PHASE SHIFTER POWER SUPPLY DESIGN

Yi-Ta Li*, Bao-Sheng Wang, Kuo-Bin Liu, Yong Seng Wong, NSRRC, Hsinchu, Taiwan

Abstract

Taiwan Photon Source is an interdisciplinary project. The phase-shift magnet is used to connect the radiation phase between two EPU48s. The power supply for this phase-shift magnet is a key element to determine the phase shift quality.

In this report, the theory of the designed circuit is firstly introduced, and then a comparison simulation result and actual measurement is summarized to prove the correctness of theoretical analysis and circuit design.

INTRODUCTION

Taiwan Photon Source interdisciplinary laboratory facilities construction plan, the phase-shift magnet will be installed in Double mini Beta 12m straight line segments used to connect the radiation phase between the two EPU48s [1].

The phase shift magnet architecture as shown in Figure 1, the ratio of the magnetic field is 1:2:1. The electron beam apply that through the phase shift magnet the route is bend, rather than a straight forward and thus change the wavelength of the photon.

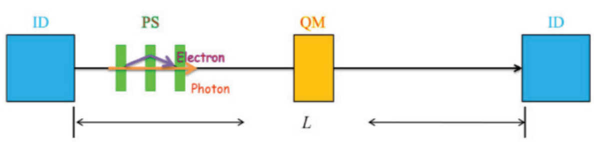

Figure 1: The photons and electrons moved schematic of between two ID.

The phase shift magnets control ways is different from the single coil magnets, so the power supplies architecture is different. In the phase shift magnet power supplies design, need to be considered many factors to avoid damage to the power supplies or phase shift magnets.

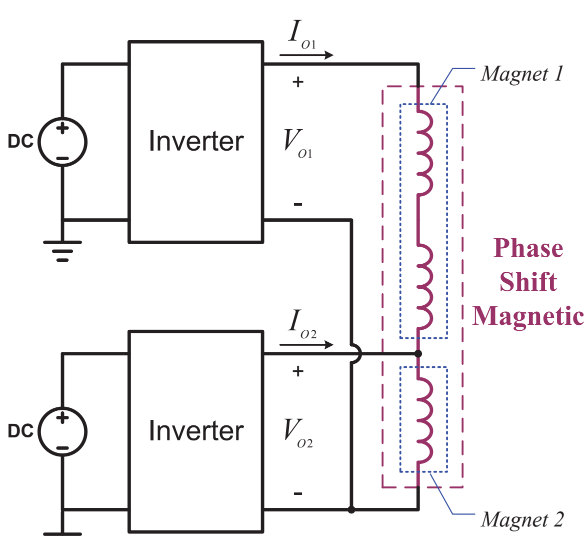

Figure 2: The power system architecture.

CONTROL SYSTEM

The power supply system architecture is shown in figure 2. The phase shift magnet is divided into two groups of magnet: the magnet 1 and the magnet 2. It's in order to facilitate the design and to simplify the complicated mathematical calculations. The power supply output equations are calculated as shown in equation 1 and 2.

$$I_{O1} = (V_{O1} - V_{O2}) / Magnet1 \tag{1}$$

$$I_{O1} + I_{O2} = (V_{O2}) / Magnet2 \tag{2}$$

The magnet consists of two groups of current source power supplies controlled. The power system architecture diagram can be converted into the load control system block diagram by calculated. The load control system block diagram is shown in Figure 3. The load control system block diagram can be easily design and planning in control system [2-3].

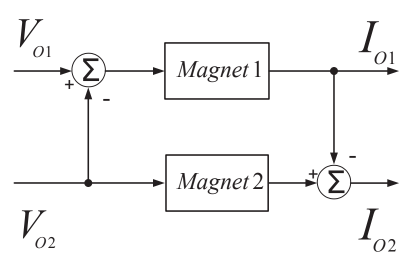

Figure 3: The block diagram of control system in the magnet load.

Because the standard of the output current within ±10(A) and the output voltage within ±48(V), so the power stage must use H-Bridge architecture. Power supply module has the first quadrant and the third quadrant output characteristics. The block diagram of control system is shown in Figure 4. Use the compensator (G_c) to control the output current. The control method is use the negative feedback control system. The H-Bridge output load circuit is shown in Figure 5. The "L_f" and "C_f" are filter devices that in order to filtered the switching frequency. The "r_L" and "r_C" are Equivalent Series Resistance (ESR).

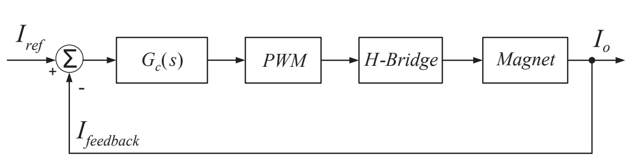

Figure 4: The block diagram of control system.

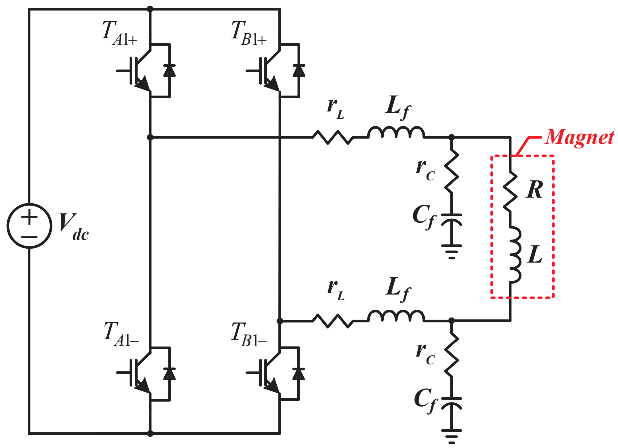

Figure 4: Output load circuit.

SIMULATION AND EXPERIMENTAL ANALYSIS

Actual test magnet device arrangement as shown in Fig. 5, the electron generated photon by through the ID, then corrected the route by the correct magnet, and then adjusted the length of electron orbit by the phase-shift magnet. Electrons into the quadrupole magnets focused, then corrected the route by the correct magnet, and then into the next ID to generated the photons that have the time difference and the same wavelength.

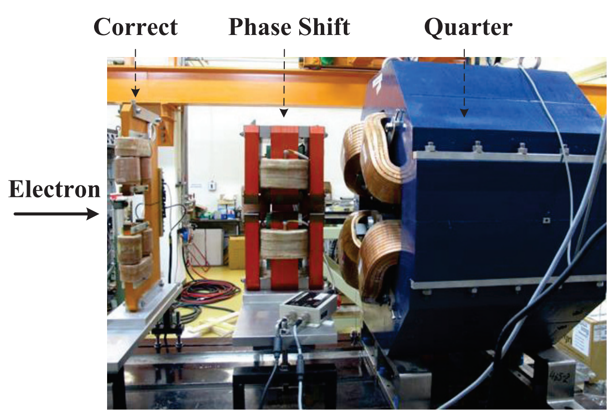

Figure 5: The actual test situation.

In the simulation and actual test, set the module 1 output current maintained at 1(A) and changed the module 2 output current from 0(A) to 1(A). Observe the two module power supply output current waveforms are working properly. From simulation waveform (see Fig. 6) can be observed when the module 2 output current changed, this moment will affect the output current of the module 1 is about 0.1(A). The actual output waveforms are shown in Fig. 7. In the actual output waveforms and simulation waveforms comparison, can observe the actual output waveforms and the simulation waveforms are very similar. When the module 2 output current changed in simulator or actual situation, will affect the output current of the module 1 and the both output current change value within about 0.1(A).

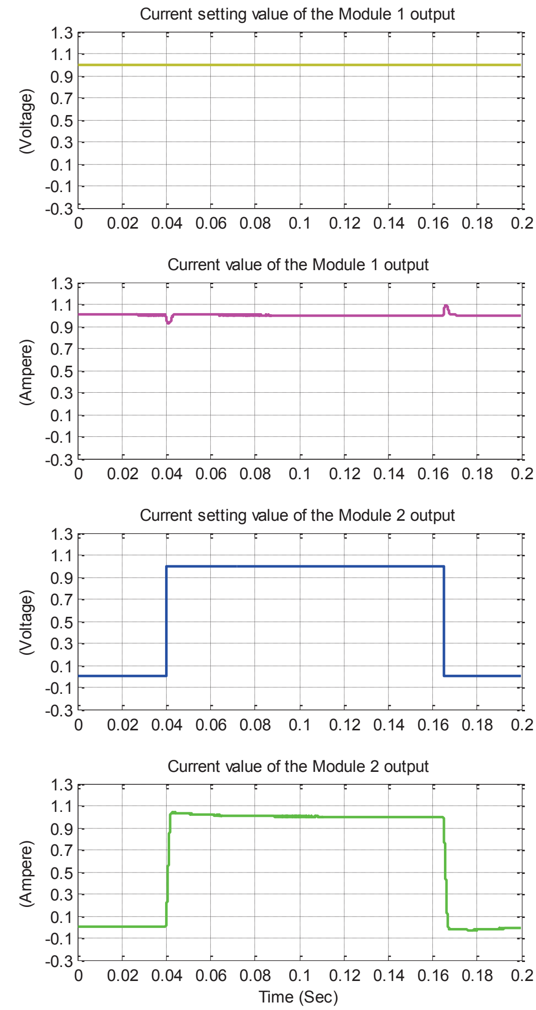

Figure 6: Simulation the module 1 output current maintained at 1(A) and changed the module 2 output.

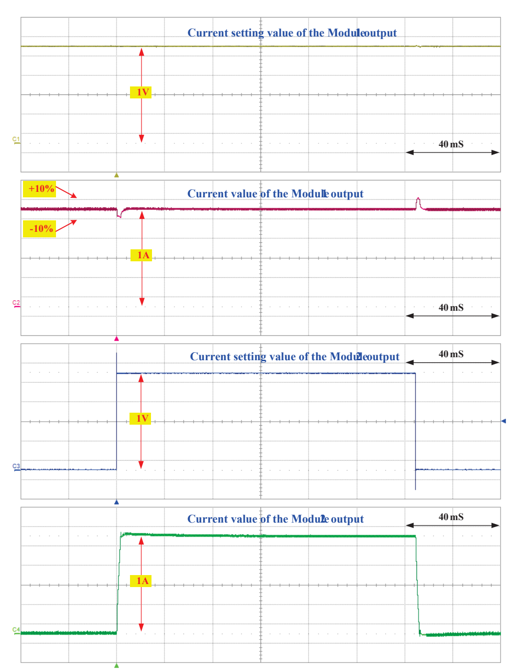

Figure 7: The actual measured value.

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In the simulation and actual test, set the module 2 output current maintained at 1(A) and changed the module 1 output current from 0(A) to 1(A). Observe the two module power supply output current waveforms are working properly. From simulation waveform (see Fig. 8) can be observed when the module 1 output current changed, this moment will affect the output current of the module 2 is about 0.01(A). The actual output waveforms are shown in Fig. 9. In the actual output waveforms and simulation waveforms comparison, can observe the actual output waveforms and the simulation waveforms are very similar. When the module 1 output current changed in simulator or actual situation, will affect the output current of the module 2 and the both output current change value within about 0.01(A).

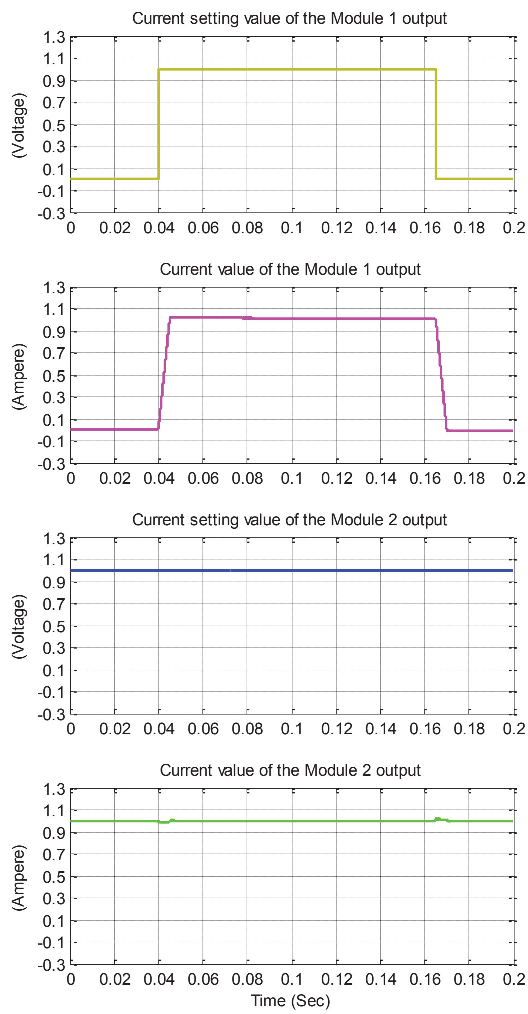

Figure 8: Simulation the module 2 output current maintained at 1(A) and changed the module 1 output.

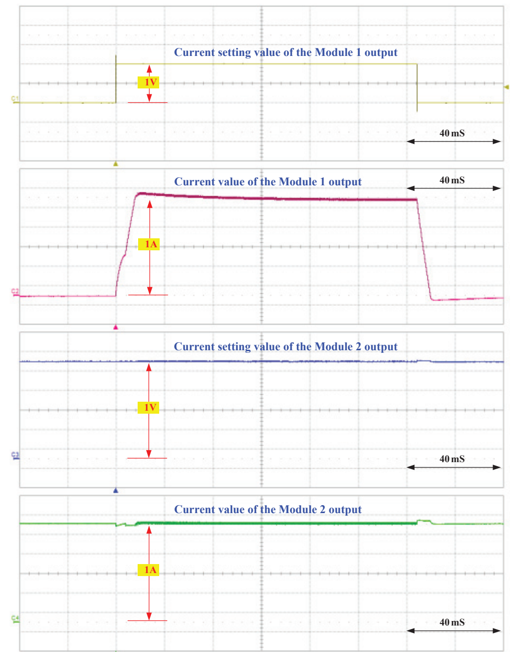

Figure 9: The actual measured value.

CONCLUSION AND RECOMMENDATIONS

Proved the feasibility of this design method by the mathematical derivation and simulate. In the simulation and actual measurement waveforms, the theoretical analysis and the actual test results are very similar. It can be proved that the circuit design of the theoretical derivation with the actual result is very similar.

On the simulated or actual measurement of the output current waveforms, can see that when the one module output current is constant and changed the other module output current, the module of output current is constant will generated a current pulse wave. But this issue does not affect the actual operation of the phase shift magnet, so this is an acceptable small problem.

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