# §19. Optimization of Operation Parameter of Mega-watt 77 GHz Gyrotron for Application to Collective Thomson Scattering Measurements in LHD

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The collective Thomson scattering (CTS) diagnostic in the Large Helical Device (LHD) has been developed as a technique for measuring bulk and fast ion velocity distribution functions in fusion plasmas [1]. CTS measurements have been made by modulating the gyrotron output power to subtract the background electron cyclotron emission (ECE) from scattered radiation because the signal intensity of the ECE is non-negligible compared with the scattered signal intensity. The CTS receiver is composed of a narrowband notch filter for blocking the intense stray radiation and a highly sensitive heterodyne radiometer. Spurious radiation outside of the notch filter frequency band is often observed by the CTS receiver during both transition and settled phases of anode voltage of the gyrotron, $V_a$ shown in Figures 1(b) and (c). Such spurious radiation can interfere with the CTS diagnostic, even though its power is at least 50 dB below that of the main mode. In the present situation, such radiation can make saturation of some intermediate frequency (IF) amplifiers. Therefore, it is important to identify these spurious radiation modes and suppress or reduce them by optimizing the operational parameters of the 77-GHz gyrotron with less degradation of the main mode power. As the result of optimization described below, the output power increased from 300 kW to 800kW without any harmful spurious radiation effect .

To resolve the issues as discussed above, we optimized operational parameters and applied the PIN switch. It has been found that the spurious radiation in the transition phase is hard to suppress without decreasing the main mode power, as implied by the mode competition calculation [2]. To completely suppress the spurious radiation in this phase of $V_a$, higher the magnetic field strength at the resonator, $B_c$ operation is required than that optimized for maximizing the main mode power in the settled phase of $V_a$. Therefore, the output power significantly decreases. Another approach to get rid of such unfavorable effects is to block all IF signal at the down converting mixer using PIN switch, combined with the suppression of the residual spurious mode that appears in the settled phase by a slight increase in $B_c$ that has little effect on the output power [3]. The results are shown in Fig. 2. Figure 2(a) shows the time evolution of the RF monitor signal and PIN switch gate. Figures 2(b) and (c) show the frequency spectrograms around the spurious radiation mode of the 77-GHz gyrotron operated at $B_c$ = 3.025 T, and Figs. 2(d) and (e) show those at $B_c$ = 3.033 T. We achieved operation in which the output power is 800 kW with the spurious mode blocked in the $V_a$ transition phase and suppressed in the $V_a$ settled phase.

The optimization of operational parameters for high power operation will be applied on the basis of the knowledge described in this study in order to improve the signal-to-noise ratio of CTS measurement.

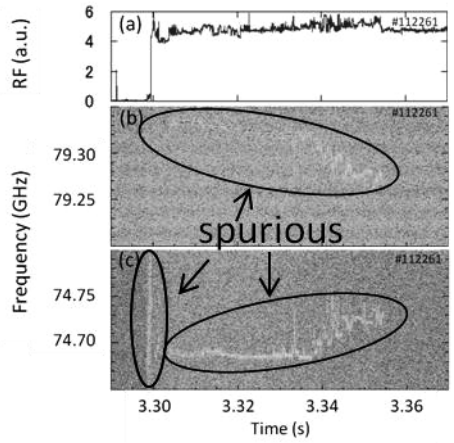


Fig. 1 Time evolution of (a) RF monitor signal, and (b), (c) frequency spectrogram around spurious radiation mode of 77-GHz gyrotron.

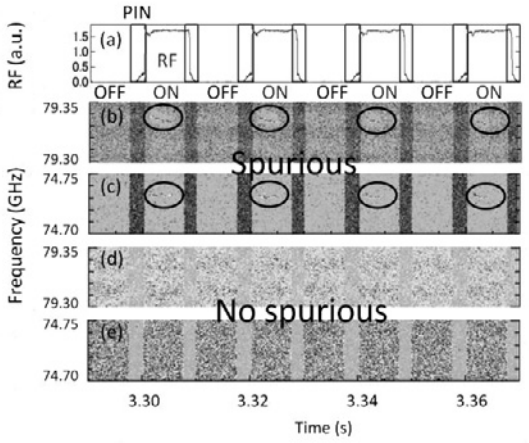


Fig. 2 Time evolution of (a) RF monitor signal (red solid line) and PIN switch gate timing (black squares); frequency spectrogram around spurious radiation modes of 77-GHz gyrotron operated at (b), (c) $B_c$ = 3.025 T, and (d), (e) $B_c$ = 3.033 T.

[1]S. Kubo, M. Nishiura *et al.,* Rev. Sci. Instrum. **81**, 10D535 (2010)

[2]S. Ogasawara, S. Kubo et al., Rev. Sci. Instrum. **83**, 10D731 (2012).

[3]S. Ogasawara, S. Kubo et al., Plasma Fusion Res. **8**, 2402069 (2013).