Transactions of the Korean Nuclear Society Spring Meeting
Jeju, Korea, May 10-11, 2007

Activities of the magnetic diagnostics for the initial magnetic field measurements in the KSTAR tokamak

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1. Introduction

The magnetic diagnostics (MDs) is essential to the plasma control and the measurements of an equilibrium magnetic field and magnetohydrodynamics (MHD) phenomenon in a tokamak. Up to now, considerable progress in the research and development activities of the magnetic diagnostics (MDs) has been done for the KSTAR [1-7]. For the initial magnetic measurements during a plasma discharge in the KSTAR tokamak, some of MD sensors were successfully installed in the KSTAR tokamak and good performance of the analog integrator required for the magnetic measurement was confirmed from the laboratory test. In the article, the current activities of the KSTAR MDs, such as the installation of MD sensors and vacuum feedthrough assemblies, the performance test of the analog integrator, are presented.

2. Magnetic diagnostic sensors

Full sets of magnetic diagnostic (MD) sensors are designed to be installed in the vacuum vessel and the cryostat of the KSTAR machine as shown in Fig. 1.

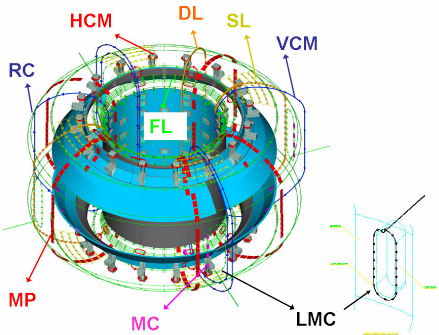

Figure 1. Full sets of MD sensors that will be installed in the KSTAR machine. Here, walls of the vacuum vessel and the cryostat are not shown.

Some MD sensors were successfully installed on the external and inner walls of the vacuum vessel for the initial magnetic measurements at the first plasmas in the KSTAR machine (see Fig.2). They are three vessel current monitors (VCMs) to measure the vessel current, three Rogowski coils (RCs) to measure the plasma currrent, five flux loops (FLs) to measure the poloidal magnetic flux, a set of magnetic field probe (MFP) array to measure the local poloidal magnetic field and a pair of diamagnetic loops (DLs) to measure the plasma beta.

The sensors are summarized in Table 1. The reliability of the installation was confirmed from the 3D position measurement using a laser tracker system [3,4]. The sensitivity of RCs and VCMs was calibrated from the current measurement in the laboratory [3,4], and the calibration of MFPs was done by using a solenoid coil in a special iron-free laboratory [5].

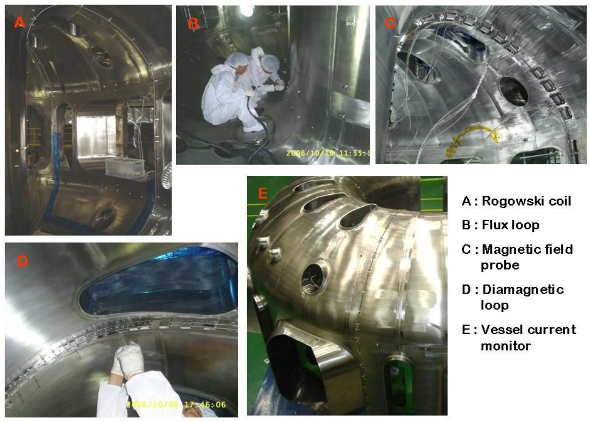

Figure 2. Initial sets of MD sensors installed in the KSTAR machine.

Table 1. MD sensors for the initial measurement in the KSTAR machine.

Sensors		No. of sensor	Measured quantity	Sensitivity or effective area
RC		3	Plasma current	6.35×10^{-8} secA^{-1}V
FL		5	Poloidal magnetic flux	4.24 m^2 - 24.5 m^2
MFP	Bz	42	Tangential component of poloidal magnetic field	0.0597 m^2
	Br	22	Normal component of poloidal magnetic field	0.0930 m^2
DL		2	Plasma beta	4.45 m^2(outer loop) 4.29 m^2(inner loop)
VCM		3	Vessel current	2.51×10^{-8} secA^{-1}V

In addition to the initial MD sensors, many other MD sensors (see Fig. 1) such as saddle loops (SLs), locked mode coils (LMCs), Mirnov coils (MCs) and halo current monitors (HCMs) have also been fabricated in order to be installed in the vacuum vessel during the vacuum break of the KSTAR machine for the next campaign after the initial measurements.

3. Vacuum feedthrough assembly

Most of the MD sensors were made of MgO cable, so the special vacuum feedthrough assembly (VFA) has been developed for the vacuum interface of signal lines from the sensors inside the vacuum vessel of the KSTAR tokamak. The VFA consists of a primary and two secondary vacuum chambers. The VFA was installed at a vertical bottom port of the vessel after finishing the vacuum test. Figure 3 shows the installation procedure of the VFA.

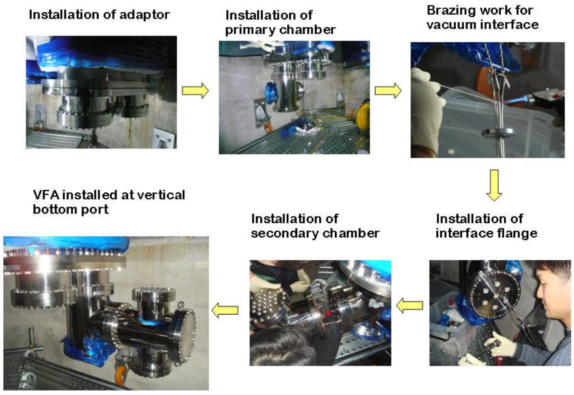

Figure 3. Procedure for installing a VFA on a vertical bottom port of the KSTAR machine.

4. Analog integrator for the magnetic measurement

Classical inductive coils are used as MD sensors for the magnetic flux measurement in the KSTAR machine. The electronic integrator is needed in order to obtain directly the value of a magnetic field from an induced voltage in the coils. The analog integrator, which automatically compensates an integrating drift, has been developed for the field measurement. The drift is compensated by the ADC-register-DAC component in the integrator. The integrator is a modular 32 channel rack-mounted type, which includes a microprocessor controller. Each module contains four independent channels for the integration. The integrator is controlled by a PC through the RS-232 interface [7]. In addition, two differential amplifiers are added to the signal path from each MD sensor to the integrator for the long distance signal transfer in the KSTAR machine because the paired cable (Belden, model 9841) of 100 m will be used as a signal line. The performance test of the integrator was done in the laboratory. Figure 4 shows typical fluxes measured by a MD sensor during two different integrating times.

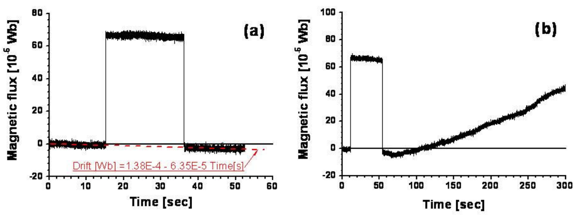

Figure 4. Typical fluxes obtained from a MD sensor in the pulse current measurements during an integrating time of 52.4 s (a) and 300 s (b).

The values of the flux are about (67 ~ 68) × 10^{-6} Wb during a current pulse width, and the integrating drifts are reached up to 3.19 × 10^{-6} Wb and 44.6 × 10^{-6} Wb during an integration time of 52.4 s and 300 s, respectively. The integrating drift during about 100 s was less than the value required in the integrator for the KSTAR MDs.

For the initial magnetic measurement in the KSTAR tokamak, the works for the set-up as shown in Fig. 5, such as connecting signal lines and commissioning signals from each sensor to the digitizer, are in progress.

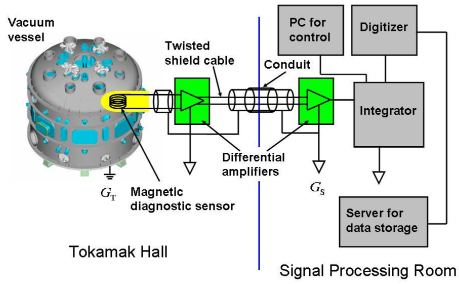

Figure 5. Block diagram of the signal path from sensor to data acquisition system for the magnetic measurement in KSTAR machine.

5. Summary

The MD sensors were successfully installed inside the KSTAR machine, which was verified from the fact that the averaging installation error of the sensor was less than 0.9 mm. In addition, good performance of the integrator was proved from the experimental results of the integrating drift being less than the value required in the integrator for the magnetic measurement in the KSTAR tokamak. Thus, it can be confirmed that the MDs will be used as a tool for the initial magnetic measurement during the first operation of the KSTAR tokamak.

The work was supported by the Korean Ministry of Science and Technology under KSTAR Project Contracts.

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