§ 3. Balance Voltage of LHD Poloidal Coils

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LHD poloidal coils have a reliable quench protection system. The system includes a quench detector as shown in Fig. 1. The induced voltage of the upper and lower coils is compensated each other for three sets of the poloidal coils. Once the potentiometer of the balance resister is adjusted, we can monitor only the balance voltage. Then any normal zone can be detected from out-of-balance voltage. However we found it difficult to adjust the balance resistor. The difference of an operation mode and a sweep rate cause off-balance voltage. The off-balance voltage induces a problem because quench detection sensitivity reduces. In this study, the cause of the off-balance voltage has been investigated.

Initial adjustment was performed in the individual operation of the IS coils. The maximum current of the IS coils was 14 kA and the ramp rate was 33 A/s. The current of the OV coils, 4.6 kA, is required for reduction of stray field. The balance voltage after the initial adjustment is shown in Fig. 2. The voltage was well-balanced. Then, the balance voltage was monitored in the normal operation (Mode #1-d-a) with the current of the helical coil, 6 kA. Figure 2 shows the balance voltage of the IS coils. The off-balance voltage of 15 mV was observed. This indicates that the upper and lower IS coils differ from each other in the mutual inductance between the IS coil itself and the other coils.

Errors of installation of the coils can cause the off-balance voltage. For instance, a vertical error of 1 mm only for the upper coil creates the off-balance voltage of 3 mV. The observed voltage of 15 mV corresponds to the error of 5 mm. However the error of 5 mm is not conceivable because the poloidal coils were installed within an error of 0.5 mm by using scribed lines.[1] We must consider another cause in parallel with the installation error. The magnetization of structures and superconductors may cause the off-balance voltage.

To investigate the cause of the off-balance, Hall probes were installed on the surface of the IS coils after the sixth experimental campaign. We then plan to measure the magnetic field accurately. The accuracy of 0.001 T is required to confirm the installation error of 5 mm. The effect of the magnetization can also be investigated by the observations of residual magnetization after operations.

Reference
1) Takahata, K: Ann. Rep. NIFS (1996-1997) 9.

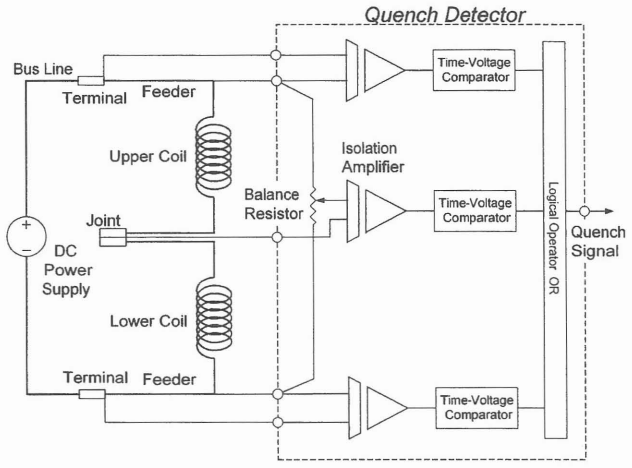

Fig. 1. Circuit diagram of the quench detector for the poloildal coils.

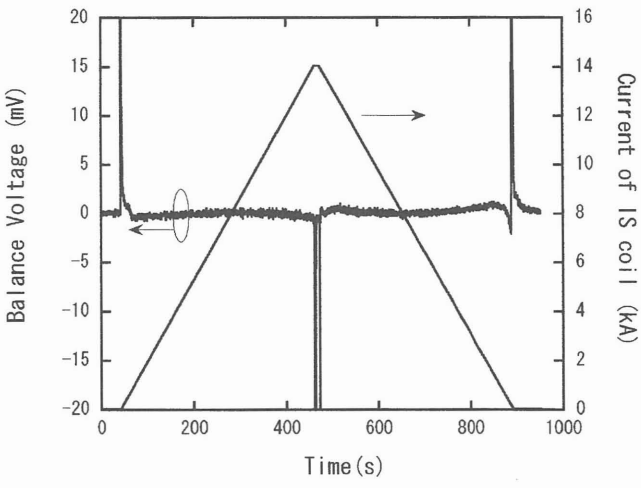

Fig. 2. Balance voltage of the IS coils in the individual operation. (IV 50 A, IS 14000 A, OV -4600 A, HC 50 A, Sweep time 420 s)

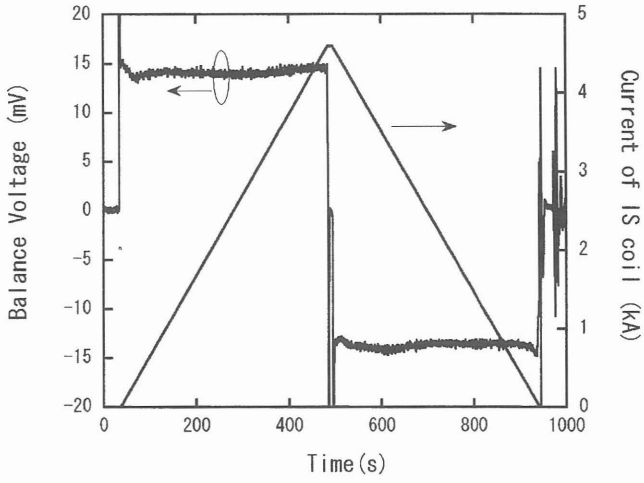

Fig. 3. Balance voltage of the IS coils in the normal operation. (Mode #1-d-a 0% 1.5 T at 3.6 m, IV 4615 A, IS 3680 A, OV -11020 A, HC 6000 A, 0.2 T/min)