§45. Collective Thomson Scattering Receiver System in LHD

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The collective Thomson scattering (CTS) has long been attracted and intensively studied as one of the most promising diagnostic methods for the ion distribution function[1]. Mainly due to a small scattering cross section, or scattering efficiency, CTS requires high power probe beam source with sharp single frequency spectrum and highly sensitive receiver near the frequency but avoiding a direct contamination of the probe frequency that requires a sophisticated stray suppression. The other important factor required for the spatially well resolved measurement of CTS is the well defined probe and receiving beams and their controllability. High power, sharp spectrum, and highly focussed well defined Gaussian beam are already realized for the electron cyclotron resonance heating (ECRH) system using gyrotron and high power transmission/antenna in LHD. We have started the trial of CTS study utilizing the existing ECRH system in LHD[2] . Here, are reported the receiver system used for CTS.

In the present ECRH system, nine gyrotrons are in operational and eight corrugated transmission lines (6- 88.9 id and 2-31.75 mm id) are connected to LHD. Two sets of injection antenna are installed on each 4-LHD ports (5.5U, 9.5U, 2-O and 1.5L). The 9.5 U port antenna set is selected as a CTS probe and receiving antenna, since 77 GHz high power is available for the probing beam and the beam controllability is well established and confirmed. This antenna set includes one another Gaussian beam mirror suitable for receiving the scattered power from definite scattering volume. One of the important parameters for the collective scattering is the "scattering volume". By using the well defined beam for ECRH, effective scattering volume can be calculated by integrating over the space using the Gaussian beam formula. Typical scattering volume for 9.5U port antenna set is about 700 cm^3.

A receiver system is installed on the upstream of the transmission line, which is normally used for high power transmission line for ECRH. A waveguide switch is attached on the 88.9 mm id corrugated waveguide transmission system. A heterodyne receiver is placed at the output of the waveguide switch. The receiver consists of a high sensitive heterodyne radiometer. The circuit diagram is shown in Fig. 1 a).

At the front end, two multi-stage notch filters with the 3 dB band width of 300 MHz and attenuation -120 dB at the center frequency, 76.95 GHz, are placed to avoid the high level stray radiation that can damage the mixer or make ghost signal at the mixer and make saturation of the intermediate frequency (IF) amplifier. A pin-switch is also inserted to block the spurious mode which might be excited at the turn on or off of the gyrotron out of the notched but sensitive frequency. Band pass filter from 72 to 82 GHz to filter out the lower side band of the mixer of the local frequency at 74 GHz

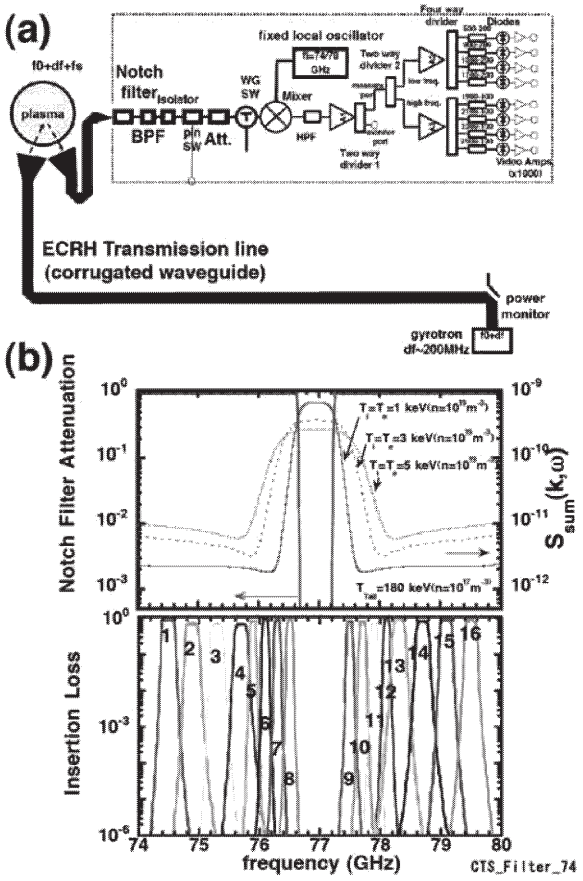

Fig. 1: (a) Block diagram of the heterodyne receiver for CTS in LHD. The notch filter, band pass filter and pin-switch are placed in front of the mixer. (b)Characteristics of the filter prepared for the local frequency at 74 GHz expected from the characteristic curve at the IF. Expected notch filter response with calculated CTS spectrum for $T_e = T_i$=1, 3, 5 keV at the density of 1× 10^{19} m^{-3} with tail ions of T_{Tail} =180 keV, n_{Tail}=1 × 10^{17} m^{-3} are shown in the upper column.

is also placed in front of the mixer. Intermediate frequency from 300 MHz to 10 GHz at the upper side band of the mixer is amplified by low noise amplifier and splitted to filter bank. Since the gyrotron oscillating frequency can subject to the shift of the order of 100 MHz during the oscillation or at the ramping up phase of the anode voltage, IF center frequency tracking system using harmonic mixer will be also attached for the precise estimation of the bulk component. Filter bank consists of 8 to 16 filters at the first trial. Fig. 1 b) are shown the expected response of the notch and bank filters in the upper and lower column, respectively. Here, calculated CTS spectrum for the cases where the bulk ion and electron temperatures are 1 , 3 and 5 keV with high enegy ions of 180 keV are over plotted in the upper column.

1) Bindslev, H., *et al.* , Phys. Rev. Lett. **97**, 205005 (2006).

2) Nishiura, M., *et al.* , Review of Scientific Instruments **79**, 10E731 (2008).