§9. Feasibility Study on Series Compensated Thyristor Converters for Superconducting Magnets

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Thyristor converters are very promising as a large current power conditioning system for superconducting magnets. However, the traditional thyristor converters operate with a lagging power factor on the ac side requiring large reactive power compensation efforts. The objective of this work is to discuss the feasibility of the series compensation of thyristor converters using variable series capacitors[1]. The series capacitors can control the magnet voltage through a unity power factor thyristor converter with a resulting leading power factor seen from the grid. Therefore, combined with the traditional thyristor converter, the combined converter system enables the magnet voltage control with a unity power factor. Additionally, by the effect of the leading and lagging current combinations, the combined converter system may also reduce the harmonic currents.

Fig. 1 shows the simulation circuit of the combined thyristor converter system in order to evaluate the reduction of harmonic currents. The combined thyristor converter system is composed of the 12-pulse converter system. Fig. 2 shows the simulation waveforms when the firing angle of the pure thyristor bank and the leading angle of the series compensated thyristor bank are selected to 7.5 deg., respectively. In this case, the ac current of each branch has 30 deg. of the phase difference. Therefore the total current waveform through the grid becomes the similar current waveform of the 24-pulse pure thyristor converter even when the actual thyristor converter system consists of the 12-pulse configuration[2]. This result verifies that the combined thyristor converter system can be expected to reduce the harmonic currents

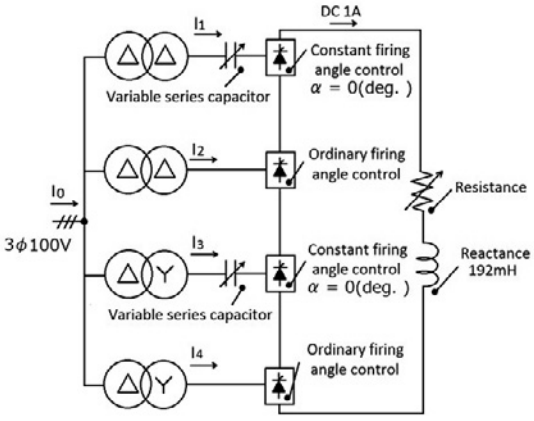

Fig. 1: Simulation circuit of the 12-pulse thyristor bank based on the combined thyristor converter system.

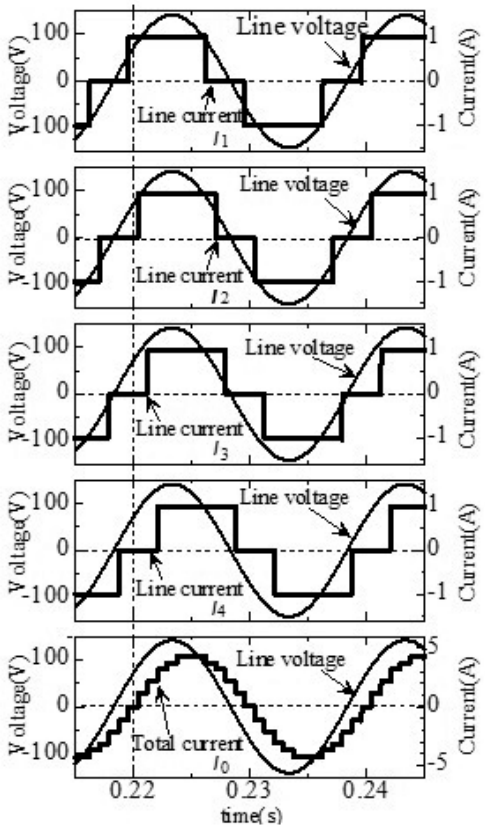

Fig. 2: Simulation waveforms of the 12-pulse combined thyristor converter system. The current of each branch corresponds to the current indicated in Fig. 1.

by selecting an optimal combination of the firing angle of the pure thyristor bank and the leading angle of the series compensated thyristor bank. Instead of the unity power factor thyristor converter in the series compensation, the leading power control capability and the harmonic current reduction of the 12-pulse diode rectifier is also experimentally evaluated by using gate-commuted series capacitors[3].

1) S. Nomura, J. A. Wiik, "Feasibility study on current source conversion for superconducting magnets using series compensated thyristor converters," IEEE Trans. Appl. Supercond., vol. 22, no. 3, 5400804 (2012).

2) D. Saito, S. Nomura, "Power factor improvement and harmonic current reduction of thyristor converters using series capacitors," 2012 IEE-Japan Industry Applications Society Conference, Y30 (in Japanese).

3) I. Matsumoto, S. Nomura, "Leading power factor control and AC current waveform improvement of multiplex diode rectifiers using gate-commuted series capacitors," 2012 IEE-Japan Industry Applications Society Conference, Y31 (in Japanese).