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Development of n=1 locked mode detection scheme using lock mode coils in KSTAR

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In KSTAR, there are harmful magnetohydrodynamic (MHD) instabilities which make plasma unstable and finally disrupted. One of the main MHD instability contribute to disruption is locked mode (LM). There are many experiments dedicated to study on the error field, for example, mitigation or suppression of edge localized modes. However, under inappropriate situation, the error field induces LM and plasma goes to disruption.

To detect the LM in KSTAR, there are 4 lock mode coils installed on the vacuum vessel. They were installed at 90 degree intervals in the toroidal direction. Cross-sectional area is 0.46 m^2 [1].

The phase and amplitude of target LM can be found using mode identification method based on Fourier decomposition. The LM of toroidal mode number, n, 1 can be diagnosed through the LM coil configuration of KSTAR. Formalism of the mode information and diagnostic data are as follows:

$$\begin{pmatrix}\delta V_1-\delta V_3\\ \delta V_2-\delta V_4\end{pmatrix}\approx 2\delta V e^{-i\varphi}\begin{pmatrix}e^{i\varphi_1}\\ e^{i\varphi_2}\end{pmatrix}$$

where δV is mode amplitude and φ is toroidal position. Subscript number indicates the quantity measured at each LM coils. To find the mode amplitude and phase, it is important to extract only the information related to the mode.

To find the mode information, external signal sources except LM have to be compensated from the LM measured signal. The toroidally symmetric external sources such as PF coils, plasma, and internal control coils can be easily compensated by finding direct compensation coefficient or removed when subtract the toroidally opposite coil signal. However, the signal from the toroidally asymmetric source as resonant magnetic perturbation (RMP) coils should be delicately removed. Especially, compensation of the eddy current induced by RMP coils are challenging issues. In this study, the lumped parameter model is adopted to deal with the eddy current signals [2, 3]. Measured signal due to the individual RMP coils including AC component are modeled as:

$$\psi_l=M_{sl}I_s(t)-H_{e1}\left[I_s(t)-\frac{1}{\tau_{e1}}exp\left(-\frac{t}{\tau_{e1}}\right)\int_0^t I_s(t)\,exp\left(\frac{t}{\tau_{e1}}\right)dt\right]$$
$$-H_{e2}\left[I_s(t)-\frac{1}{\tau_{e2}}exp\left(-\frac{t}{\tau_{e2}}\right)\int_0^t I_s(t)\,exp\left(\frac{t}{\tau_{e2}}\right)dt\right]$$

There are two place where eddy current can be induced: passive stabilizer and vacuum vessel. Subscript 1 and 2 represent this. The H_e and τ_e can be found in the vacuum calibration shot. The figure 1 shows the compensation results using lumped model.

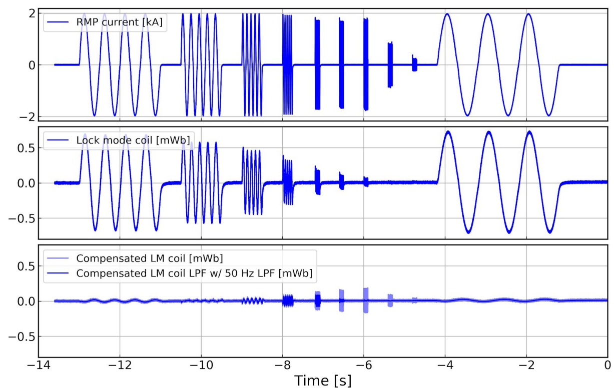

Figure 1. RMP coil compensation results using lumped model.

The overall mode detection scheme using LM coils is applied to the LM experiment in KSTAR. For example, in shot #12927, the mode evolution by the RMP coil current was studied. Overall details of the detection schemes and its application will be presented.

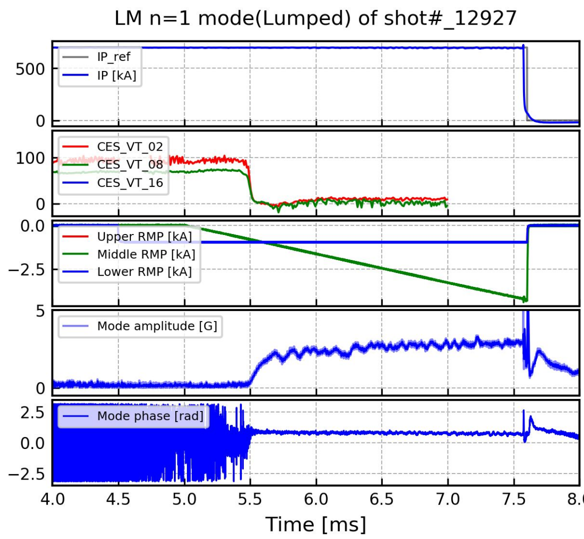

Figure 2. Example of mode detection using LM coils in KSTAR.

References

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