Development and Application of Electron Cyclotron Emission System on KSTAR

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An electron cyclotron emission (ECE) radiometer is an essential tool to investigate radial electron temperature profile in magnetically confined plasmas[1]. Measurement of electron temperature profile which measurement region covers whole plasma area is important[4] to evaluate the diffusivity of the plasma. Since the ECE from optically thick plasma can be treated as black body radiation, the amplitude of ECE is proportional to the electron temperature. Furthermore, the frequency of the ECE is proportional to the magnetic field strength, since the ECE is emitted due to gyro motion of electrons. In general, distribution of magnetic field strength in torus experimental devices is a function of radial position, and the radial temperature distribution can thus be measured by resolving the ECE signals with electron cyclotron frequency or its harmonics. The ECE frequency of KSTAR covers millimeter wave band. We have developed ECE radiometer system for KSTAR. Befor the radiometer is applied to the plasma, the Calibration measurement is necessary to evaluate absolute electron temperature from the digitized signal. Fig. 1 shows experimental setup of the calibration. We employ hot load source as a black body radiation source. Temperature of the surface of the source can vary from room temperature to 900K. In order to conduct the radiation onto the corrugate waveguide, the upper side of the mirror can be rotated 180 degree as shown in Fig. 1. During the propagation path, we install a chopper blade to cut or transmit the radiation periodically. Rotation frequency is 20Hz. Surface of the Aluminum blades is covered by Eccosorbs. When the chopper passes the radiation from the hot source, the radiometer measures high temperature body. While, when the surface of the Eccosorb is faced on the measurement path, radiation from the Eccosorb, which correspond to black body radiation from room temperature object, is detected. In order to reduce noise voltage of the output signal, further bandwidth limitation with a bandpass filter is employed. Lower and higher cutoff frequencies of the filter are 0.1Hz and 1 kHz, respectively. Amplitude of the noise is proportional to square root of the bandwidth. By inserting the filter, amplitude of the noise is decreased below 1/54. In order to decrease the noise amplitude more, box-car integration is employed. A photo interrupter attached in the chopper supplies on/off signal which can be used as trigger of the oscilloscope. N times averaging of the signal reduces more noise by 1/square root of N.

Fig. 2(a) shows one of the calibration results. A dotted curve is a chopper on/off signal supplied by the optical interrupter. High voltage denotes that radiation from the hot load is passing through the chopper. Low voltage corresponds to room temperature. A solid curve is the detector signal which corresponds to 159GHz channel. It is found that detector output is fluctuating along with the interrupter signal. Voltage difference between high and low voltage (1 mV) corresponds to temperature difference between Eccosorb and the hot load (68.8 K). Voltage difference between high and low voltage is plotted as a function of temperature difference as shown in fig. 2(b). It is confirmed very clear condition that detector output is proportional to the temperature. When this radiometer is applied to actual plasma with 10 keV temperature, output amplitude is estimated to be about 1500 V. It is found that this system needs attenuators with 23 dB loss to avoid signal saturation.

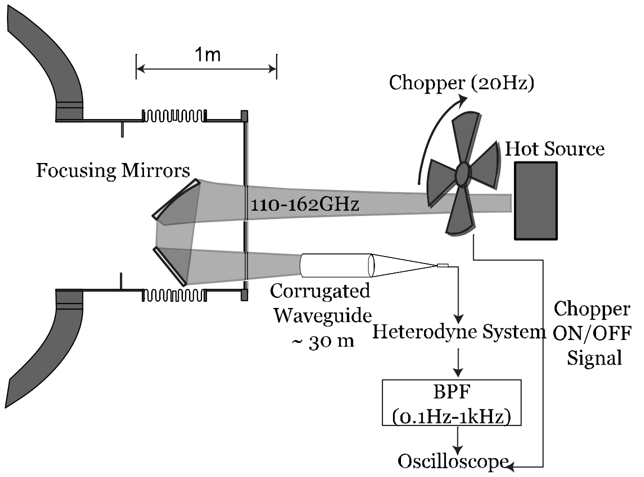

Fig. 1 Experimental setup for calibration measurement

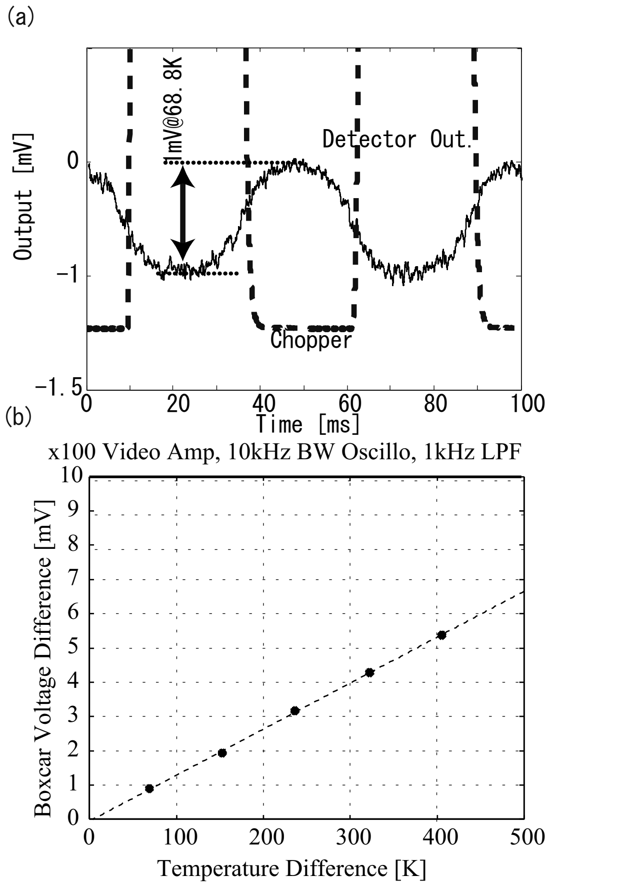

Fig.2 Time responses of the detector output and the chopper gate signal(a), Linearity of the detector output against temperature.(b)