DESIGN AND IMPLEMENTATION OF THE WHITE CIRCUIT BYPASS CAPACITOR PROTECTION SYSTEM

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Abstract

To meet high performance 1.5GeV injection requirement, the white circuit system of the booster synchrotron in SRRC must be working in accordance with the 1.5GeV injection current state. If the booster operation current of the white circuit system deviates from the normal working point too much, the injection efficiency will be deteriorated and the white circuit bypass capacitor will be damaged. A protection system of the booster white circuit bypass capacitor dynamic current and voltage must be monitored and detected to prevent this capacitor from being damaged. The new white circuit bypass capacitor protection system was designed to detect the bypass capacitors dynamic characteristic. The interlock protection is active when the bypass capacitors work in over current or voltage reverse state, and afterward the white circuit bypass capacitor protection function is achieved. Results and working function will be presented in this paper.

1 INTRODUCTION

The white circuit system is required for the booster synchrotron in SRRC. It is capable of accelerating the beam energy of the booster ring from 50MeV to 1.5GeV. In the process, the operating current $\boldsymbol{I_m}$ flowing through the while circuit system is

$$I_m = I_{DC} - I_{AC} * \cos(\omega t)$$

When there is machinery operation malfunction or breakdown, the current I_{AC} of the AC power supply would be larger than the current I_{DC} of the DC power supply, the bypass capacitor will work in over current or voltage reverse state. With a high capacitance of the bypass capacitor, when using an electrolyte capacitor which is polarized, the capacitor will be damaged or detonated when an opposite polarity or over current situation occurs. To protect the capacitors, a white circuit bypass capacitor protection system is required. It is designed to turn on the interlock system to cut-off the related power supply when an error condition is detected. The white circuit bypass capacitor protection system is a safety detection system designed to ensure that the white circuit of the booster ring operates in a safe correct state.

2 DESIGN PRINCIPLE

To observe the dynamic characteristic of the white circuit bypass capacitor operated in a normal state, the dynamic current is shown in Figure 1. On the basis of these values, the setting of the working point in the circuit design may be switched and calculated.

When the booster operation current of the white circuit system is deviated from the working point, it reveals that a system error is detected. The circuit will generate a interlock signal immediately to turn off the AC power supply of the booster ring. The white circuit system will stop working simultaneously to achieve the major function of protecting the bypass capacitors.

The related circuit block diagram is shown in Figure 2.

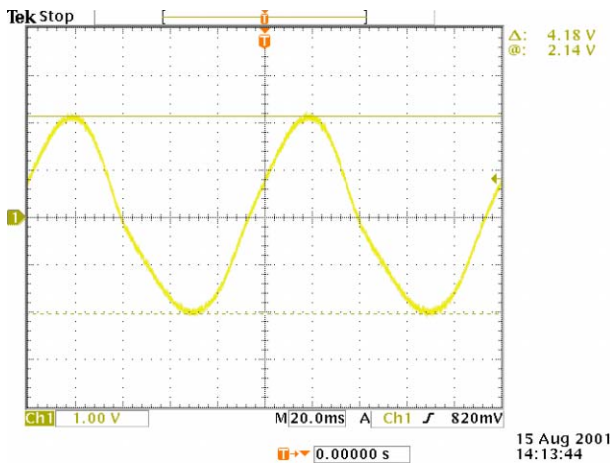

Figure 1. White Circuit Bypass Capacitor Current (Dipole)
Current sensor output: 20Amp. /V

In figure 2. C3 is the while circuit bypass capacitor we are going to protect. The DCCT installed across the C3 capacitor is a Hall current sensor to detect if any over current flows though the C3 bypass capacitor. Diode D1 and R1 from a voltage detector to detect if there is voltage reverse across the C3 bypass capacitor. Whenever there is a over current or voltage reverse; the protection circuit will signal an abnormal condition and at the same time turn off the AC power supplies and halt the booster operation.

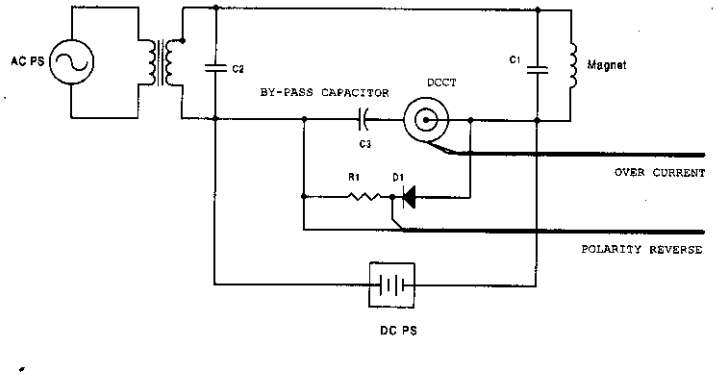

Figure 2. The white circuit bypass capacitor protection system block diagram

3 TESTING RESULT

After finishing the overall circuit design, the white circuit bypass capacitor protection system prototype was built and installed into the booster ring's system to test the performance. The interlock signal is incorporated in the operation system, as shown in Figure 3. To verify if the protection system works, an abnormal signal is shown in the booster ring when an error of the system is functioned. As shown in Figure 3, it works just as what we expect.

Figure 3. Operation manu show the interlock of the white circuit bypass capacitor protection system

The white circuit bypass capacitor protection system circuit board is implement and illustrated in Figure 4.

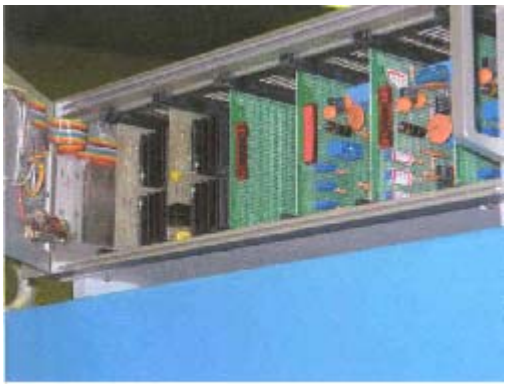

Figure 4: The white circuit bypass capacitor protection system circuit board

The Internal arrangement of the white circuit bypass capacitor protection system is in Figure 5.

Figure 5: Internal arrangement of the white circuit bypass capacitor protection system

When the booster operation current of the white circuit system is deviated from the working point, it reveals that a system error is detected. The circuit will generate the interlock signal immediately to turn off the

AC power supply of the booster ring. The white circuit system will stop working simultaneously to achieve the major function of protecting the bypass capacitors. To detect the malfunction situation, the main protection system has to be installed inside the booster ring, thus it is very difficult to reset the error signal by the operator So we design a remote control box for the white circuit bypass capacitor protection system, too. The remote control box of the white circuit bypass capacitor protection system is put on booster power supply area. It is very easy for the operator to observe the operating status and reset the error signal. Besides, we can very easy remove the interlock signal when the white circuit bypass capacitor protection system is damaged.

The main control system and remote control system of the white circuit bypass capacitor protection system of the final protection system are illustrated in Figure 6 and Figure 7 respectively.

Figure 6: Picture of the white circuit bypass capacitor protection system (main control box)

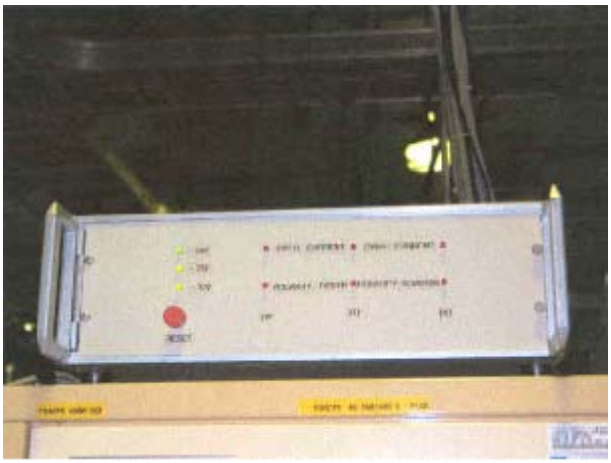

Figure 7: Picture of the white circuit bypass capacitor protection system (remote control box)

4 CONCLUSION

In this paper, a protection system of the booster white circuit bypass capacitor is built. The new white circuit bypass capacitor protection system is used to detect over current and voltage reverse situation. When these situations occur, the interlock protection will be active to protect the white circuit bypass capacitor from being damaged.

To protect the Dipole Magnet system, the Focusing Quadrupole Magnet system, and the Defocusing Quadrupole Magnet system individually also, three sets of the white circuit by pass capacitor protection systems are designed for three distinct working operation points. A complete integrated protection system is built and installed in the booster ring system. The protection function is fully developed and well performed.

5 REFERENCES

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