# §14. Impedance Matching System of Folded Waveguide Antenna

Torii, Y. (Nagoya Univ.), Kumazawa, R.

In the LHD 4th experimental campaign, a plasma was produced using a folded waveguide (FWG) antenna.

The FWG antenna was installed in the horizontal vacuum port on the LHD. To launch a slow wave, the installed angle of the antenna is 38.9 degree for the RF electric field to be parallel to the magnetic field at the last closed magnetic flux surface. The dimension is 1,050mm in width, 428mm in height, and 3,950mm in length. It can be moved by 1,150mm in the radial direction. The antenna consists of 24 areas separated by 23 vanes, which made a wide effective width to lower the cutoff frequency to the ion cyclotron range of frequency (ICRF). RF power is fed at the second vane through a electrode, which is connected to a coaxial transmission line. The FWG antenna experiments have tried since 3rd experimental campaign. However, a movable contact of the electrode to acquire impedance matching had some troubles. External matching circuit was installed in 4th campaign.

It is indispensable to match distributed constant circuit. A mismatched circuit have some disadvantages: fear of damages of RF amplifier by reflected RF power, inefficient RF transmission, etc. In the 4th experimental campaign, the matching circuit consisting of two capacitors was installed between the FWG antenna and the transmission line.

The impedance matching system is shown in Fig.1. In this figure, the part from the connection of ceramic feed-through to that of coaxial cable is drawn. Capacitors are installed in containers, which are described as $C_1$ and $C_2$ in the figure. The containers were rigid to bear the pressure of 3 atm nitrogen in order to increase in the RF stand-off voltage. Sockets of the capacitors are connected to the inner conductor of the coaxial line with fingers to avoid breakdown. Both capacitors are vacuum variable ones: the range of 30–650pF and stand-off voltage of 60kV. The capacitances are operated from the RF control room.

The equivalent circuit with the antenna, transmission line, and capacitors is shown in Fig.2. In the figure, $r$, $l_{2a}$, and $l_{12}$ are a resistance of the antenna, a length of the coaxial line between the antenna and the capacitor, and a length of the coaxial line each capacitor, respectively. Notations, $V_a$, $I_a$, $V_{in}$, and $I_{in}$ are a voltage at the antenna, a current at the antenna, an input voltage, and an input current, respectively. The characteristic impedance of coaxial transmission lines is 50Ω. A coaxial line of $l_{12}$ = 490mm was the inductor between two capacitors. Here, $V_{in}$ and $I_{in}$ of the circuit are described using a fundamental matrix,

$$\begin{pmatrix} V_{in} \\ I_{in} \end{pmatrix} = \begin{pmatrix} 1 & 0 \\ j\omega C_1 & 1 \end{pmatrix} \begin{pmatrix} \cos kl_{12} & jZ_0 \sin kl_{12} \\ j\sin kl_{12}/Z_0 & \cos kl_{12} \end{pmatrix} \times \begin{pmatrix} 1 & 0 \\ j\omega C_2 & 1 \end{pmatrix} \begin{pmatrix} \cos kl_{2a} & jZ_0 \sin kl_{2a} \\ j\sin kl_{2a}/Z_0 & \cos kl_{2a} \end{pmatrix} \times \begin{pmatrix} V_a \\ I_a \end{pmatrix}$$

where $Z_0$ and $k$ are a characteristic impedance of the coaxial line and an RF wave number on transmission line, respectively. When the ratio of $V_{in}$ to $I_{in}$ is equal to $Z_0$, the circuit is matched.

The impedance matching test was carried out at two frequencies, i.e. of 25.3 and 37.4MHz, which are the resonant frequencies of the folded waveguide antenna. The stand-off voltage of above 30kV at the bottom of the capacitor was achieved.

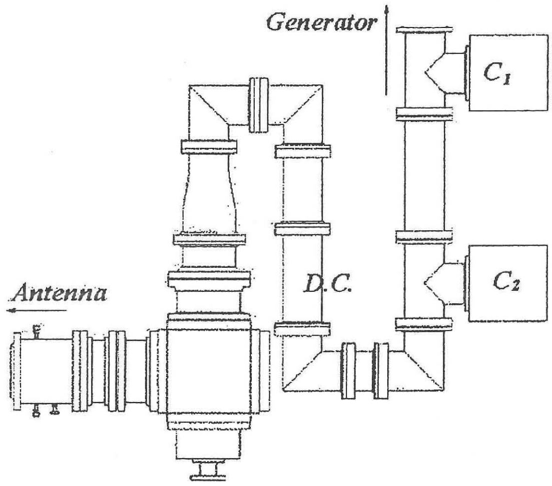


Fig.1: Matching system for folded waveguide antenna. The capacitors are installed in containers described as $C_1$ and $C_2$. D.C. is directional coupler.

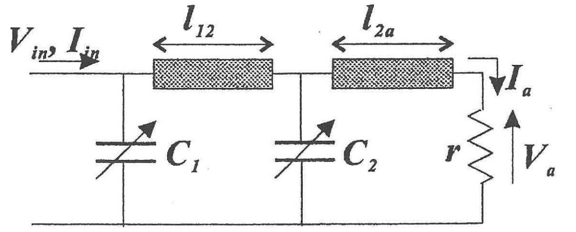


Fig.2: Equivalent circuit of the matching system. Hatched boxes are coaxial lines. It is assumed that the antenna has a resistance $r$ only.