§29. Frequency Feedback Control for High RF Voltage and Long Pulse Test

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In previous section, we reported successfully achieved results on RF transmission system with high voltage and long pulse operation. One of the most important means is frequency feedback control. This frequency feedback control is important in the case of a temporal plasma loading resistance change due to L-H transition or a plasma density change. The RF reflected power can be reduced within 1ms by frequency feedback control with the aid of twin stub tuner[1]. In this R&D test, the RF reflected power increases with time without plasma as shown in Fig. 1, where the time evolution of RF forward power, P_{fw}, reflected power, P_{ref} and RF voltage, V_{rf} is shown in the case of typical operation without frequency feedback control. In this operation, the RF voltage is 22.5kV in the beginning of the pulse, however, it decreases to 16kV with the increase in reflected RF power. In the end of RF pulse, the reflected power fraction exceeds 50%. The RF power supply would have to be halted to protect the tetrode tube in final amplifier with the interlock system, which was not used. Figure 2 shows the typical operation with frequency feedback control, where same RF forward power is used as in Fig. 1. In this operation, the reflected power fraction, P_{ref}/P_{fw} can be kept less than 1% by the frequency modulation, from 42.02MHz to 41.95MHz. Then, the RF voltage can be kept at constant voltage, V_{rf}=22.5kV. Here the required frequency modulation, df/f is 0.2% in 50sec. When the higher RF voltage is applied, the required df/f increases and modulation rate becomes faster.

The cause may be attributed to thermal expansion of transmission line in the radial and axial directions. Figure 3 shows the dependence of the impedance-matched frequency on filling gas pressure, where the frequency decreases with the filling pressure. The characteristic impedance increase in transmission line causes the frequency change. When the characteristic impedance increases, the required RF wave length becomes shorter to compensate the effect. However, the quantitative assessment is not done yet to explain the phenomena.

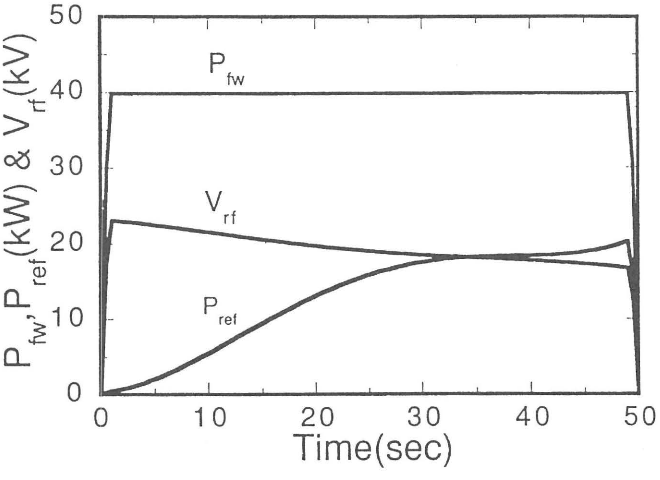

Fig.1 Time evolution of RF power, reflected power and RF voltage without frequency feedback control.

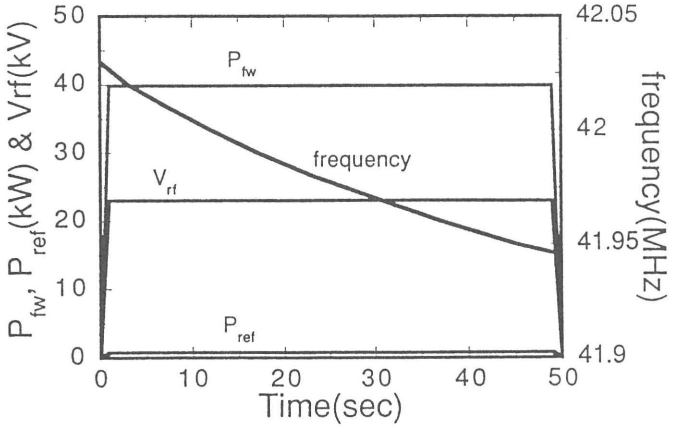

Fig.2 Time evolution of RF power, reflected power, RF voltage and frequncy with frequency feedback control.

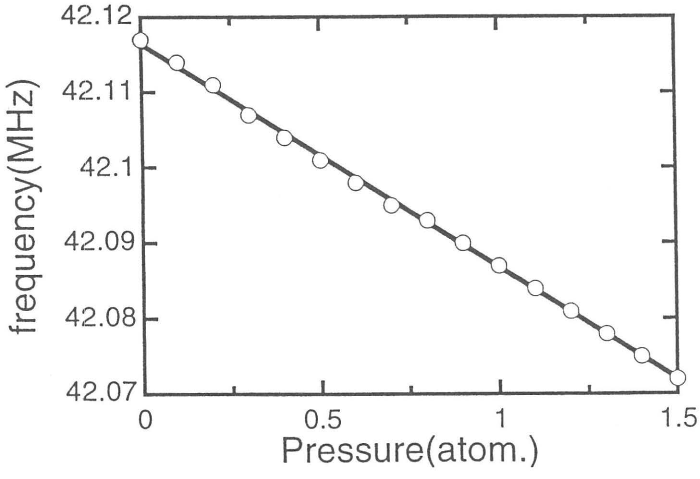

Fig.3 Dependence of impedance-matched frequency on filling gas pressure.

References

1) Kumazawa, R., Mutoh, T., et al., Proceeding of 17th Symposium on Fusion Technology (1992), Vol.1, pp.554-558.