§3. Broadband Multichannel Radiometer for ECE Measurements on KSTAR

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A broadband heterodyne radiometer system has been developed and installed on KSTAR(R = 1.8 m, a_p = 0.5 m, k = 2.0, B_t < 3.5 T, I_p < 2 MA) to measure second harmonic electron cyclotron emission (ECE) at the magnetic field of 3 T. The system consisting of two radiometers (110-162 GHz and 164-196 GHz) can cover a frequency range of 110-196 GHz. The unique and key components to construct this ECE diagnostic instrument are specially-designed detector modules and a diplexer for splitting ECE radiation with high efficiency. The KSTAR ECE diagnostic instrument has been developed under the Korea-Japan KSTAR collaboration which started in 2004. In the second experimental campaign (2009.10 – 2009.12) of KSTAR we have successfully achieved electron temperature profiles from the measured ECE spectrum after absolute calibration. The minimum detectable electron temperature with a time response of 1 μs is about 0.23 eV.

Figure 1(a) shows a block diagram of a broadband heterodyne radiometer system. Two radiometer systems (D-band: 110-162 GHz, G-band: 164-196 GHz) are combined with a diplexer, and can cover the wide frequency range of 110 – 196 GHz. The detail of the D-band radiometer system is also shown in the figure. The ECE radiated from the plasma is observed along the major radius with a concave ellipsoidal mirror located inside the tokamak. The ellipsoidal mirror can be rotated 180 degrees to collect radiation from a hot (873 K) blackbody radiation source in the case of calibration. The ECE radiation collected by the antenna is imaged onto the end of a 63.5-mm-diam corrugated waveguide of 25 m in length via a fused quartz window. The corrugated waveguide is designed to transfer microwaves from 50 to 220 GHz with small loss (~ 1.0 dB/km at 100 GHz). The beam spot size on the ECR layer is about 5 cm.

Figure 1(b) shows typical ECE signals emitted from the different radial positions of the plasma at the magnetic field of 1.96 T. Waveforms of the plasma current and line integrated density are also shown. In the figure, selected chord signals, corresponding to the 2nd and the 3rd harmonic ECE, are plotted. At the present, the instrument has not been calibrated yet, and will be calibrated to achieve electron temperature profiles after the 3rd experimental campaign in 2010. The details of the calibration procedure are described in ref. 1

1) Y. Kogi, et al. , Rev. Sci. Instrum. **81**, 10D916 (2010).

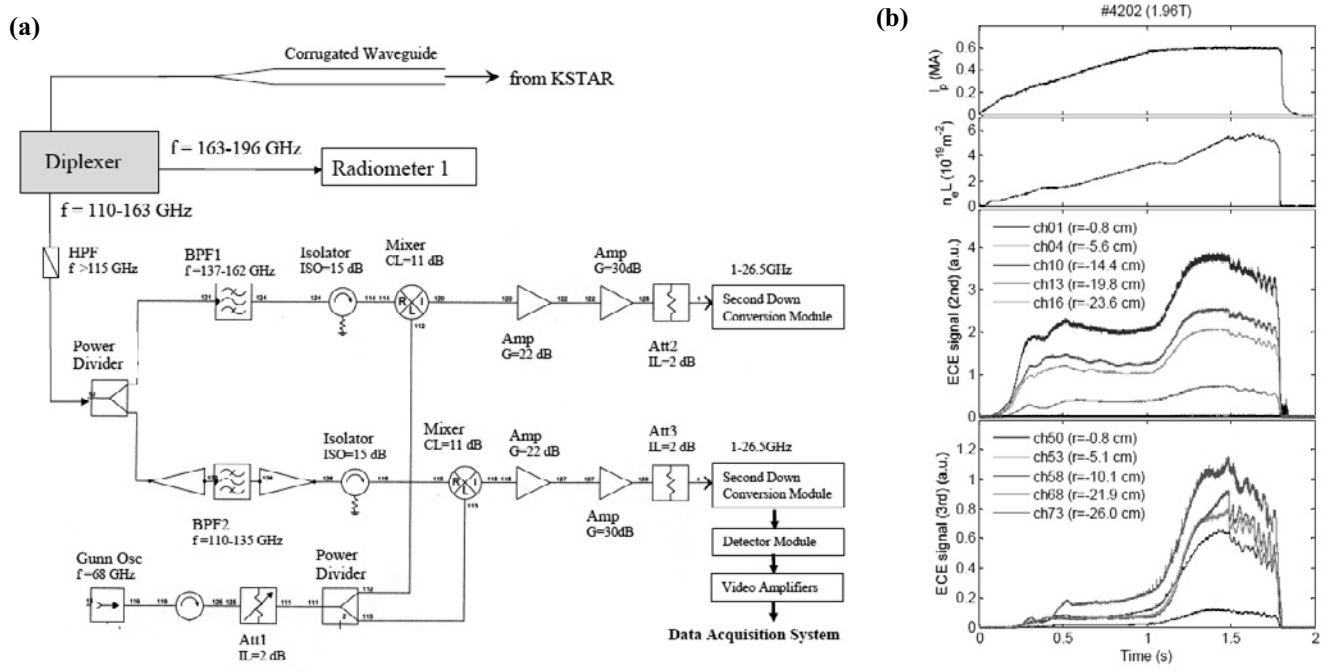

Fig. 1 (a) Block diagram of a broadband heterodyne radiometer system of the KSTAR ECE diagnostic.
(b) Time traces of plasma current, line density and ECE signals from different radial positions of the plasma..