A DESIGN OF SWITCH MAGNET POWER SUPPLY

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Abstract

The paper introduces a design of power supply for switch magnet in HIRFL. The main circuit topology used Buck chopper regulator, full-bridge inverter output and power units in parallel in the power supply is introduced. The operation principle and control strategy is analyzed in this article. The power supply can be operated in DC and pulse mode, has the very good output current long-term stability, high reliability and dynamic response characteristics. Finally, some experimental data and waveforms of the power supply are shown to demonstrate the performance of the design.

SUMMARY

With construction of CSR and acceleration of proton at HIRFL, the existing beam handling system can not meet the requirements of nuclear physics experiments for more and more beam time. In order to match a new beam distribution system based on time is being constructed in HIRFL, a new switching magnet power supply is designed. Whether there is beam in CSR or not, the new beam distribution system can use the beams from SFC and SSC at the same time to do physics experiments at experimental terminals.

POWER SUPPLY PARAMETERS

- ✓ Maximum Output current: ±1050A
- ✓ Operation mode: DC/Pulse
- ✓ Maximum rise speed: (0-±1050A) /0.15s
- ✓ Maximum fall speed: 0.15s (±1050A-0)/0.15s
- ✓ Output current flat top time: 0.5s to DC
- ✓ Current stability: $<2\times10^{-4}$/8hour (±400-±1050A)
- ✓ Current ripple: $< 2\times10^{-4}$ (±400A-±1050A under 1kHz)
- ✓ Current repeat error: $<2\times10^{-4}$ (±400-±1050A)
- ✓ Current error: 0.1A
- ✓ Load parameters: Resistance: 28.2mohm, Inductance:18.7mH

The waveform of simulation work in pulse mode is shown below, the first picture shows the current waveform, and the next picture shows the voltage waveform.

MAIN CIRCUIT STRUCTURE

Main circuit structure is shown in Figure 2. The bus voltage is 200V after the diode rectifier and the bus voltage is 50V after the buck chopper. In process of rise and fall of the current, the buck chopper does not work and the bus bar voltage holds 200V so as to ensure the current change rate sufficient. When it works in a stable state, the bus bar voltage controlled by the buck chopper maintains at 50V to ensure that the duty cycle is reasonable.

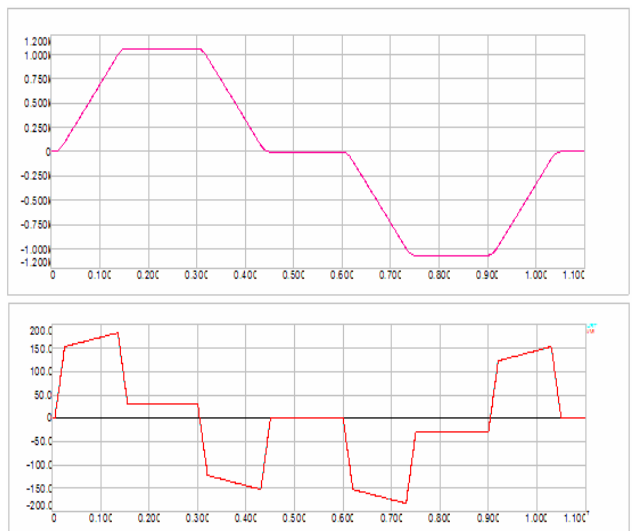

Figure 1.Waveform of power supply in pulse mode

In the power cabinet it has an input rectifier transformer and two power units, and in the control cabinet it has the control circuit for the power supply, the input and output power distribution and output filter circuit. The power supply is operated by PLC control, and displayed by a

5.5-inch touch screen. Figure2. is the main circuit structure

WORKING PRINCIPLE

The power supply system is composed of 3 parts, including input phase-shifting transformer, buck chopper regulator, and full-bridge inverter. The device from the AC network side is equivalent to 12 pulses rectifier to reduce the harmonic pollution on the grid. The power supply uses two power units in parallel as output mode.

The power supply control strategy is the outer ring current stabling flow mode and the inner current sharing mode.

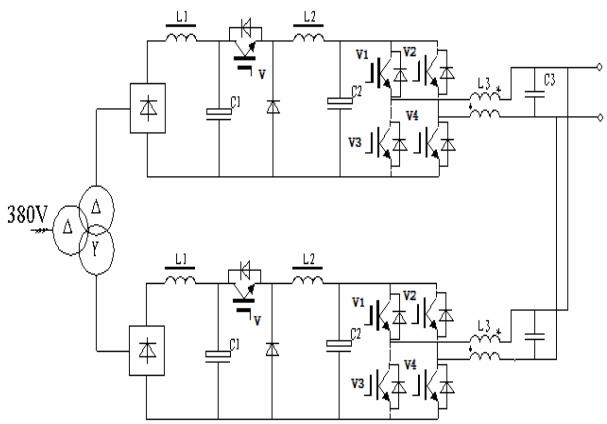

Figure 2.Main circuit structure

Buck Chopper

As the power supply works in the DC / pulse mode, it is necessary to ensure a high stability in DC mode and meet the sufficient current change rate in pulse mode. According to the load parameters, the formula: $V_0 = I_0R + L(di/dt)$, the maximum load voltage is 160.5V in pulse mode. In DC operation, the bus bar voltage controlled by the buck chopper maintains at 50V to ensure that the duty cycle is reasonable and the output current is stability. In pulse mode, the buck chopper does not work; the bus bar voltage keeps 200V to ensure the enough voltage when the current is rising.

Full-bridge Inverter

Power supply uses the full-bridge inverter output in parallel structures to improve the running reliability of power supply. Full-bridge inverter can asily meet the needs of four-quadrant operation, meanwhile it also achieves steeples output change to achieve positive and negative current output. Under controlled by the driving pulse, when the output of the power supply is positive, V1 and V4 conduct. When the output of the power supply is negative, V2 and V3 conduct. The full-bridge in parallel works in staggered phase mode.

IGBT driver use 2SD315A and PWM driver pulses transmit with the optical fiber, which make the control circuit and power circuits completely isolated.

CONCLUSION

After the switching magnet power supply put into operation, we measured the main parameters of the power supply. The output current stability is better than 2.5×10^{-5}, and the output current in pulse mode reaches the design specifications, and meet the requirements for the beam distribution system based on time. Figure 3 shows the waveform of output current 1000A rise. The waveform of power supply in pulse mode is shown in Figure 4.

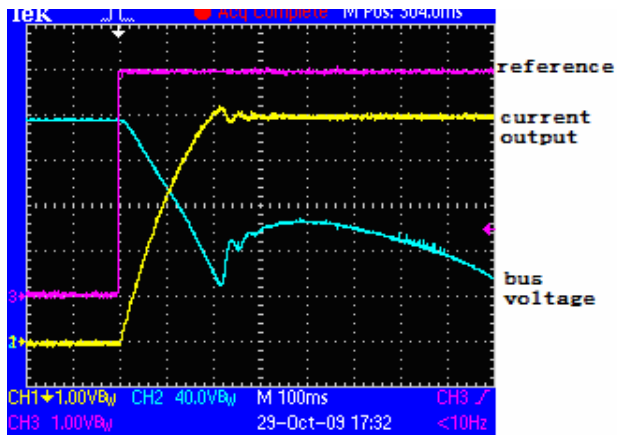

Figure3.The waveform of output current 1000A rise

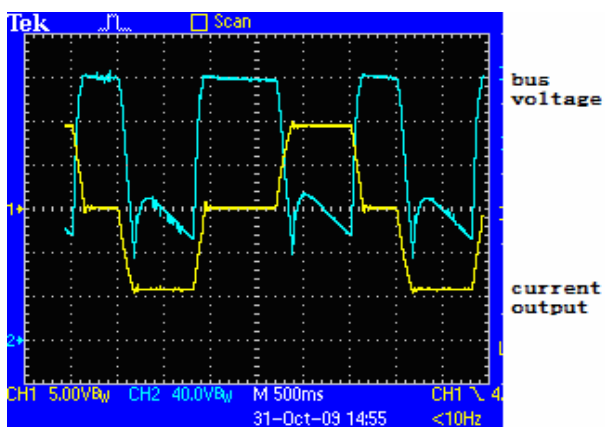

Figure 4 .Waveform of output in pulse mode.

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