§25. Study of High-Performance Array Antennas for Millimeter-Wave Imaging Array

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It is considered to be one of the major issues to clarify the behavior of various instabilities and relations between instabilities and plasma confinement. ECE imaging (ECEI) is a promising method to measure electron-temperature profile and its fluctuations precisely. An ECEI system is composed of a detector array, quasi-optical system, and IF system. Each subsystem plays following roles. The optical system is composed of optical mirrors and dielectric lens. These optics are utilized to focus ECE from plasma on the detector array within the specific bandwidth. In the present plan of the beginning experiment, we will collect the fundamental component of ECE with frequency range from 70 to 76 GHz. The ECE is then received by the detector array, and is frequency-converted to IF signal by means of LO wave. In the IF system, signal is then fed to power dividers and bandpass filters to resolve radial temperature distribution, since the frequency of ECE is proportional to magnetic field strength. While poloidal and toroidal temperature distribution is obtained by 2D array of the detector. We have studied and improved design of the detector to be suitable for ECEI measurement. In this report, we will describe prototype design of ECEI system and application to LHD plasma.

Figure 1 shows the prototype 3ch ECE detector array. The LO wave and the ECE wave are received in the antenna region indicated in fig. 1. The antenna corresponding to 1 detector channel is composed of 4 patch antennas for conditioning radiation pattern of the antenna. The detected LO and ECE waves are mixed in a Schottoky barrier diode denoted by "mixer" in fig. 1. The IF signal is then fed to a HBT amplifier, which has bandwidth of DC - 6 GHz and gain of 12 - 18 dB. The amplified signal is then fed to IF system as shown in figure 2.

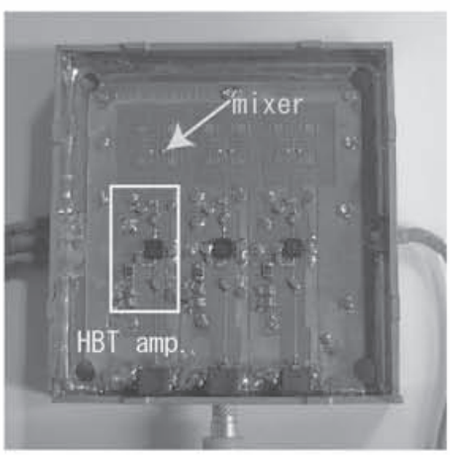

Fig. 1 Prototype 3ch detector array

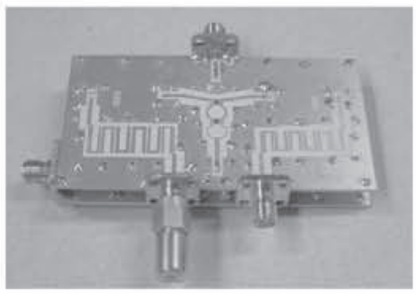

Fig. 2 IF system correspoinding to 1 detector channel

The IF signal is amplified again by the same type 2-stage HBT amplifiers and divided by Wilkinson power divider into 4 channels. Each divided signal is fed to band-pass filter whose band centers are 2.5, 3.5, 4.5, and 5.5GHz. The bandwidth of each filter is 1GHz. The filtered signals are detected by video detectors of commercial components. Finally these signals are digitized by ADCs.

We have installed the ECE system at 4-O port, and performed preliminary experiment in order to confirm applicably of our system. Figure 3 shows observed detector signal. Red, blue, yellow, and black curve indicate bandpass frequencies of 2.5, 3.5, 4.5, and 5.5GHz, respectively. We have confirmed that these signals are proportional to the electron temperature. We consider that signal amplitude difference in each channel is due to the gain and NF property of the HBT amplifiers, and antenna performance.

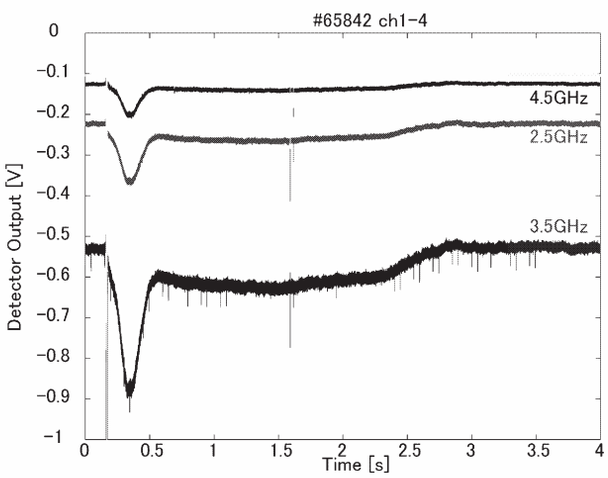

Fig. 3 Detector output

This deterioration of S/N ratio will be fixed by increment of the transmission at the diagnostic window by cleaning of adhesive object onto the window surface in the next experimental campaign.