Verification of Regenerating and Absorbing Functions for a Ground-based Electrical Power Storage System

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Recent remarkable advances in power storage media have led to the development of new power supply systems for electric motor vehicles and for power supply backups. The electric double layer capacitor (EDLC) is an especially promising power storage medium. Its strong points include rapid charging and discharging capacity, long life, easy maintenance, low pollution and high efficiency. Ongoing developments are rapidly making it possible to increase EDLC capacity.

We have developed a ground-based power storage system that utilizes an EDLC as the storage medium. The system uses a step-up/step-down chopper unit to control the electrical charging and discharging. System configuration is shown in Fig. 1.

We installed the system at the end of a feeding circuit, as shown in Fig. 2, then carried out verification tests to ascertain how effectively the regenerated power was utilized. The tests involved charging electricity to the power storage during regenerative operation of the train, and discharging electricity from the power storage during powering of the train. The test was carried out on a 15.5 km double-track section. On this section, each trainset consists of six cars, all capable of regenerative operation. Headway is about 4 minutes during rush hour and about 7 to 10 minutes at other times. The feeding voltage is 750 V DC, and DC substations have been installed at intervals of every one or two railway stations.

Fig. 3 shows various charging characteristics (measured over a period of 2 minutes) when the power storage unit was being charged with the maximum electric current. In the third and fourth graphs, the positive currents represent charging, while the negative currents represent discharging. The following facts can be ascertained from Fig. 3:

(1) The maximum current charged to the power storage unit was 866 A.
(2) The feeding voltage at Osakako Station, while the power storage was being charged, was never higher than 860 V, suggesting that excessive voltage rises were restrained.
(3) The EDLC voltage rose from 317 V to a maximum of 430 V while the power storage was being charged. However, that maximum voltage was still lower than the rated maximum voltage (500 V), and no problems with the charging energy capacity of the power storage unit were seen.
(4) The maximum charging power of the EDLC was 637 kW and the charging energy was 4,735 kJ, both close to the maximum rated values.

The verification tests confirmed that our power storage system can greatly improve energy recovery rates. (Without the power storage system, only a fraction of the energy regenerated by the train while braking just before stopping at station can be supplied to a remote load.) The tests also confirmed that charging of the power storage system with regenerated power restrained the rise in feeding voltage at station by tens of volts, on average.

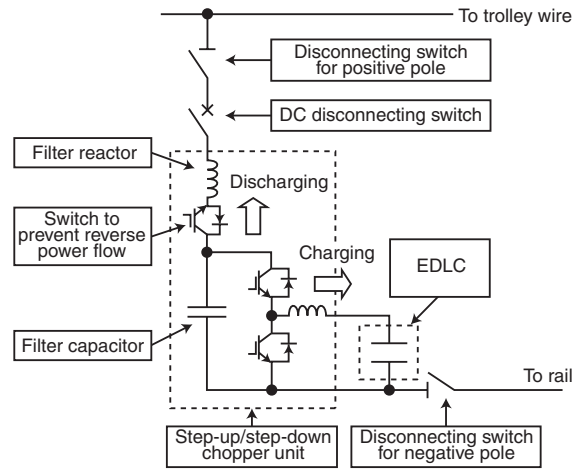

Figure 1. Power storage system configuration

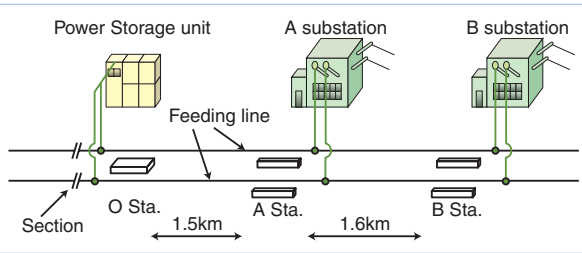

Figure 2. Test section

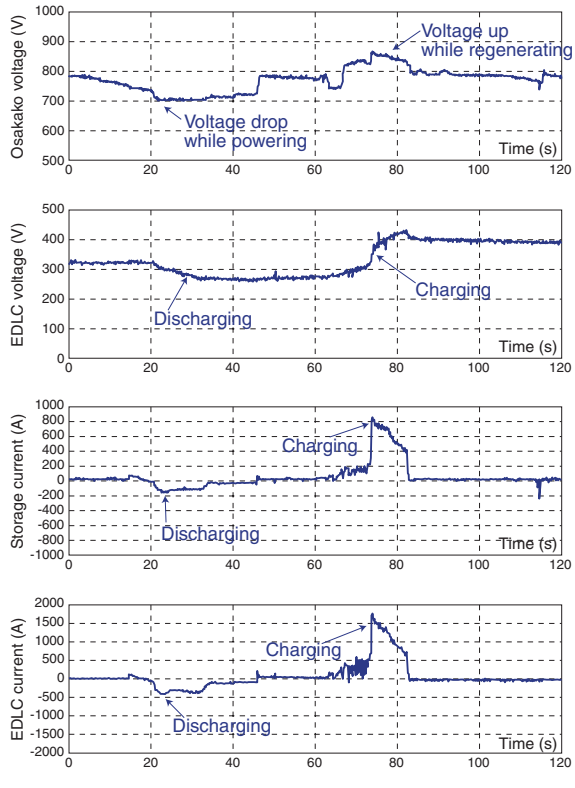

Figure 3. Charging characteristics of regenerated power