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

Yong-Seng Wong, Kuo-Bin Liu, Chen-Yao Liu, Bao-Sheng Wang

NSRRC, No 101 Hsin-Ann Rd., Science-Based Industrial Park Hsinchu 30077, Taiwan, R. O. C.

Wong.ys@nsrrc.org.tw

Mon-Af-Po1-12 [96]

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 wingding has a total length magnetic period of 56.56cm, 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.

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 ±20 ppm 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.

Methods

Large size Superconducting magnet power supply

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

Proposal superconducting magnet power supply

A power rack size is 19 inch, The space of dimensions (H*W*D) is 2030mm* 600mm* 900mm.

Air cooling, cooling water system are not necessary.

Satisfies the safety standards for galvanic isolation

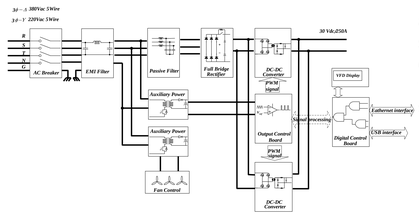
Simply Fixed frequency control and circuit structure.

Low voltage stress and low conduction losses.

Low cost.

Zero voltage switching and high efficiency.

Power Supply



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.

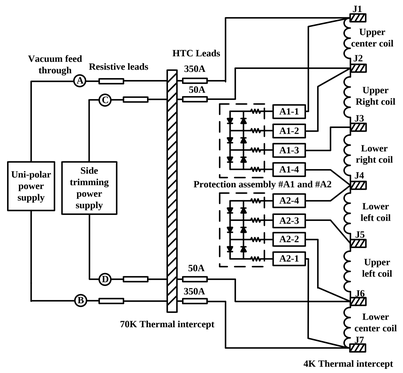
The features of the 62100H-30 includes current mode with dual loops control. It is able to provide a stable and fast output response providing excellent protection for different load variations. The self-diagnosis routine and full protections against voltage phase loss, over/under voltage at input, over 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 synchrotron.

Power Range: 11.25kw
Voltage Range: 0 ~ 30V
Current Range: 0 ~ 375A

Current Slew Rate Control
Output Current waveform digitizing
OVP, Current Limit, Thermal Protection
Standard USB Interface
Optional Ethernet/ LXI interface
Safety interlock & Remote inhibit control (I/P)

Results

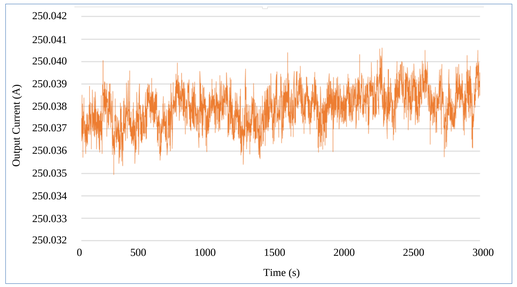
SWLS Magnet Quench Protection Circuit



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

Results

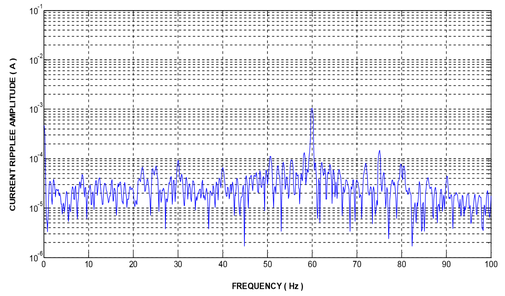
Experiment Result of Long Term Performance, Output Current Ripple and Training Magnet Curve



Experiment result of output current long term (up of 8 hours) performance. The main power supply output current within ±0.005A or within ±20 ppm. The long term performance of the proposal main power supply is better than it specified ±50 ppm range.

The main power supply of superconducting are supplies high precision output current performance during 8 hours period. The long term performances of the SWLS, SW6 and IASW power supply are required ±50 ppm.

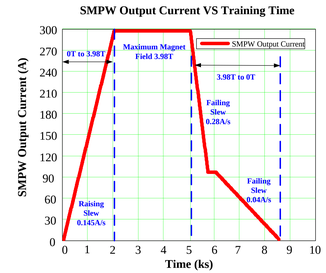
The main power supplies output current 250A, the measurement are use a HP 34410 8.5 digits multi-meter (sample rate is 10 second) and LEM IT 600-S Ultrastab DCCT.



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 decade field from 3.98T to 0T.

Presented at the 25th International Conference on Magnet Technology , 2017 Aug. 26 – Sep. 01, Amsterdam, Netherlands; Session: H2- Power Supplies and Flux Pumps; Program I.D. number: PO1-12-96