§11. RF Voltage Reduction by Pre-stub Tuner

Kumazawa, R., Mutoh, T., Shimpo, F., Seki, T., Watari, T., Masuda, S., Nishimura, K.

We have fabricated ICRF heating R&D system for LHD, consisting of two stub tuners with pre-stub tuner[1]. The pre-stub tuner is located between RF antenna and impedance matching circuit. Selecting its location, it remarkably works to reduce RF standing voltage between the pre-stub tuner and the impedance matching circuit. RF voltage, V_L and current, I_L at pre-stab tuner position are calculated with RF voltage, V_A and current, I_A at ICRF heating antenna position according to a following equation;

$$\begin{pmatrix} V_L \\ I_L \end{pmatrix} = \begin{pmatrix} \cos 2\pi A & jZ_0 \sin 2\pi A \\ j/Z_0 \sin 2\pi A & \cos 2\pi A \end{pmatrix} \begin{pmatrix} 1 & 0 \\ -j/Z_0/\tan 2\pi A_p & 1 \end{pmatrix} \begin{pmatrix} V_A \\ I_A \end{pmatrix} \quad (1)$$

Here A_p and A are normalized length of pre-stab tuner and normalized length between pre-stab tuner and antenna, respectively. These values are normalized by the RF wave length. The maximum voltage of RF standing wave, V_{max} can be calculated along the transmission line by two quantities of V_L and I_L obtained in eq.(1). This value is compared with that of RF standing wave between the pre-stab tuner and RF antenna, V_{max0}. Reduction coefficient of V_{max}/V_{max0} will be assessed in the following section.

Figure 1 shows a calculated contour map of V_{max}/V_{max0}. The horizontal axis is the normalized length between the antenna and the pre-stab tuner, A and the vertical axis is the normalized pre-stab tuner length, A_p. Here the solution is periodic in every 0.5 of A and A_p. Numerical values of contours indicate V_{max}/V_{max0}. When A_p is 0.25, there is no reduction because the pre-stab tuner does not work. When A is selected 0.16, the ratio of V_{max}/V_{max0} can be reduced from 1.0 to 0.4 according to shortening the pre-stab tuner length, A_p from 0.25 to 0.067. When A_p is further shortened beyond A_p=0.067, however, V_{max} increases and exceeds to V_{max0} at A_p=0.037. The RF power dissipation between the pre-stab tuner and the impedance matching circuit can be reduced to 0.16 by the effect of pre-stab tuner.

The pre-stab tuner effect was experimentally demonstrated in the R&D impedance matching system for LHD[1]. RF power of 2.3W was transmitted to the impedance matching system from a signal generator. RF voltages were measured at 3 points between the impedance matching circuit and the pre-stab tuner and near the pre-stab tuner. At A_p=0.25, RF voltage measured at 4 different positions showed a standing wave along the transmission line with same maximum RF peak voltage of 270V. When A_p=0.067, RF voltages became smaller between the pre-stab tuner and the impedance matching circuit. Then the RF voltage near the pre-stab tuner(between the pre-stab tuner and the antenna) was same. Figure 2 shows the RF standing wave voltage distribution, where the original point to measure was the position of a tuning stab tuner in the antenna side. The pre-stab tuner was located at 12.2m in Fig.2. It is clear in this figure that the RF standing wave voltage can be reduced to 0.4 of V_{max0} by the pre-stab tuner.

Reference

1) Kumazawa, R., et al., Annual Report 1992-1993, 52.

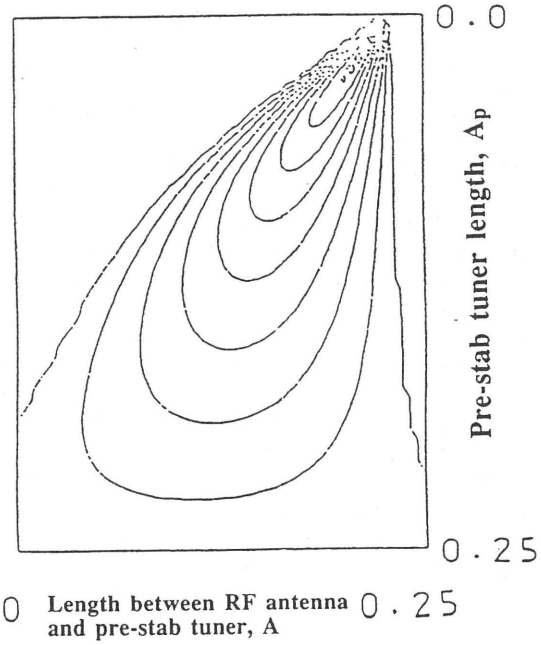

Fig.1 Contour map of V_{max}/V_{max0} in parameter range of A and A_p.

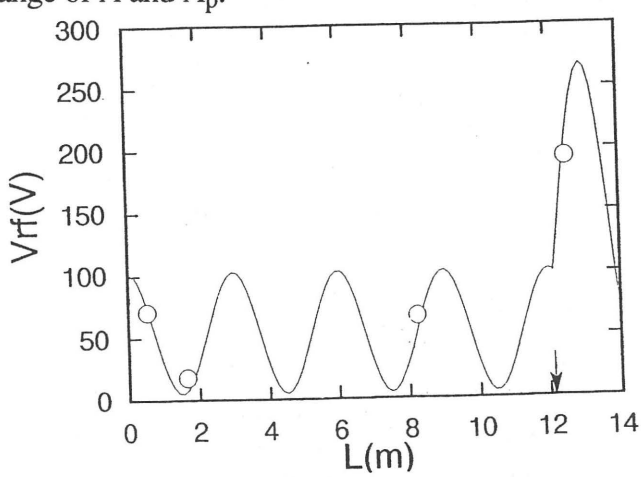

Fig.2 RF standing wave distribution with pre-stab tuner effect.