§5. Development of Quench Detection System using Fuzzy Theorem

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In the LHD system, a number of superconducting coils are installed. Therefore, strong electromagnetic noises are induced by large superconducting coils each other. In such a case, the traditional quench detection system monitoring only voltage signal would not be sufficient. So, the authors proposed to apply Fuzzy theorem into the quench detection system.

For last 2 years, the authors concentrated their efforts on the quench detection of the superconducting bus-lines. As a result of the research, it is confirmed that the superconducting bus-lines are so steady for all the operational condition including the fast energy dumping. So, in FY 1999, the authors started quench detection of the superconducting coils of the LHD.

In the new quench detection system, Fuzzy theorem is applied incorporating not only the voltage signals but also other signals, e.g. the liquid He level, the liquid He inlet flow rate, the currents, etc.. The signals are digitally processed by PCs, and through some Fuzzy calculation we obtain the "dangerous rate" of the coil.

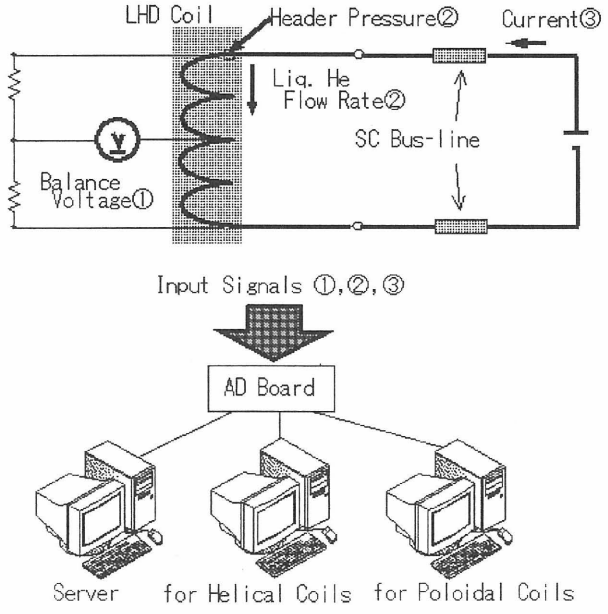

Fig.1 Schematics of Detection System

As shown in Figure 1, the balance voltage, the mass flow rate of liquid He, the header pressure of liquid He vessel, and the coil current are selected as fundamental input signals for the Fuzzy system.

The typical examples of the dangerous rates obtained by the actual excitation experiment of the Helical Coil and the Poloidal coil are shown in Figure 2 and 3, respectively. As can be seen in Figure 2, a considerable high value of the dangerous rate up to 0.7 was detected in Helical coils. Particularly, in H-I (Helical Inner) coil, the high value was recognized to continue for about 3 seconds. On the other hand, in H-M (Helical Middle) and H-O (Helical Outer) coil, the high value was observed for only less than 0.5 sec.

Meanwhile, as can be seen in Figure 3, we can understand that the dangerous rates for the Poloidal coils are relatively small. The highest value is for the OV coil is smaller than 0.3.

From these results, it would be concluded that this Fuzzy monitoring system can be used as one of the powerful supports for the quench detection of superconducting coils

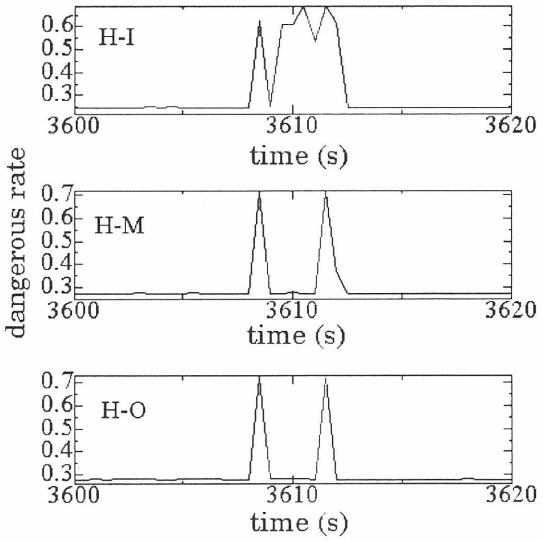

Fig. 2 Dangerous Rates of Helical Coils

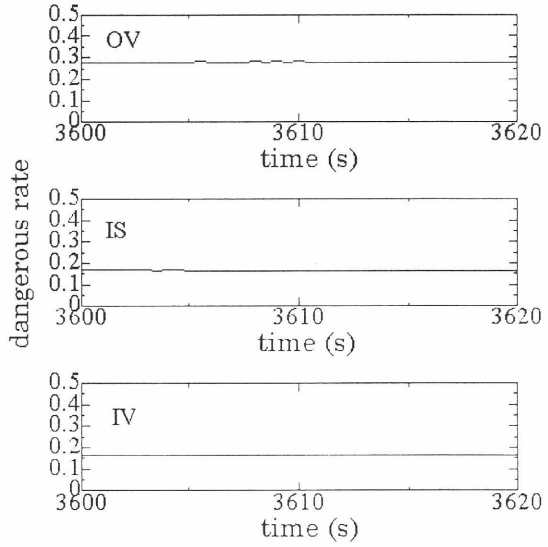

Fig. 3 Dangerous Rates of Poloidal Coils