## §26. Development of Frequency Tunable Microwave Source by Gyrotron

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Application of high frequency gyrotrons is effective in improving the S/N ratio of the plasma scattering measurements because of their capacity to deliver high powers. We had already carried out plasma scattering measurements using a submillimeter wave gyrotron (Gyrotron FU II). It turns out that the stabilization of gyrotron output is required to improve the performance of the measurement.

We have achieved cw operation of the submillimeter wave gyrotron, Gyrotron FU IV. This gyrotron consists of sealed-off tube and magnet system. The superconducting magnet produces the main field in the cavity region whose intensity can be raised up to 12 T. Three subsidiary copper coils are used in the electron gun region. Both fields can be adjusted independently to control the formation of the electron beam produced by the Magnetron Injection Gun (MIG). The cw operation ($TE_{03}$ mode, $f$=301 GHz, $P$=20 W) is obtained under the following conditions: magnetic field intensity in the cavity region $B_0$=10.8 T, cathode potential $V_k$=-16 kV, anode potential $V_a$=-2.9 kV.

The output power and the frequency of cw operation had fluctuations ($\Delta P/P$~4 %, $\Delta f$~2 MHz) due to the fluctuations of the cathode potential ($\Delta V_k$~40 V) and the anode potential ($\Delta V_a$~0.5 V). The fluctuation of the output power correlates with that of the cathode potential $\Delta V_k$. When $\Delta V_k$ decreases to the minimum value, $\Delta P/P$ reaches its maximum.

In order to suppress the fluctuation level of the cathode potential and the anode potential, high voltage power supplies are equipped with smoothing circuits consisting of a resistor, an induction coil and a capacitor [1]. The fluctuation level was decreased ($\Delta V_k$~0.6 V, $\Delta V_a$~0.2 V) by introducing the smoothing circuits. Accordingly, the fluctuations of the output power and the frequency were decreased from $\Delta P/P$~4 % to $\Delta P/P$~1 % and from $\Delta f$~2 MHz to $\Delta f$~50 kHz.

A gyrotron functions as a voltage controlled oscillator [2]. This enables us to attain a high stability of output frequency by introducing a phase lock loop (Fig.1). Compared to conventional sources (gunn oscillator, BWO), a gyrotron has small frequency modulation sensitivity. The value of the gyrotron FU IV obtained by changing the potential of body electrode is 0.016 MHz/V. In order to compensate the mismatch of modulation sensitivity, we introduce an amplifier between a phase lock module for gunn oscillator and a control electrode. The phase lock signal is fed back to the body electrode of the gyrotron across a load resister of 1 kΩ. The body electrode is connected with cavity region and its potential is close to grounding potential. Frequency stabilization is effectively improved by introducing phase lock loop from $\Delta f$~50 kHz to $\Delta f$~1 kHz (Fig.2)

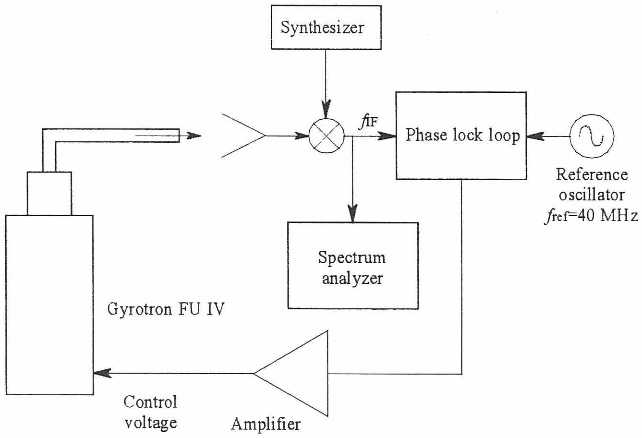
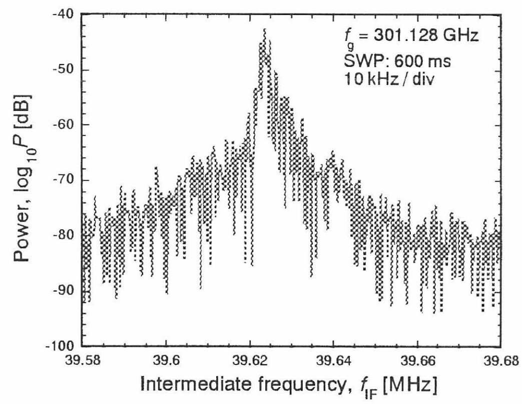



Fig.1 Block diagram of a phase lock system.

(a)




(b)

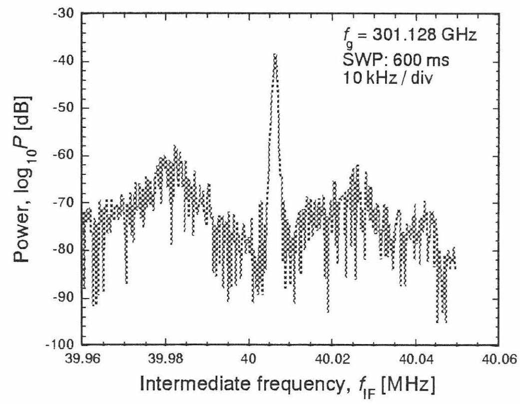



Fig.2 Observed frequency spectra of intermediate signals. (a) without phase lock stabilization and (b) under phase lock stabilization.

Reference

1) Ogawa, I., et al., Fusion Engineering and Design, **53**, (2001) 571.
2) Idehara, T., et al, Phys. Rev. Lett., **81**, (1998) 1973.