§ 55. Joint Test of an Digital Integrator for Long Pulse Experiments in LHD

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Magnetic measurements in magnetic confinement devices are very important for controlling and maintaining stable plasmas in addition to an understanding of equilibrium parameters. The development of high-precision integrator is one of main subjects for the application to the fusion reactor because the conventional analog-integrator has a large thermal drift which makes an accuracy of measurements worse. In this study, the development and test of long-time integrator has been performed in long-time operation of LHD in collaboration with JAERI and NIFS. The integrator is tested through the measurement of plasma current. In JAERI, a digital integrator based on the method using a voltage-to-frequency converter (VFC) and an up-down counter (UDC) has been developed and applied to JT-60U experiments [1]. On the other hand, the multi-analog integrator system has been developed in LHD. A measured signal is transferred to several analog integrators with low thermal drift (a few μV/s) and each integrated time of 100 ms is alternatively changed using multiplexer. This technique has an advantage for an avoidance of data saturation and drift linearity although thermal drift itself is not removed. The advantage of a digital integrator is very small thermal drift. A goal of this study is the detailed comparison of their performance in the joint test. In this fiscal year (2002), the digital integrator was mainly tested.

The test was held from February 5 to 8, 2003. Figure 1 shows the measurement system of plasma current and the photo is shown in Fig. 2. A signal of Rogowski coil located inside vacuum vessel (gain = 5.2572×10^{-8} Vs/A) is transferred to VFC (-1～1V→250 kHz～1250 kHz) through a shielded twist-pair cable and digitally integrated with UDC. Integrated data is straged in a personal computer. Figure 2 shows the integrated signal in long-time discharge (shot# 41306). The NBI#2 in the co-direction maintains plasma and is switched to NBI#3 in the counter one in the middle of discharge, and the plasma is kept during 61 second. Line averaged electron density is about 1×10^{19} m^{-3} and central electron temperature approaches about 1 keV. Plasma current is mainly driven by neutral beam injection and reaches about 30 kA in co-direction at t = 30 s. The integration is started at 40 s before the discharge and continued during 300 s. The drift is 0.158 mVs during 300 s and corresponds to Ip ~ 3 kA. The ratio of the drift to time is almost constant.

Reference

1) Kurihara,K. and Kawamata, W., Proc. 17th IEEE/NPSS symposium on Fusion Engineering (San Diego, 1997), pp 799-802

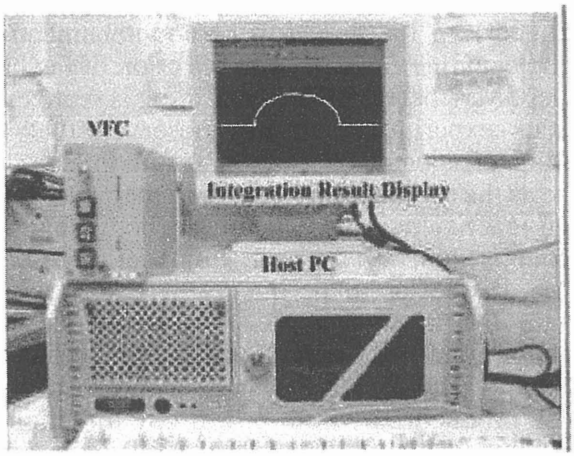

Fig.2 System configuration

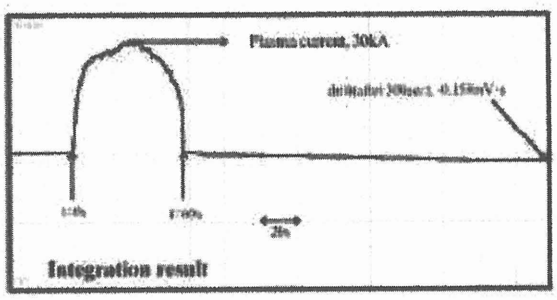

Fig.3 Waveform of plasma current in #41306 discharge

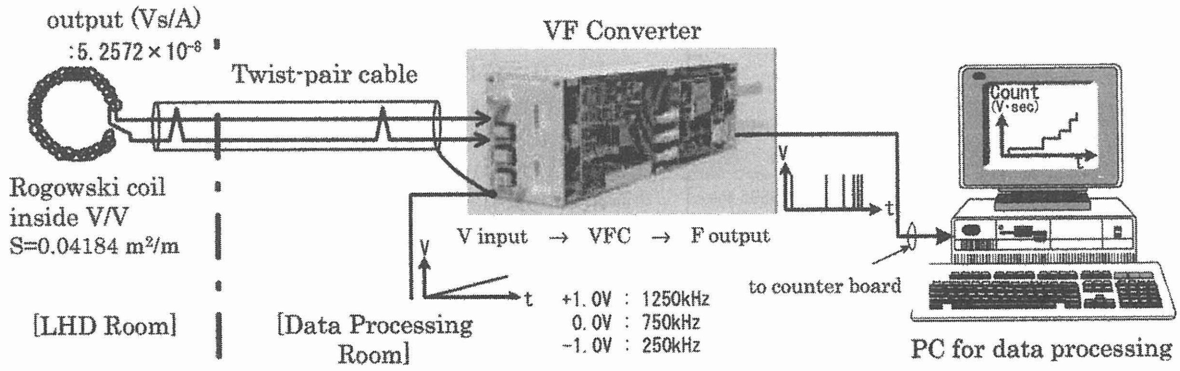

Fig.1 Schematic configuration of plasma current measurement in LHD