HIGH PRECISION PROGRAMMABLE OF TPS QUADRUPOLE MAGNET POWER SUPPLY

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Abstract

In 1993, the first of Taiwan light source was held on October 16. First beam stored in the storage ring and facility at synchrotron radiation research centre (SRRC) was opened to users and the full energy injection to 1.5Gev after seven years.

In 2007, the president of Executive Yuan Taiwan had been announcement to set up a third-generation synchrotron radiation. Taiwan Photon Source (TPS) project total budget of NT6, 885 million from 2007~ 2013. TPS project will improve technical capability to build to3.3Gev electron energy. Totally had been installed 1032sets of magnet power supplies for the storage ring and 152 sets for the injector. In the future, Taiwan photon source set up complete and operation, it will offer one of the world's brightest synchrotron x-ray sources.

INTRODUCTION

Most of power supplies used for magnets, especially in particle accelerators, relies on AC-DC converters to control the current delivered to the magnets. Particle accelerator is use magnet energy to moving electron particle, quadrupole magnet can collected particle for high energy particle accelerator [1]. So that, quadrupole power supply must supply energy to quadrupole magnet. TPS project has been installed with 240 quadrupole magnets and 240 quadrupole power supplies [1]. The 62075H-30N maximum power supplies can product 7.5kW energy. The current control range from 0A to 250A, the current stability +-6mA ppm (0~30mins) and +-12.5mA ppm (0~8 hours). Voltage and current ripple is 15mV and 100mA. Chroma 62075H-30N has wide adjust range for slew rate control, Voltage slew rate is 1V~5000V/s and current slew rate is 1A~1000A/s. The specifications of the power supply are listed in Table 1 [2].

To expand the chroma 62075H-30N can use by serial or parallel function with Master/Slave control. Maximum serial control can connect 2 modules (Maximum parameter is output voltage=60V; output current=250A and output power=15kw). Parallel control can connect 10 modules (Maximum parameter is output voltage=30V; output current =2500A and output power =75kw).

POWER SUPPLY OPERATION THEORY

Chroma 62075H-30 can divide by power module and control board. Power module include has AC to DC and DC to DC, input choke and capacitor will transform input AC voltage (3 phase 380Voltage) to DC voltage stored in DC bus capacitor. Full bridge circuit and transformer can adjust the DC bus voltage to a high frequency and low DC voltage. Full bridge MosFET operation frequency is 80kHz and primary inductor is 2.7mH. Power module component specifications are shown to Table 2 [3].

Table 1: 62075H-30N Power Supply Specifications

Specification	62075-30N Power Supply
Input Voltage	3 phase 380V ±10%
Current Control Range	0~250 Ampere
Voltage Control Range	0~30 Voltage
Maximum Output Power Energy	7500W
Current Stability	±6.25mA p-p (0~30 mins) ±12.5mA p-p (0~8 hours)
Output Noise (P-P)	60mV
Voltage Ripple (rms)	15mV
Current Ripple (rms)	100mA
Voltage Slew Rate Range	0.001V~5V/ms
Current Slew Rate Range	0.001A~1A/ms or INF

Table 2: 62075H-30N Power Module Specifications

Component	Part Number	Parameter
3 Phase Rectifier Bridge	IXYS VUO68-16NO7	68A/1600V
Input SCR	IXYS MCD40-16I06	60A/1600V
Gate Driver	IXYS IXFK 44N80P	800V/44A
Transformer	EE65.2/65/27.4 (2pcs)	2.7mH
Secondary Diode	DSS 2x101-02A	200A/200V

Dummy load parallel to output capacitor, it can produce a low voltage to compare output voltage pass to control board to calculate. Controller states have current feedback control, voltage feedback control; constant current mode and constant voltage mode (CC/CV) detect controller and isolated driver. Dummy load signal will set to control board G_{DCCT}, PID controller had obtained GDCCT singal to UC3895. UC3895 is a phase-shift pulse width modulation (PWM) controller that implements control of a full-bridge power stage by phase shifting the switching of one half-bridge with respect to the other. Controller states also have protection circuit such as over temperature protection (OTP); over voltage protection (OVP); over current protection (OCT); over power protection (OPP); dummy load controller; CV/CC detect and shut down circuit protection. Figure 1 has shown to chroma 62075H-30N power module state and control board.

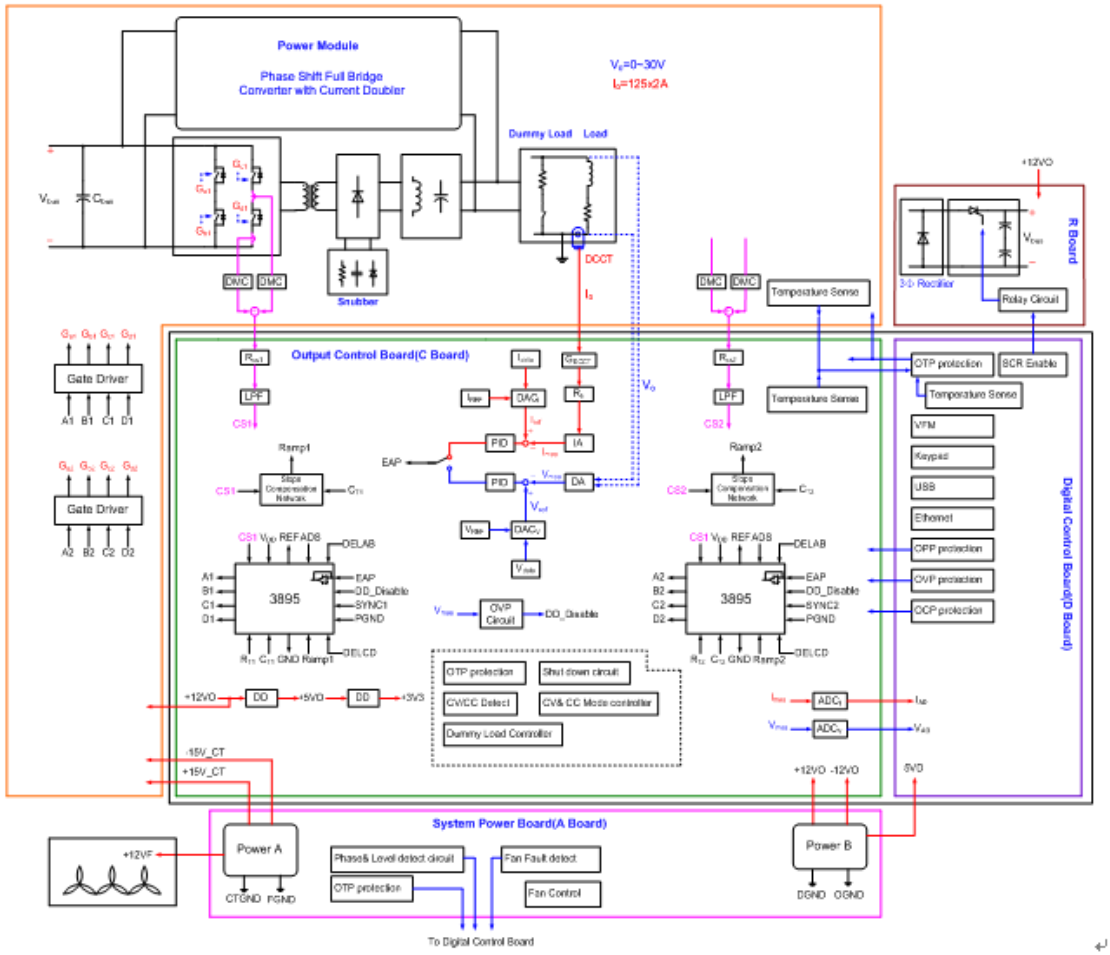

Figure 1: Chroma 62075H-30 power supply circuit.

TESTING WAVEFORM AND CURRENT RIPPLE

Set up a quadrupole loading to detect power supply current ripple and current stability. Quadrupole loading inductor is 23.5mH and resistor is 81.6m ohm. Power supply setting a full power to supplies to loading and using Danfysik Untrastab 860 current transducer and HP34410 multi-meter record transfer data. Figure 2 has shown to current transducer and power supply and quadrupole loading at laboratory.

Figure 2: Quadrupole power supply and quadrupole magnet loading at laboratory.

The specification of long team stability, power supply output current must keep to +-12.5mA ppm, setting output current is 250A and quadrupole loading, within 4 hours' time output current from 250.0016A reduce to 250.0000A and stability a constant current. At 4~8 hours, output current ripple varied less than 0.1mA (5ppm). Figure 3 has shown to long term output current ripple testing for 250A.

Agilent 35670A dynamics signal analyzer would analysis the data and show to the monitor. Testing the waveform about current ripple and frequency relationship, Output current ripple and frequency bode plot has shown to Figure 4, the peak current ripple is 1mA at 60Hz and low than 0.1mA current ripple at other frequency.

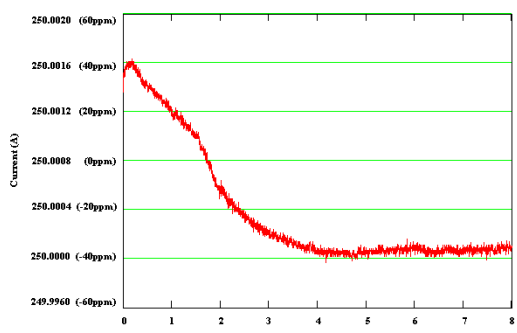

Figure 3: Long term current output ripple testing for 250A.

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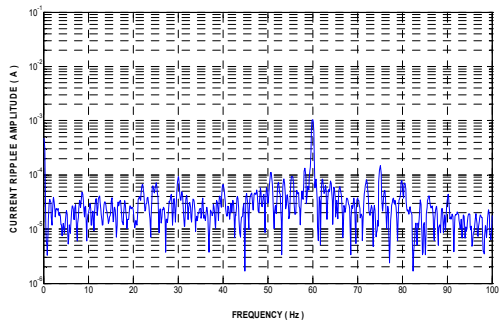
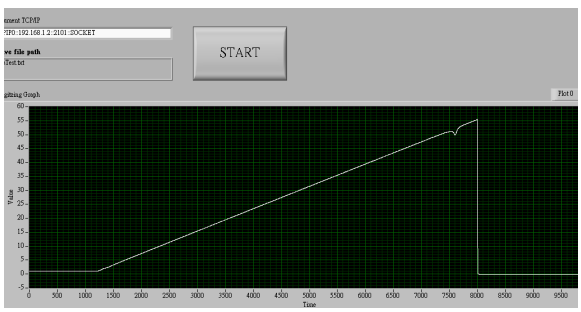


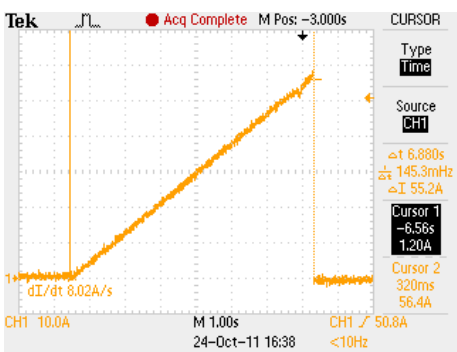
Figure 4: Output current ripple and frequency bode plot.

REMOTE CONTROL AND DIGITIZING TRIGGER DATA

Remote control communication function will use the network line (USB/Ethernet/RS485/RS232/GPIB) to connect main power supply and passing command. Detected the current data can using a trigger waveform by external pulse. The waveform data can up to 64k samples Post-mortem buffer shall be built inside and this buffer must record data of output current. Sampling rate must be adjustable and maximum sampling rate is 10ks/sec. It can stored record 10000 points data and user can adjust the medium point. This function can let user understood the power supply operation information. Figure 5(a), (b) has shown a cut-off output current (setting over current protection at 55A) when the trigger rising at power supply broken.



(a) Remote control digitizing trigger data.

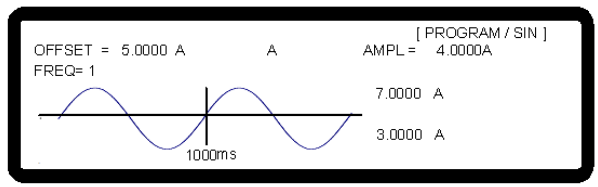


(b) Digitizing trigger data by oscilloscope.

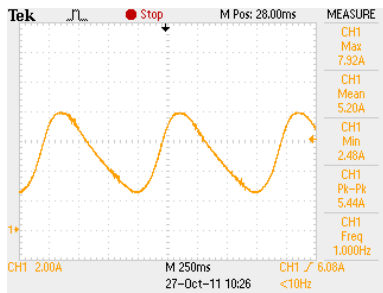
Figure 5: Digitizing trigger data show for remote control and oscilloscope.

SINWAVE PROGRAMMING

Remote control cans easily setting a sinwave programming at Chroma 62075-30N that can mix into a DC current. Figure 6(a) has shown a sinwave programming, it has contained 5A DC current mixed to4A AC current and Frequency 1Hz. Testing the function to measure it can produce a mixing current. The quadrupole power supply output minimum current is 2.48A, maximum current is 7.92A and frequency is 1Hz has shown as Figure 6 (b).



(a) Remote control sinwave programming data



(b) Sinwave programming data

Figure 6: Sinwave programming data show for remote control and oscilloscope.

CONCLUSION

This paper has proposed and discussed a high precision programmable power supply to use at quarupole magnet. It has some feature contain as low ripple current at low frequency and steady state at long team. For this feature can measure supplies a steady current into beam machine, the output current operation at full loading has less than 10 ppm during the steady state. Convenient to change the output current use the programming function, it cans remote control or local control when the output current normally operation.

REFERENCES

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[2] Yong-Seng Wong, Kuo-Bin Liu, Jhao-Cyuan Huang, Wu-Shien Wu, “Using a High Precision Programmable DC Power Supply of TPS Magnet,” APEC, pp. 3358-3360, 2011.

[3] Chroma Ltd Mar 2008, *Programmable DC Power Supply 62000P Series Operation & Programming Manual*, version 12.