§26. Development of Alfvén Eigenmode Sensing System Using a Pair of Loop Antennas on LHD

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In controlled fusion experiments, one of the most dangerous MHD modes driven by energetic particle is the toroidicity induced Alfvén eigenmode(TAE)[1]. In a fusion-burn plasma, the vacuum vessel and/or various plasma facing components may be damaged by energetic alpha particles lost by TAEs, so that it is important to estimate the growth rate which can represent MHD stability factor for these modes and find a way of the stabilization.

In the Large Helical Device, an active sensing method for AEs using externally applied perturbations has been adapted to measure the resonant frequency and the damping rate experimentally[2]. In the method, a plasma response for applied perturbations is measured around AE frequency range by sweeping the driving frequency of the applied perturbation. Magnetic perturbations ranging less than several hundred kHz are applied to a plasma by two loop antennas. These loop antennas are placed by 180◦ away in the toroidal direction. The configuration of the AE sensing system including signal flow is shown in Fig. 1. The antenna installed inside the vacuum vessel at the vertically elongated section of LHD, as shown in Fig. 2. The maximum current of each antenna is 20A, and the maximum amplitude of the vertical component of the perturbation field Bz at the midplane of the LHD plasma is estimated to be $\sim 8\times10^{-7}$ T. The antenna current and the applied voltage are monitored at the position close to the antenna. The magnitude of applied voltage to an antenna and a time-dependent sweeping pattern of the driving frequency f_{ext} are created by a function generator controlled by PC in the control room of LHD. The sweeping range of f_{ext} is adjusted to include the expected range of AE frequency, which is dependent on the toroidal field, plasma density, fuel species, magnetic configurations and so on. This control pattern signal is amplified by a high-speed bipolar power supply. If the AE frequency range is predicted very well, the sweeping range of the frequency can be narrower so that a more detailed frequency dependence of the transfer function could be obtained. This AE sensing system is operated, being synchronized with a main time sequence of an LHD plasma. The operation for the AE excitation can be systematically controlled along the time sequence of application of the perturbation. The parameters that specify the maximum amplitude of applied voltage, temporal sweep-pattern of f_{ext}, delay time and so on are set up before the next plasma shot of LHD. The AE sensing system receives a main trigger signal at 0.5s before the plasma initiation for start-up preparation, and is driven with an appropriate delay time, responding to the above-mentioned control pattern. It is fully controlled through generic Ethernet LAN with GUI software.

[1] A. Fasoli *et al.* : Nucl. Fusion **47**, S264 (2007).
[2] T. Ito *et al.* : Fusion Eng. Des. **83**, 249(2008).

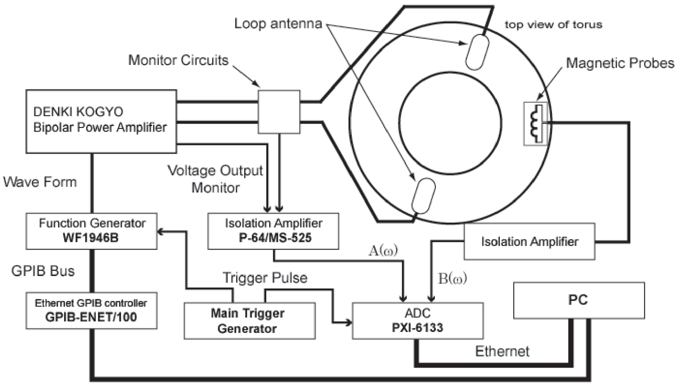

Fig. 1. System configuration of an AE sensing system in LHD with signal flows. Two antennas are arranged by 180◦ away in the toroidal direction, and are in operation in-phase or out-of phase to specify the toroidal mode number of the applied perturbations.

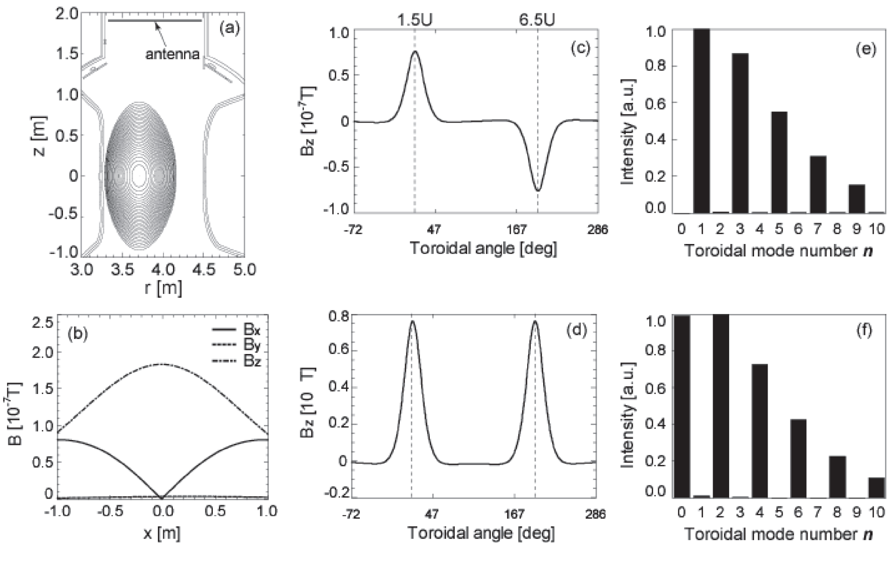

Fig. 2. (a) Cross-sectional view of a loop antenna placed inside the vacuum vessel and plasma in the vertically elongated section of LHD. The rectangular area of the antenna is about 1.13m×0.54 m. (b) Spatial distribution of magnetic field components. B_z is the vertical magnetic field produced by the antenna current. (c) and (d) Toroidal distributions of B_z in “odd” and “even” mode operations. (e) and (f) Fourier spectra of B_z shown as a function of the toroidal mode number in “odd” and “even” mode operation.