

Complex feedback control system and circuit structure.

High cost.

Low Efficiency.

Difficulty in maintenance

Large size Superconducting magnet power supply

The space of dimensions (H*W*D) is 1765mm* 3700mm* 1050mm.

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Methods

SWLS Magnet Quench Protection Circuit

The electrical layout of SWLS, the main power supply is responsible for changing the main coils to eliminate the first and 7 or second field integral.

Conclusion

Proposed a novel high precision and high current/ low voltage power converter to upgrade previous large volume of spare bipolar power converter in TLS.

This power supply has high stability, low output current ripple characteristics.

Slope slew of raising and failing were be change through the firmware in order to satisfy the operation of the system.

Experimental results of proposal power supplies current performance within ±0.005A or within ±0.02ppm at long term testing

Maximum output current ripple is 0.976mA in 60Hz and else less than 0.1mA current ripple in other frequency.

The proposed converter saves five times the area of the previous superconducting magnet power supply, and the cost of the power supply is 6 times.

Zero voltage switching and high efficiency are realized.

The features of the 62100H-30 includes current mode with dual loops control. It is able to provide a stable and fast output response providing excellent protection for different load variations. The self-diagnosis routine and full protections against voltage phase loss, over/under voltage at input, over voltage/current at output, over power, over temperature, fan fail and remote inhibit ensure the quality and reliability for even the most demanding magnet power supply system in synchron.

Power Supplies

Superconducting magnets of power supply was design divide to input state and output state. Input state have include: AC Breaker, EMI Filter, Power Factor Correction (PFC) and Full Bridge Rectifier. Output state have include: DC-DC converter, Output Control Board and Digital Control Board.

Power Supply

The main power supply of superconducting are supplies high precision output current performance during 8 hours period. The long term performance of the SWLS, SW6 and SW8 power supply are required 150ppm.

The main power supplies output current 250A, the measurement are use a HP 34401 8.5 digits multi-meter (sample rate is 10 second) and LEM LT 600-5 Ultraslab DCT.

The main power supply output current ripple amplitude versus frequency, the maximum output current ripple is 0.976mA in 60Hz, and else less than 0.1mA current ripple in other frequency.

Dynamic spectrum analyzer (Agilent A35670A) is measures the magnitude of an input signal versus frequency within the full frequency range of the instrument.

Experiment result of output current ripple amplitude versus frequency, the maximum output current ripple is 0.976mA in 60Hz, and else less than 0.1mA current ripple in other frequency.

Experiment result of superconducting multipole wiggler training to prove reliable stability.

Step 1: SMPW output current from 0A to 297A, SMPW was reached maximum field of 3.98 Tesla and keep the output current to observe the magnetic field and current stability.

Step 2: SMPW output current from 297A to 0A, the SMPW will decay field from 3.98T to 0T.

Results

Experiment Result of Long Term Performance, Output Current Ripple and Training Magnet Curve

Experiment result of output current long term (up of 8 hours) performance. The main power supply output current within 0.005A or within 120 ppm. The long term performance of the proposed main power supply is better than it specified 150 ppm range.

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