§13. Parallel Connected DC Active Filter

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For fusion plasma requires high current control accuracy to the power supplies exciting the magnets. At the same time, superconducting coil management system requires the low output voltage noise of power supplies for diagnostics and fault detection. The parallel connected dc active filter gives a solution of ripple reduction, for the large current dc power system.

Figure 1 shows a conceptual diagram of presented dc active filter connected to a main thyristor rectifier in parallel. In this figure, a current source IGBT PWM converter sinks ripple component i_r of output current of thyristor rectifier through a filter reactor L_{f1}. As a result, this reactor generates counter ripple voltage $L_{f1}\frac{di_r}{dt}$ and it cleans dc voltage supplied to superconducting magnets.

This parallel type active filter has following merit compared with the series type filter when it is applied to a low voltage and large current rectifier. (a) Capacity of active filter becomes very small compared with the main rectifier show in following. (b) Capacitance of passive filter can be reduced and response of power supply becomes well. (c) Controllability in small output current becomes well because dc circulation current through main rectifier and active filter keeps the minimum operation current of thyristor operation. (d) Active filter can work as a fine current controller for load current. (e) Easy to append to the power system.

For this filter, the necessary capacity for active filter is estimated from following requirements. (1) Rated voltage of filter must be lager than main rectifier. (2) Rated current must be lager than twice of maximum current ripple i_{rp}. The peak current i_{rp} for 12 phases rectifier is estimated as

$$i_{rp} = \frac{0.034}{2\omega L_{f1}} V_p,$$

where L_{f1} is a series inductance of rectifier, V_p is peak voltage and ω is source frequency.

As a result, the ratio of filter capacity Q_f and rectifier capacity Q_r becomes as follows,

$$\frac{Q_f}{Q_r} = \frac{2i_{rp}}{I_{on}} = \frac{0.034}{\omega L_{f1}} \frac{V_p}{I_{on}}$$

where I_{on} is rating output current of rectifier. A series reactor in active filter L_{f2} must satisfy following equation,

$$L_{f2} < \frac{1}{sin\frac{\pi}{12}} L_{f1} = 3.8 L_{f1}$$

The specifications for an active filter for a dc power supply for OV coil in second plasma phase of LHD is show in table 1. As shown in the table, the necessary capacity of active filter is about 1% of main rectifier and it is enough small.

Figure 2 displays a case that uses an parallel connected dc active filter. In this simulation, the active filter operates with switching frequency of 10 kHz. This figure shows that the ripple current generated by rectifier is compensated by an active filter and output voltage ripple suppressed to less than 0.3V.

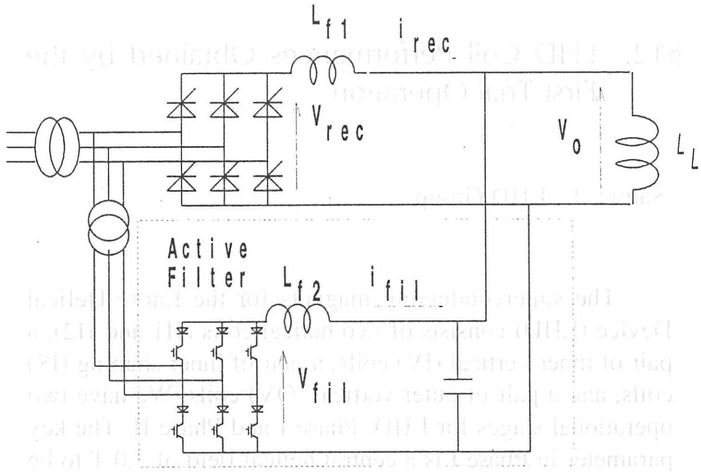

Fig. 1. Conceptual Diagram of Parallel type Active DC Filter.

Tab. 1. Ratings of Active Filter and Rectifier for OV Coil

	Main Rectifier	Active Filter
Output Voltage	33 V	33 V
Output Current	31.3 kA	320 A
Capacity	1.03 MVA	10.6 kVA
Q_f/Q_r	-	1.03%
Series Reactor	9.5 μH	36 μH
Type	12 Phase Rect.	PWM Conv.

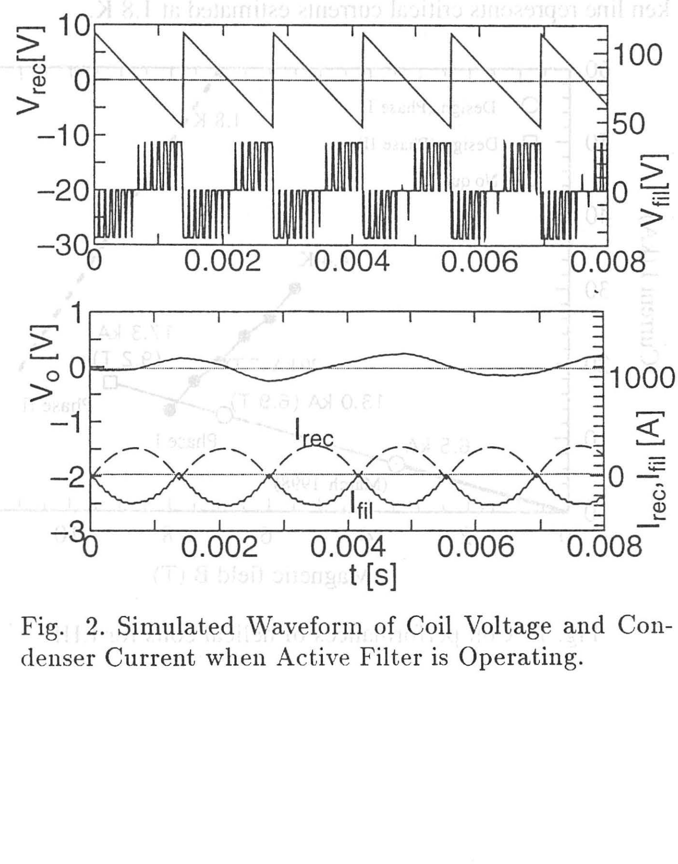

Fig. 2. Simulated Waveform of Coil Voltage and Condenser Current when Active Filter is Operating.