§2. Imaging Study of Dynamic Behaviors of Plasma Using Phase-Imaging Interferometer

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In tandem mirrors, an electrostatic potential is created in order to improve axial confinement. The radial electric field due to this potential often causes an $\boldsymbol{E}\times\boldsymbol{B}$ rotation shear. The verification of this effect is one of the most critical issues to understand the physics basis for recent confinement improvement. Understanding the mechanism of this effect requires the use of sophisticated diagnostic tools for measurement of plasma profiles and their fluctuations. Significant advances in microwave and millimeter wave technology have enabled the development of a new generation of imaging diagnostics as visualization tool of plasma parameters.[1] This report describes the development of millimeter wave imaging diagnostic system, so called phase imaging interferometer, applied to the GAMMA 10 tandem mirror.

The detailed description of the present phase imaging interferometer is shown in elsewhere.[1,2] The imaging array consists of beam-lead GaAs Schottky barrier diodes bonded to 4×4 (2D) bow-tie antennas fabricated using photolithographic techniques on a fused-quartz substrate. The quadrature (I-Q) detection system provides the phase difference between two intermediate frequency (IF) signals obtained by mixing the transmitted signal (RF) and the local oscillator signal (LO). The phase difference is proportional to the line density of plasmas. In FY2006, sixteen I-Q detectors were fabricated to apply to all of the imaging array channels. One of the problems in the I-Q detector is lack of reliability caused by unstable input signal to the detector. When the input signal is small, the system often does not work well or causes phase error. Therefore, in FY2007 we have newly designed and fabricated an I-Q detector with automatic gain control (AGC) in order to keep the input signal constant.

The IF system of the newly fabricated I-Q detector is shown in Fig. 1. It consists of IF module and LO module as shown in the figure. The LO signal is passed through an band-pass filter (BPF) with 100-180 MHz, amplified by 44 dB , and fed to another amplifier with AGC. The frequency of the amplitude controlled signal is doubked by an doubler, and fed to an I-Q demodulator chip in the IF module. The IF signal is also passed through an BPF, an amplifier, and an AGC amplifier, and fed to the IF port of the I-Q demodulator. After mixing with the LO signal, the IF signal is treated by I-Q detection.

The performance of the system is characterized by using two types of IF input signals, constant and amplitude modulation signals. Figure 2 shows the evaluation of the dynamic range for the input signal. The output level of the AGC amplifier is changed from -40 to 0 dBm. When the output power is fixed to -40 dBm, it shows the constant value for the input power from -57 to 0 dBm.

The dynamic behavior is tested by using an amplitude modulation signal. In Fig. 3 is shown the results for two different frequencies. It is seen that when the changing time is less than 20 μs the output signal cannot be kept constant as shown in the right figure.

In summary, a new quadrature phase detection with automatic gain control system was completed and characterized in FY2007. It is shown that the system works as designed. The dynamic range of the input signal is -57 dBm to 0 dBm, and the time response is 20 μs. The reliability of the I-Q detector is expected to be improved by using present system.

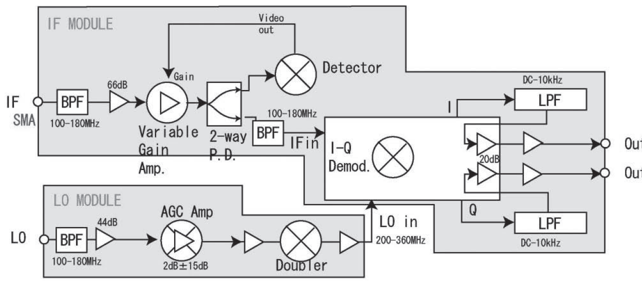

Fig.1. Schematic of the IF system of new I-Q phase detector.

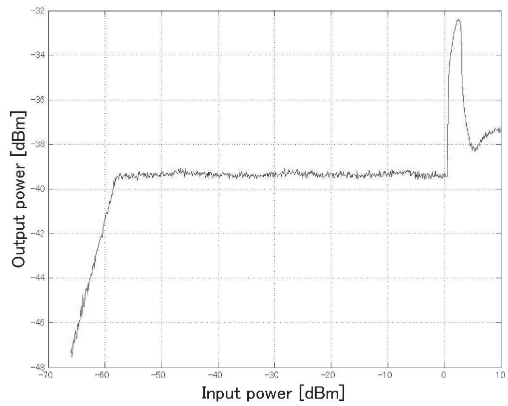

Fig.2. Evaluation measurement of dynamic range of the system.

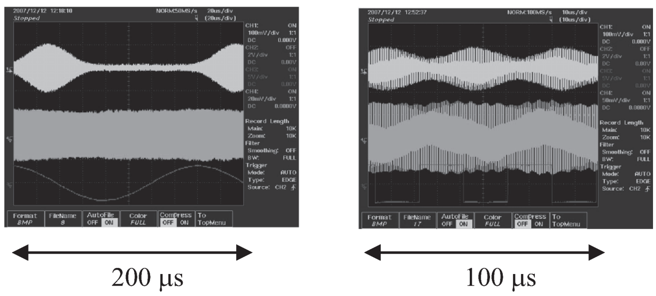

Fig.3. Measurement of dynamic behavior of the system.

1) Mase, A. *et al.*: Proc. Int. Symp on Laser-Aided Plasma Diagnostics, NIFS-PROC-68 (2007) 15.
2) Mase, A. *et al.*: Trans. Fusion Sci. Tech. **51** (2007) 52.