Development of Microwave Imaging Reflectometer with Tapered Slot Antenna Array

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Calibration of the KSTAR ECE System [†]

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An electron cyclotron emission (ECE) diagnostic system on KSTAR tokamak was built in last year. The ECE system consists of quasi-optical light collection optics and a heterodyne radiometer. The ECE heterodyne radiometer operates in a single side band and has an eight-channel power divider and filter banks to cover a frequency range of 72 to 84GHz. The heterodyne radiometer measures the electron temperature and its profiles of the initial plasma (B_T=1.5T, R_o=1.6 m, a=0.3m) of KSTAR. It is very important to calibrate the ECE radiometer absolutely with a high accuracy because there are no diagnostic tools comparing electron temperature data with the results of the ECE radiometer in initial operation period of KSTAR. The operation frequency range of the ECE radiometer is in E-band, so we can use a commercial noise source for relative calibration between channels of the ECE radiometer, which has an advantage of high temperature 20 times higher than other calibration sources. For absolute calibration of the ECE system including quasi-optical light collection optics, we use a temperature controlled calibration source that has a maximum temperature of 900 ° K. We use a chopper system and a precision digital voltmeter for data acquisition. The calibration error is less than 10%.

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Development of Microwave Imaging Reflectometer with Tapered Slot Antenna Array [†]

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Understanding the mechanism of anomalous transport in magnetically confined plasmas is one of the most important subjects on fusion researches. Reflectometry is now widely used in both tokamak and other magnetically confined-plasmas. It has the advantage of detecting local density behavior with high spatial resolution. Recent computer simulations suggest three-dimensional structures of plasma turbulence. These new computational results need to be examined experimentally to fully understand the plasma turbulence and anomalous transport mechanism. Thus, novel diagnostics to measure the 3-D structure of plasma turbulence are required. Recently, millimeter-wave imaging technique has been developed for measurements of density and temperature profiles and their fluctuation components in magnetically confined plasmas. This technique uses a single set of optics with multichannel detector array instead of a multichannel optical path with a single detector for each path. A bow-tie antenna element has been mainly used for millimeter-wave imaging antenna arrays. The purpose of this research is to develop a microwave imaging reflectometer by use of a tapered slot antenna(TSA) array on the focal plane. The tapered slot antenna has advantages such as a broad bandwidth, low cost and a compact, light-weight. In addition, manufacturing of the array antenna is easy for its planer shape. A TAS have a nearly-symmetrical radiation pattern compared to that of a bow-tie antenna. TSA has good property of a high directivity. This antenna research has been active especially in the communication fields. We designed a LTSA(Linearly Tapered Slot Antenna) with corrugated structure for X-band. The corrugated structure improves radiation patterns of LTSA. The input impedance can be tuned over a wide range of frequency by adjusting the element dimensions, leading to a good matching condition without complex matching circuit. The impedance matching condition is calculated by an equivalent circuit model. By optimizing the strip-line dimensions, the bandwidth of 7-14GHz with VSRW<2 is obtained. The 3dB-beamwidth is 26 degree in the E-plane and 48 degree in the H-plane, respectively. In this paper, characteristics of the designed LTSA and mockup experiments of the reflectometer using a metal target instead of a plasma are reported.

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