§59. Quench Detection of Superconducting Bus-line Using Fuzzy Theorem

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In the LHD system, the superconducting coils are fed by superconducting power-leads, i.e. the superconducting bus-lines. Considering electric insulation aspects, the superconducting bus-lines don't have voltage detection leads just close to the conductor. The voltage detection leads are running along the thermal insulation pipe apart from the conductor. Therefore, we have to take into account some difficulties to detect the normal voltage of the bus-lines due to the heavy electromagnetic noises into the detection signal. In order to solve this problem, the authors proposed a detection system to cancel the voltages of the positive and the negative bus-line conductors each other. And, in this system, Fuzzy theorem is applied incorporating not only the voltage signals but also other signals, e.g. the liquid He inlet pressure, the flow rate, the currents, etc.. The signals are digitally processed by PCs, and through some Fuzzy calculation we obtain the "dangerous rate" of the bus-lines.

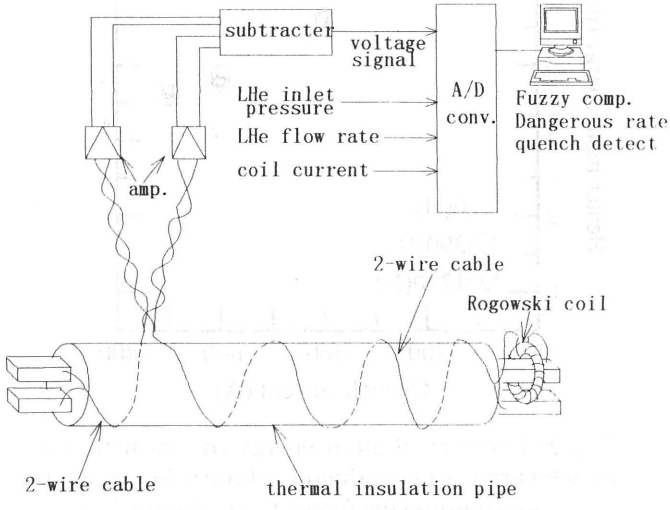

Fig. 1 Quench Detection System of SC Bus-line.

As shown in Figure 1, the voltage taps are attached on the power lead terminals both at the power supply side and the SC coil side. As for the voltage signal cable, the positive and the negative voltage signal wires are wound together tightly on the thermal insulation pipe of the bus-lines.

The preliminary experiment at Seikei University was carried out using a small experimental system. Through the experiment using this system, the fundamental principle was confirmed. The inductance of the experimental coil is 1H. We used two 0.2mm ϕ NbTi superconducting wires with length of 5m imaging the superconducting bus-lines. These wires are wound in a solenoidal coil shape with a diameter of 100mm and 60mm for the positive and negative polarity bus-line, respectively. A manganine heater is attached on the positive polarity lead wire with the length of 5cm to generate normal conducting region artificially. The experiment was carried out with the low frequency AC of 1Hz. The experimental result shows that the inductive voltage can be cancelled.

The quench detection system basing on this principle was applied to the superconducting bus-lines, and the data were collected at the first excitation experiment of the LHD. Two PCs and A/D converters were used. Signal wires were connected to A/D converter board. A quench detection experiment was carried out at the LHD site. The monitored signals are, 1) the voltage of the positive polarity bus-bar, 2) the voltage of the negative polarity bus-bar, 3) the liquid He inlet pressure, 4) the liquid He flow rate, 5) coil current. The experimental result shows that although some voltage noise with a magnitude of about 1mV was observed both in the positive and negative polarity bus-lines, by making the subtraction between these two voltages, the noise can be reduced to lower than 0.1mV. The monitored signals and the calculated "dangerous rate" are shown in Figure 2.

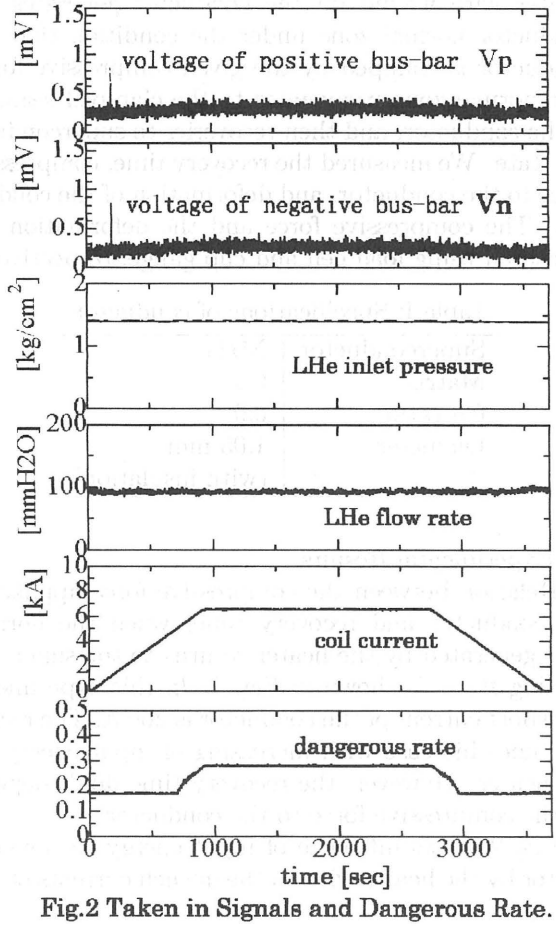

Fig.2 Taken in Signals and Dangerous Rate.