MAGNET POWER SUPPLY WITH POWER FLUCTUATION COMPENSATING FUNCTION FOR HIGH INTENSITY SYNCROTRON

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Abstract

A new power supply for high intensity syncrotron using IGBTs and a superconducting magnet is proposed. The power supply can absorb the fluctuation of active and reactive power caused by charging and discharging the syncrotron magnet. The system is composed of three-level ac/dc converter, chopper circuits and superconducting magnet. The chopper circuit for superconducting magnet and syncrotron magnet can be connected to the same dc bus of the power supply and this feature can reduce the power rating of ac/dc converters.

1 INTRODUCTION

The power supply for high intensity syncrotron magnet draws larger amount of power from utility network. For example, the JHF 50-GeV main ring, which consists of 96 bending magnets, 176 quadrupole magnets, 48 sixtupole magnets and 176 steering magnets will require 135MW of total active power and 37MW of dissipation power by estimation[1]. Moreover, the charging and discharging cycle is repeated with 3.42s of the cycle time at the initial operation, and the repeating frequency will be raised up by twice in future.

Taking this situation into consideration, energy storage system using adjustable speed type flywheel and IGBT power converter are studied in the JHF project[1],[2]. In this paper, the power supply using a Superconducting Magnetic Energy Storage (SMES) is proposed. Features of the system are as follows:

1) It is possible to compensate the fluctuation of active and reactive power and to reduce the influence to utility power network due to the operation of accelerator,

2) The superconducting magnet and syncrotron magnet can be connected to the same dc bus of the power supply and this feature can reduce the power rating of ac/dc converters because the fluctuation of power is compensated at dc side.

3) The system does not have large rotating parts which is seen in flywheel system.

The configuration of the main and control circuit, and simulation results are presented.

2 CONFIGURATION OF THE SYSTEM

2.1 Main Circuit

Fig.1 shows the configuration of the proposed circuit. Taking the maximum voltage applied to the Bending magnet into consideration, The V_d=32kV was chosen and three-level circuit was chosen. As for the SMES, the magnet is divided into two magnets considering the insulation voltage of the superconducting magnet. The voltage rating of IGBT is 4.5kV at present, so 8 IGBTs will be connected in series taking the margin into consideration.

By using this configuration, the power rating of ac/dc converter can be reduced, because fluctuation of the power is compensated at the dc side between choppers.

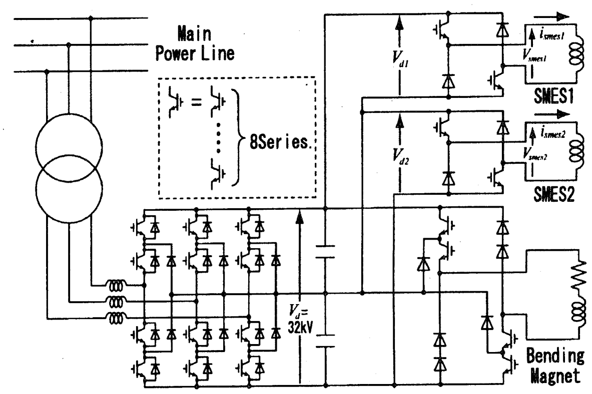

Figure 1: Configuration of the Main Circuit.

2.2 Control System

Fig.2 shows configuration of the control system. The power fluctuation is detected by using moving average method because the operating cycle is previously known and the fluctuation of the power can be detected effectively with this method. The duty factor of two choppers for SMES can be calculated as shown in Fig.2.

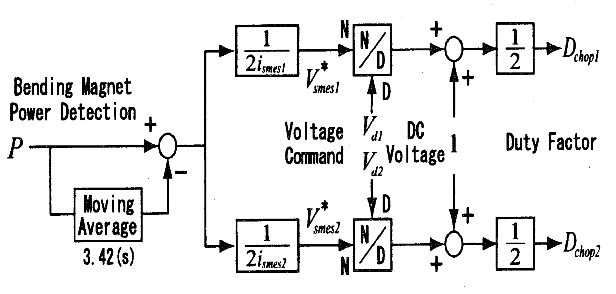

Figure 2: Configuration of the Control System.

3 SIMULATION RESULTS

Compensation of fluctuation of active power of bending magnet was simulated. Fig.3 shows the charging and discharging pattern of the bending magnet of JHF 50-GeV main ring and applied voltage of the magnet.

Simulation results of the proposed system is shown in Fig.4, which was obtained by using the PSCAD/EMTDC software. The fluctuation of the output power of the bending magnet is successfully compensated by the SMES and the power of the source side is constant. Reactive power which is not shown in the figure can be controlled at zero or any value by using the ac/dc converter. The SMES installed at the bending magnet power supply can not only compensate the power fluctuation of bending magnet but also the power fluctuation of other magnets such as quadrupole magnets.

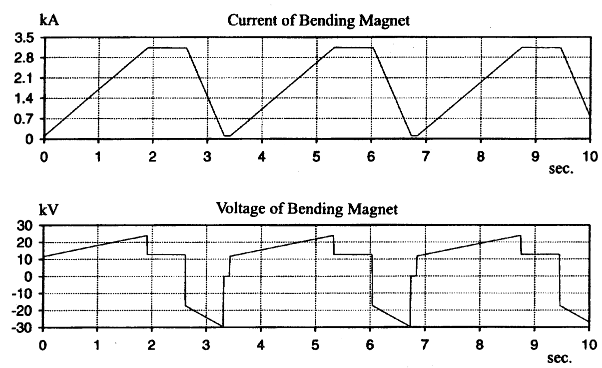

Figure 3: Current and Voltage Waveform of the Bending Magnet.

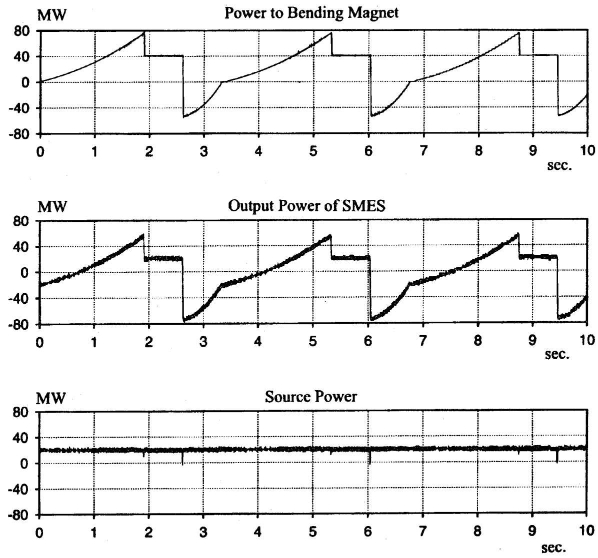

Figure 4: Simulation Result of Power Compensation.

4 CONCLUDING REMARKS

The new power supply for high intensity syncrotron using IGBT converters and Superconducting Magnetic Energy Storage (SMES) was proposed and simulation results for of JHF 50-GeV main ring was presented. It can compensate fluctuation of power of bending magnet at the dc side of the power source. The power rating of ac/dc converter can be reduced due to compensation at dc side, and reactive power can be controlled at zero or any value. The system does not have large rotating parts which is seen in flywheel system.

Further simulation study such as compensation of power of quadrupole magnets will be carried out.

REFERENCES

[1] M.Muto, Y.Mori, K.Niki, H.Sato, T.Kubo, and Y.Kanai "On the Power Supply System of the JHF 50-GeV Main Ring Magnets", KEK Report 98-14, February, 1999.

[2]M.Muto, Y.Mori, K.Niki, S.Koseki, H.Kubo, M.Toriyama "Highly-Performed Power Supply Using IGBT for Syncrotron Magnets", Contributed to PAC99.