Real-time Digital Lock-In Amplifier Implementation for Dispersion Interferometer Diagnostic on EAST tokamak

Yuan Yao [1,*], Ziheng Lu[1], Jiamin Zhang[1,2], Weiming Li[1], Yuyang Liu[1,2], Bili Lin[1], Yinxian Jie[1,2] and Haiqing Liu[1,2]

[1]*Institute of Plasma Physics, Chinese Academy of Sciences, Hefei 230031, Anhui, China*
[2]*University of Science and Technology of China, Hefei 230026, Anhui, China*

To measure the electron density (line-averaged) and provide the real-time feedback for the plasma control system, a dispersion interferometer system has been developed on the Experimental Advanced Superconducting Tokamak (EAST) device. The fundamental principle of a dispersion interferometer lies in measuring density by detecting variations of the plasma refractive index using lasers. The dispersion interferometer utilizes the co-linearity of the fundamental frequency and the second harmonic to avoid the impact of mechanical vibrations on the plasma density measurements. Additionally, due to its shorter wavelength, the signal experiences fewer wrapping, resulting in a lower unwrapping-error rate. Due to the low efficiency of the frequency-doubling crystal, the power of the second harmonic is relatively low. To obtain accurate interference information, it is necessary to use a lock-in amplifier module to acquire modulation signals at 50 kHz and 100 kHz, and to process the intensity of this signal to obtain plasma density. In this paper, a dual-phase lock-in amplifier is designed for the interferometer system. By two phase channels, the dual-phase lock-in amplifier module can handle complex signals and provide more comprehensive phase information better. This capability makes it suitable for extraction of weak signals in dispersion interferometer. The real-time data processing system is implemented on a development board, utilizing an FPGA for digital signal processing and interfacing with the backend for output. The data acquisition system was applied in the EAST experiments, providing stable and reliable density data.

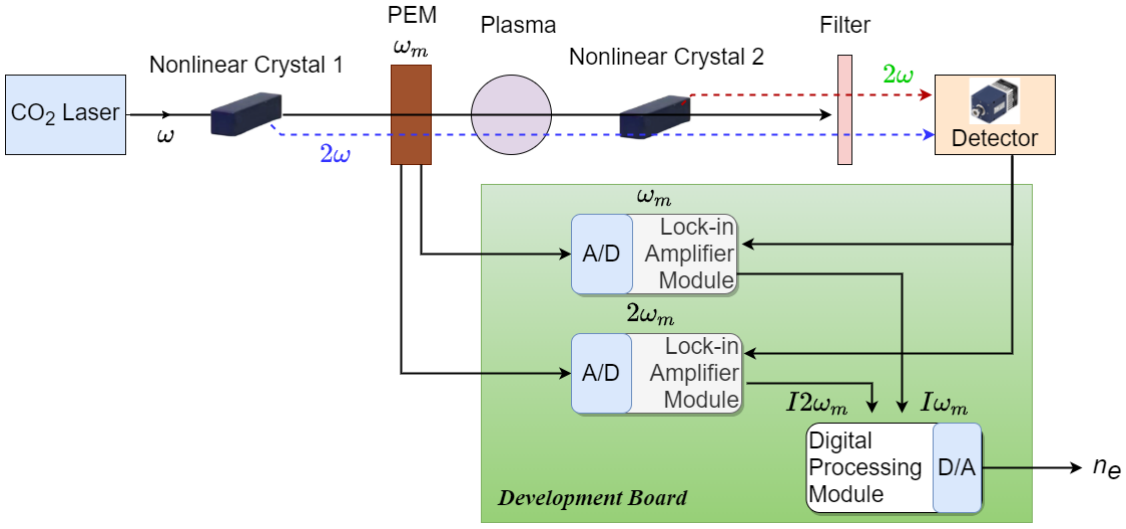

Figure 1. An Overview of the DI system with Lock-in Amplifier Modules.

[1] Liu, D. M., *et al.* Review of Scientific Instruments 92.5 (2021).

[2] Liu, Y. Y., *et al.* Plasma Science and Technology, 2024, 26(3): 034011.

*Presenting author: yyao@ipp.ac.cn

ID: Other