

## § 2. Pulse Height Analysis of the Spike Signals Observed on the Balance Voltage of the LHD Helical Coils

Yanagi, N., Imagawa, S.

The cryogenic stability and mechanical properties of the helical coils (HC) have been one of the most important items to be clarified in the series of excitation tests for the superconducting coil system of the Large Helical Device (LHD). For these studies, the balance voltage signals measured between the corresponding pairs of the HC blocks have been intensively analyzed. The balance voltage contains a number of spike signals during ramp-up and ramp-down processes of excitation. They might be generated by rapid changes of the self-inductances of the coil windings due to mechanical displacement (conductor motions) caused by electromagnetic force. Pulse height analysis (PHA) has been successfully applied to these signals and we found that the number of counts of spike signals obey exponential distribution functions [1, 2].

The total intensity of spike signals measured in a single excitation is an effective measure to investigate the changes of mechanical properties of the coil windings. As has been found in the former experimental cycles, it was again found in the sixth cycle that the total intensity drastically reduces from the second run with a same excitation condition as is shown in Fig. 1. This observation clearly indicates a favorable training effect of the windings. Moreover, it is observed that the total intensity obtained in the first excitation in each experimental cycle shows a continuous decrease, especially for the high-energy component. This suggests that the training effect is not fully lost after warm-up and re-cooling of the coils.

From the fifth cycle, the balance voltage has been measured using a new monitoring system with a high-frequency resolution ( $\sim 10$  kHz), in addition to the former low-frequency ( $\sim 10$  Hz) monitors. Comparing the waveforms observed by the two systems, it is found that the high-frequency measurement contains more signals than those observed by the low-frequency ones. This is due to the fact that many signals have oscillatory waveforms (frequency  $\sim 1$  kHz) and thus they are cancelled out through a low-pass filter. It was also confirmed that these oscillatory signals coincide with those observed in the balance voltage of the poloidal coils. Mechanical disturbances and subsequent vibrations of the poloidal coils might be the cause of this kind of balance voltage.

For the high-frequency signals, the electrical noise could be an obstacle to obtaining good pulse height analysis. In this respect, the balance voltage was measured

during a “1M” mode shutdown process with a discharging time constant of 300 s, so that the DC power supplies could be practically disconnected from the coils. The obtained signals are found to be less disturbed by noise as is shown in Fig. 2.

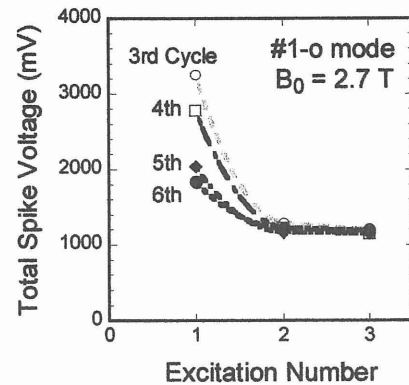


Fig. 1 Cumulative spike-voltage signals as a function of the excitation number in each operation cycle.

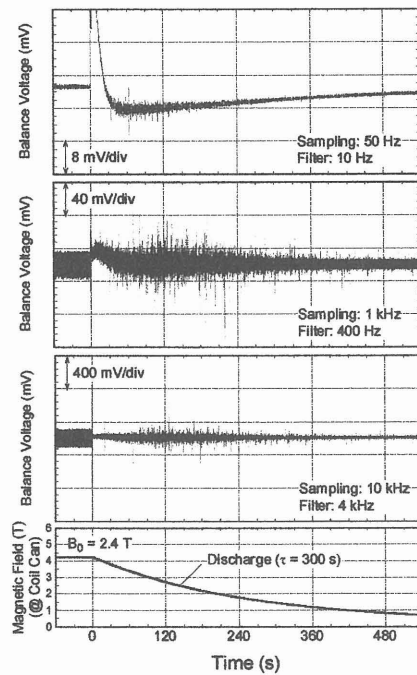


Fig. 2 Waveforms of the balance voltage signals observed with different frequency resolutions: 10 Hz (top), 400 Hz (second), 4 kHz (third) during a “1M” mode discharging process. The decay curve of the magnetic field (measured at the HC coil-can) is shown at the bottom.

### References

- 1) Yanagi, N. et al.: in Proceedings of ICEC18 (Mumbai, 2000) pp. 179-182.
- 2) Yanagi, N. et al.: IEEE Trans. Appl. Supercond. 12 (2002) pp.662-665.