ISBN: 978-3-95450-184-7 doi:10.18429/JACoW-IPAC2018-THPAL054

MODIFICATION OF A POWER SUPPLY FOR LOW-ALPHA OPERATION IN THE TAIWAN PHOTON SOURCE

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Abstract

In this paper we describe the modifications of power supplies needed to operate the storage ring with a low momentum compaction factor (low alpha) to generate short x-ray pulses. This design includes an external polarity reversal circuit in quadrupole and sextupole magnet power supplies. The polarity reversal circuit contains four relay module where each relay can receive signals from the D-type analog interface. The power supply control system must be enhanced to switch output polarity. The operating principle and analyses of polarity reversal are discussed in more detail. Finally, a prototype polarity reversal circuit with 30 V, 250 A and 7.5 kW output power is implemented in the laboratory to verify the expected performance for the TPS low alpha operation.

INTRODUCTION

The Taiwan photon source (TPS) has a circumference of 518m and is operating at 3GeV, a minimum emittance of 1.6 nm-rad and its beam commissioning started in the latter part of December 2014. The storage ring consists of 24 DBA cells, each with 2 dipoles, 10 quadrupoles, 7 sextupoles and 7 correction magnets. In TPS, the nominal momentum compaction factors α_1 and α_2 are 2.4×10^{-4} and 2.1×10^{-3}, respectively, and the nominal bunch length is 10 ps rms. When we operate TPS in the low alpha configuration, the electron bunch length can be significantly shorter, thus making it an economical way to obtain short photon pulses. Moreover, coherent THz/IR radiation can be generated. Recently, low emittance lattices with $\alpha_1 < 1\times10^{-5}$ have been developed for picosecond pulse users operation and possible coherent THz/IR radiation [1,2].

Yet, the output polarity of some power supplies must be reversed in order to achieve the desired result. The output delivers a positive current in normal mode while some power supplies must be switched to a negative current for low alpha operation. This note is focused on the polarity reverser of the power converter, which has four relay modules and each relay can receive signals from the D-type analog interface to switch the power supply output polarity [3,4]. Section II describes the theory and specifications for the operation of the power converter. A diagram for the mechanism and proposed polarity reversal circuit with D-type anolog interface are also discussed in this section. In section III, we discuss the remote and local control functions and in section IV we show the polarity reversal of the output current during machine operation while conclusions are discussed in section V.

POLARITY REVERSAL CIRCUIT AND SPECIFICATION

The TPS sextupole power supplies were of the model 62075H-30E obtained from CHROMA. For the low-alpha experiments, a set of current polarity reversal devices must be built for these power supplies. The new output polarity reversal function required can be implemented in two ways:

(1) A new layout of the CHROMA 62075H-30E power supply circuit.

(2) Adding an external relay device to the CHROMA 62075H-30 power supply.

Adoption of Solution (1): All specifications completely refer to the original specifications of the CHROMA 62075H-30E, but new PROGRAMMING COMMANDs need to be added to control output polarity. The switching and output specifications must be changed to meet the specifications 0~30V/0~250A, 0~-30V/0~-250A.

Adoption of Solution (2): Adding external relays to the CHROMA 62075H-30 power supply to allow output polarity reversal. The control interface needs to be controlled through the 25pin D-type analog interface on the back of the 62075H-30. Based on this control mode, the CHROMA 62075H-30 needs to accept the necessary programming commands to control polarity switching and specifications for this solution are shown in table 1:

Table1: External Relay Device Specification

Item	Specification
Storage Temperature Range	0℃ to +50℃
Operating Temp Range	25℃ ± 2℃
Relative Humidity	30% to 90%
AC Input Voltage	1 phase 220 V ± 10%
AC Input Voltage Frequency	60 Hz ± 1 Hz
Input Voltage/Current Specifications	0~30V/0~250A
Output Voltage/Current Specifications	0~30V/0~250A, 0~-30V/0~-250A
Size (L*W*H)	610*428*132.8 mm

Our choice is solution (2) because solution (1) implies a greater risk for the power supply. The polarity reversal device uses four contact relays of the type TYCOEV20 HAAANA including an auxiliary contact (white) to detect the state of the relay switch. On the PCB board of the polarity reversal device will be a 5V signal when the auxiliary contact status is closed. The polarity reversal device is connected to the power supply. In the state where

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the polarity is not switched (A & B relays are closed), the output current is the same as that of the original power supply. Conversely, when the polarity is reversed, the polarity is switched (C & D relays are closed), the output current has the opposite polarity of the original power supply. Figure 1 shows the diagram for the polarity reversal. It includes four relays, two cooling fans, copper conductors and a 9pin D-type analog interface on the backplane. Figure 2 shows the diagram of the polarity reversal device connected to the model 62075H-30E DC source power supply. Copper conductors serve as the connections between the two parts. One side connects to the current output of the DC source and the other end to the input of the polarity reversal device. The output of the polarity reversal device is connected to the magnet cable and AC 110V/60Hz is the electricity source.

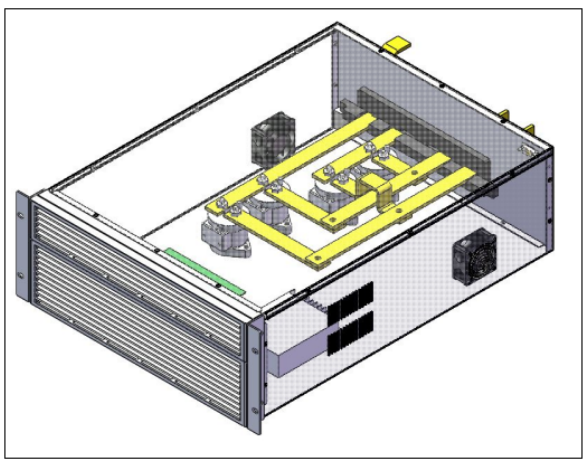

Figure 1: Diagram of the polarity reversal mechanism.

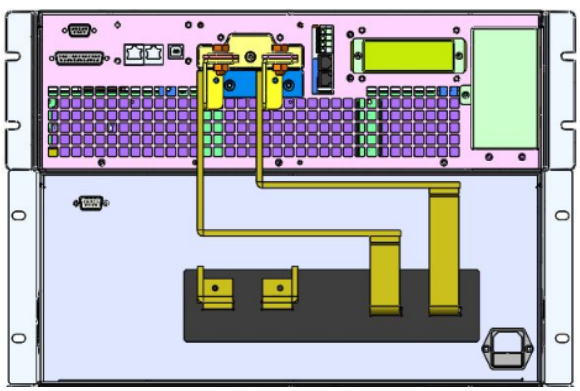

Figure 2: Diagram of the polarity reversal mechanism and DC source power supply.

REMOTE AND LOCAL CONTROL POLARITY SWITCHING FUNCTION

The polarity reversal device can be controlled by remote and local control. The remote control is through the Ethernet, where the computer host sends the command code to the power supply receiver. Then, the power supply sends the command code to the polarity reversal device via the D-type. Figure 3 shows the remote control panel. The power switch state is OFF, and the internal configuration set to polar off (normal) state where the pin 12 (+) and pin 13 (DGND) are at low output voltage (0V_{dc}). Alternatively, for the Power switch state ON, defined by the internal configuration set to polar on (polarity reverse) state and the pin 12(+) and pin 13 (DGND) are at high output voltage (+5V_{dc}). It should be noted that this command code can be issued only while the output state is OFF and the output current is zero. It is not possible to give this command when the output is ON. Figure 4 shows the local control panel, where the local control function is a built-in [DISPLAY SETUP] item, so that people can switch the polarity of the output locally. Dual devices generate the same polarity when the polar change is in the OFF state. The status of the polar change can be switched to the ON state via the button on the front panel. At this time, the output current will be inverted on the DC source and polarity reversal device.

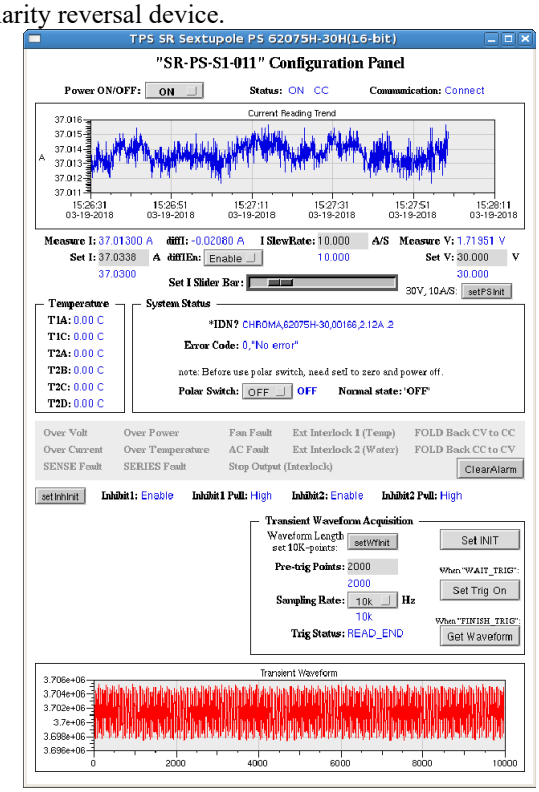

Figure 3: Remote control panel.

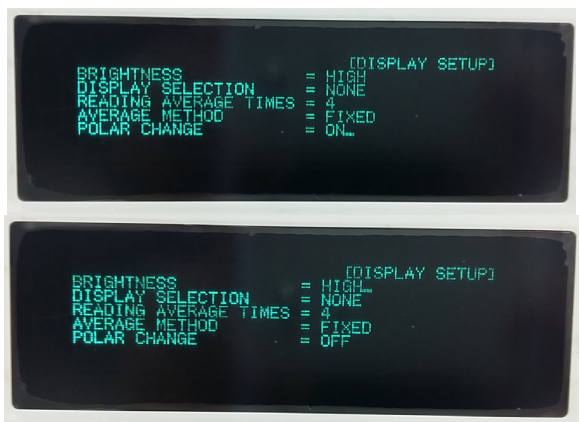

Figure 4: Local control panel (Polar change ON and OFF).

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EXPERIMENTAL RESULTS OF THE POLARITY REVESAL DEVICE

Experimental current waveforms are presented in this section. The stability of the current is very important for the beam and therefore the Model 62075H-30 DC Source must be high precision supplies and constant output current during an 8 hour period through the polarity reversal device to magnet loading. A remote control function can capture the full power positive/negative current stability on the magnet load. A long term stability of the DC power supply of ±100 ppm is required. For measuring instruments we use the HP 34410 8.5 digit multi-meter and LEM IT 600-S Ultrastab DCCT. Figure 5(a) is an output current waveform when the polarity reversal device is in the OFF state and the output current is within ±0.005A or within ±20 ppm. Figure 5(b) is the output current waveform when the polarity reversal device is in the ON state and the output current is within ±0.00375A or within ±15 ppm. The long term stability of the main power supply is better than the specified ±100 ppm range.

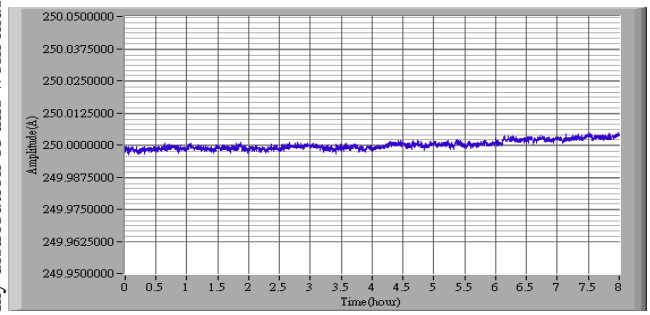

Figure 5(a): Output current waveform of the polarity reversal device when the polar switch is in the OFF state.

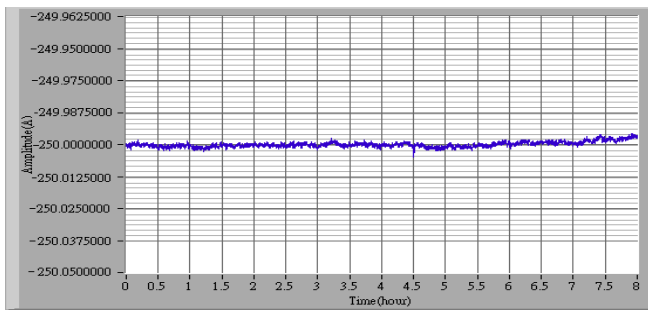

Figure 5(b): Output current waveform of the polarity reversal device when the polar switch is in the ON state.

CONCLUSION

Low alpha operations of the TPS storage ring have been commissioned recently and further developments are still ongoing [2]. With the polarity reversal device, the desired output current of the sextupole magnet power supplies can be quickly reversed, and the current stability meets the requirements of high-spec experimentation. This project cooperates with other subsystems of the NSRRC center. The remote control allows the operator to operate the machine easily while local control can be started when, for example, an abnormality of the network system occurs and the system manager directly introduces the command code to the machine to meet specific requirements for various beam conditions.

ACKNOWLEDGMENTS

The authors also gratefully acknowledge helpful comments and suggestions from colleagues, which has improved the presentation.

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