§67. Upgrade of the Receiver System for Collective Thomson Scattering of LHD

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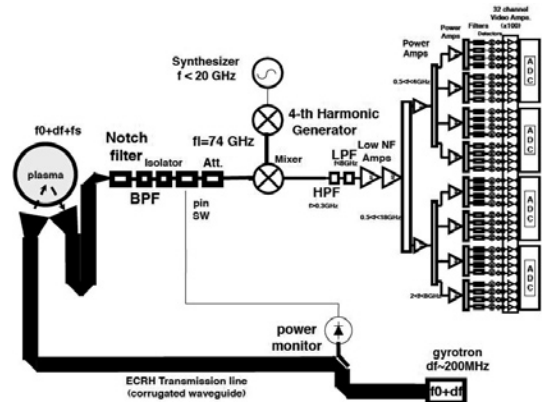
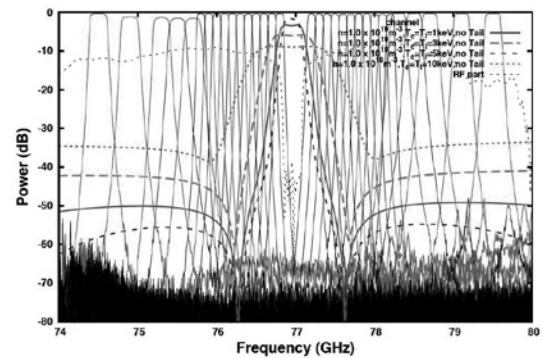Fig. 1: Block diagram of the 32 channel receiver system for CTS.

Fig. 2: Frequency response of the filters. That of notch filter is plotted black dotted line. Calculated CTS spectra for $T_i = 1, 3, 5$ and 10 keV are also over plotted.

Collective Thomson scattering (CTS) system is composed from high power ECRH system in LHD. The necessary features for CTS, high power probing and receiving beams, both with well defined Gaussian profile and with the fine controllability are endowed in the ECRH system. The 32 channel radiometer with sharp notch filter at the front end are attached to the ECRH system transmission line as a CTS receiver. CTS study utilizing the existing ECRH system in LHD[1] has been started with 8 channel receiver system from FY2008. After the successful detection of the signal that can be attributed to the collective Thomson scattering of the high power gyrotron beam, the receiver system is upgraded for the precise estimation of the scattered spectrum.

The block diagram of the upgraded receiver is shown in Fig. 1. The receiver consists of a highly sensitive heterodyne radiometer with multi-channel filter bank. At the front end, two multi-stage notch filters with the 3 dB band width of 300 MHz and total attenuation of -120 dB at the center probing 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 is excited at the turn on or off of the gyrotron out of the notched but sensitive frequency, although this pin-switch were kept open in the experiment described here since the actual level of this spurious signal does not degrade the spectrum. An RF band pass filter from 72 to 82 GHz to suppress the lower side band of the mixer of the local frequency at 74 GHz is placed in front of the mixer. IF from 300 MHz to 6 GHz at the upper side band of the mixer is amplified by low noise amplifier and divided to filter bank.

Filter bank consists of 32 filters followed by rectifiers and video amplifiers The frequency characteristics of all these components are measured by vector network analyzers. In Fig.2 are shown the frequency responses of each IF filter of the receiver where IF part and RF part are combined assuming the local frequency of 74 GHz that is well stabilized and tuned, since the local power of mixer is generated by a fourth harmonic generator fed by a synthesized oscillator. This choice of the combination of the fourth harmonic oscillator and synthesizer gives the system much flexible as well as the high stability of the local frequency. Gain of each channel is adjusted to avoid the gain compression, and to stay in linear regime

Fig.2 are over-plotted the frequency characteristics of the filters measured by vector network analyzer (VNA). Here are also shown the frequency characteristics of the notch filter by black dotted line and calculated CTS spectrum for ion temperatures of 1, 3, 5 and 10 keV. Inside 22 channels beside the center frequency have 3-dB bandwidth of 100 MHz and 100 MHz separation from each other cover the both sides of bulk ion components, while far 10 channels cover the high energy part with the 3-dB bandwidth of 200 MHz. Relative sensitivities of the receiver channels are calibrated by chopping the liquid nitrogen and room temperature absorbers placed in front of the opened transmission waveguide that is so to say "hot and cold" method. Linearity of the output signal is checked and adjusted the relative amplification of each channel by sending the level controlled swept output from synthesizer in the IF frequency range that simulates the mixer output so that the output signal levels are within linear regime in the actual experimental condition.

1) S. Kubo *et al.*, Plasma Fusion Res. Vol.**5**, (2010) S1038.