§19. Feasibility of Frequency Feedback Control for Impedance Matching in MW Level ICRF Heating

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We developed a frequency feedback control of impedance matching for plasma loading resistance change during an ion cyclotron range of frequency(ICRF) heating[1]. During steady state of ICRF heating experiment, the plasma loading resistance changes gradually with density or abruptly in L-mode to H-mode transition. We demonstrated that the frequency feedback control could make the reflected power fraction reduce to less than 0.2% with quick response time, 0.2ms. In this experiment RF electrical resistance was used instead of plasma loading resistance. It changed in the range of 2ohm to 6ohm and the reflected power fraction would have increased to 10% if the frequency feedback control did not work. The required frequency modulation was 0.24%. This experiment was done by double sub tuner system, where the normalized length between double stub tuners was quarter. A twin stub tuner was equipped on the RF oscillator side. The RF power is low such as 1W. Low RF power experiment gives us the required frequency modulation, however, we do not know how a high power RF oscillator could deliver RF power in variable frequency.

Then we examined a dependence of RF output power on variable frequency in 1MW level as shown in Fig.1. Here 95% of RF output power is guaranteed in the range of 0.6% of frequency modulation, where the central frequency is 50MHz. We should pay attention to an increase in control grid current, Ig1. The allowed Ig1 is up to 10A, however, we will need to reduce Ig1 by tuning T- and M-stub tuner in the final amplifier cavity. On the other hand, the screen grid current is same in this frequency range.

The required modulation frequency range depends on how plasma loading resistance changes and how long the shorter stub tuner of the twin stub tuner is[1]. Figure 2 shows the typical example of the relation between the required modulation frequency, df/f and the shorter stub tuner, As in the case of RF loading change from 2.2ohm to 5.6ohm. The shorter the value As is, the smaller required df/f becomes. However, the maximal voltage of RF standing voltage in the twin stub tuner, Vrf increases as As becomes shorter, which can be interpreted by an increase in RF stored energy there. When we select As=0.021, the required modulation frequency, is 0.6% and Vrf is 40kV, which is already achieved in long pulse operation. When we intend to transfer RF power more than 1.5MW, we should develop Vrf=50kV or an oscillator with more wide-band frequency range up to 1%.

Reference

1)R.Kumazawa et al., Proc. the 17th Symposium on Fusion Technology, 554(1992).

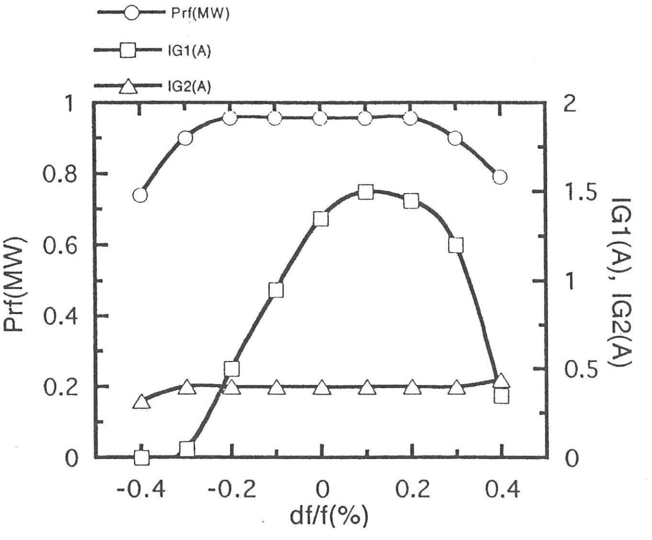

Fig.1 Dependencies of RF power, control grid current and screen grid current on frequency in 1MW level.

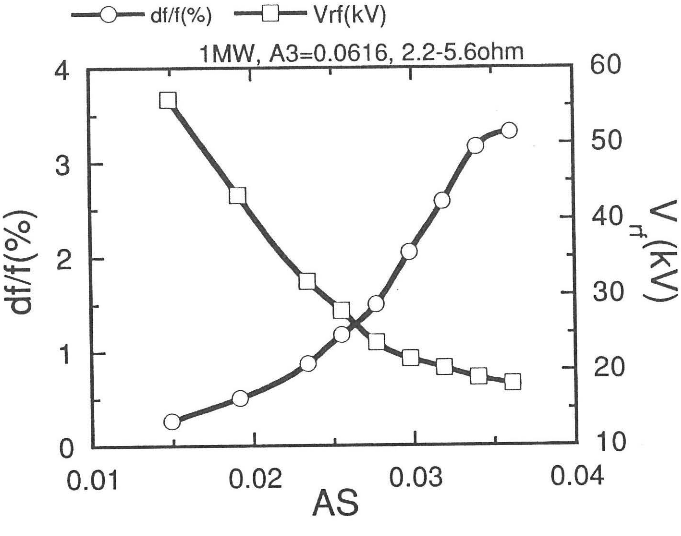

Fig.2 Dependencies of required modulation frequency and maximal RF voltage on shorter stub tuner in twin stub tuner in RF loading changes from 2.2ohm to 5.6ohm.