§6. Twin Stub Tuner for Frequency Feedback Control in H-L Mode Transition Plasma during ICRF Heating

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In the previous section the feasibility of a frequency feedback control against the large change in the plasma loading resistance during the H-L mode plasma transition is described. When a long stub tuner such as more than 10 times RF wave length is used as the A1 stub tuner, the impedance matching system becomes huge and a considerable RF power loss occurs due to ohmic resistance: An effective ICRF heating is not expected. Instead of using the long stub tuner we have invented a twin stub tuner consisting of a short (A_S: less than 0.1 RF wave length) and a long (A_L: a little less than half RF wave length) stub tuners as shown in Fig.1. RF voltage and current in the inlet and the exit of the twin stub tuner are expressed with using V, I and V, I_{TW} as shown in Fig.1

$$\begin{pmatrix} V \\ I \end{pmatrix} = \begin{pmatrix} 1 & 0 \\ \dfrac{1}{jZ_0 tan2\pi A_R} & 1 \end{pmatrix} \begin{pmatrix} V \\ I_{TW} \end{pmatrix} \qquad (1)$$

$$\frac{1}{tan2\pi A_R} = \frac{1}{tan2\pi A_S} + \frac{1}{tan2\pi A_L}$$

The twin stub tuner works as conventional stub tuner according to the above equation.

A combination of the short and the long stub tuner provides a good performance as expected in the long stub tuner, i.e., A_{eff} >10. The characteristics of the twin stub tuner are shown in Fig.2, where the resultant normalized length of the twin stub tuner A_R is plotted in the different four A_S=0.005~0.02. The shorter the A_S becomes, the steeper a slope of A_R, i.e., dA_R/dA_L becomes. In A_S=0.015 the change of the resultant of the twin stub tuner is from 0.13 to –0.13, i.e., ΔA_R=0.26 by the small change of the long stub tuner, e.g., ΔA_L~0.0025.

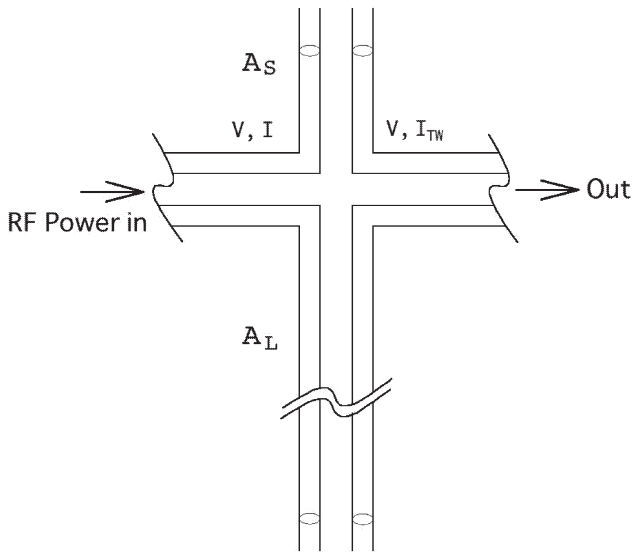

Fig.1 Twin stub tuner.

We differentiate eq.(2) by a frequency f and derive a following equation;

$$\frac{dA_R}{df} = \frac{tan^2(2\pi A_S)\cdot tan^2(2\pi A_L)}{\{tan(2\pi A_S)+tan(2\pi A_L)\}^2 + tan^2(2\pi A_S)\cdot tan^2(2\pi A_L)} \qquad (2)$$

$$\times\{\frac{1}{sin^2(2\pi A_S)}\frac{dA_S}{df} + \frac{1}{sin^2(2\pi A_L)}\frac{dA_L}{df}\}$$

From this equation, the effective length of the twin stub tuner A_{eff} can be calculated. The shorter A_S becomes, the longer A_{eff} becomes as shown in Fig.3. When A_S=0.02 is employed, the twin stun tuner works as A_{eff}~30

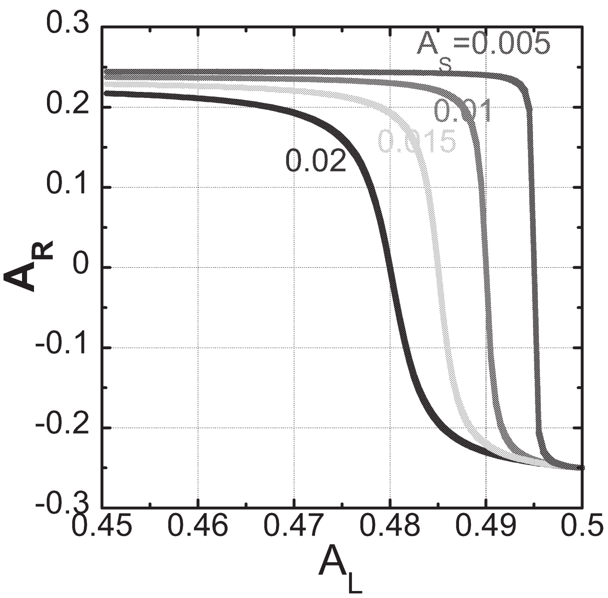

Fig.2 Reduction of reflected power fraction in the loading resistance range of 2W to 8W by changing A1.

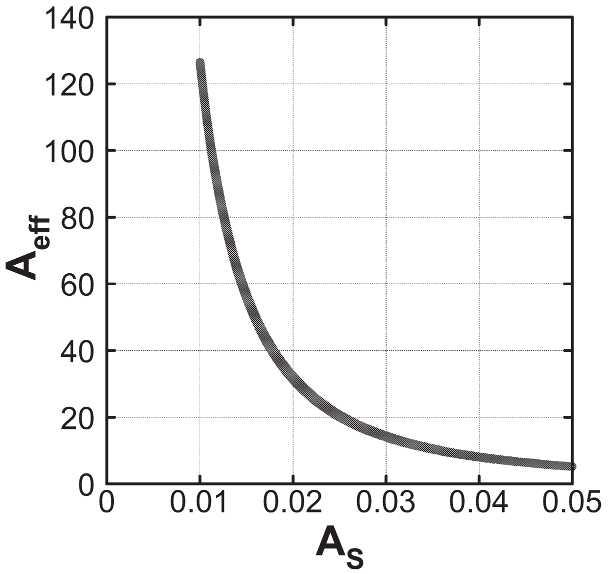

Fig.3 Dependence of A_{eff} on normalized length of short stub tuner.