§14. ICRF Hardware at Third Campaign

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i) ICRF waveform control system[1] In the third campaign ICRF waveform control system is introduced. Fig.1 shows the schematic diagram of the system. It is composed of a personal computer with Microsoft Windows 98 operation system, a data acquisition card with analog outputs and National Instruments Labview programming language. Labview makes analog modulation signal complying with required waveform, and outputs it through data acquisition card. By outputing modulation signal transmitted to RF power generator, amplitude modulated RF waveform is generated.

This system creates either multi-square pulse, stair wave or sine modulation, placed on main RF pulse and offset pulse. The main RF pulse is a square waveform which has ramp-up and ramp-down abilities, and offset pulse is a square waveform only.

Fig.2 shows a typical modulated RF power waveform at # 11487. Here, P is radiation power at ICRF antennae and W_p is plasma stored energy. This waveform is created by 4Hz sine wave on main RF pulse with rising time 0.70s. We can see the P and W_p are modulated.

ICRF waveform control system enables to generate various ICRF power waveforms. Modulation experiment with this system gives an evaluation of energy confinement time.

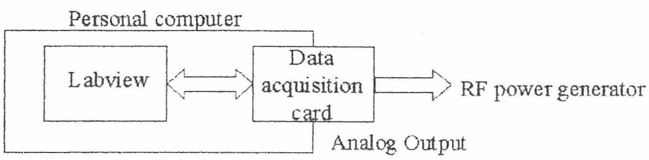

Fig. 1: The schematic diagram of waveform controlling system.

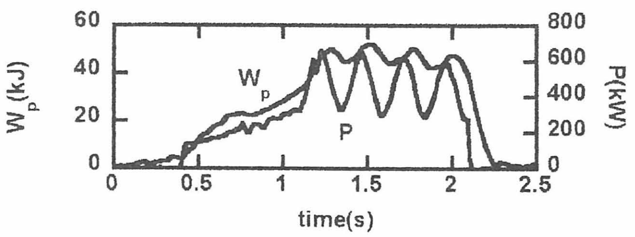

Fig. 2: A typical modulated RF power waveform, # 11487.

ii) Triple liquid stub tuner system[2] In the third cycle, triple liquid stub tuner system is introduced. Fig.3 shows the schematic drawing of the liquid impedance matching system consisting of the three liquid stub tuners, i.e. stub1, stub2 and stub3, which are identical and are electrically terminated at the bottoms. The length of the stub tuner is 4.5 m. RF power is supplied from the right hand side through D.C. break and is transmitted to the ICRF antennae. The liquid surface level can be changed from 0.3 m to 4.0 m.

By changing the magnetic field, ICRF heating study can be performed at various frequencies. So it is important to match impedances at various frequencies to reduce reflection from ICRF antennae. Strong RF reflection power from ICRF antennae damages RF power generator. On the other hand, high voltage in this liquid stub tuner system causes break down, and high RF power cannot be transmitted to the ICRF antennae by the breakdown. Therefore it is necessary to control three liquid surface levels independently. But, however liquid surface levels are controlled independently, there still remain the frequency region in the absence of the impedance matching and at which there is high RF voltage in the liquid stub tuner system. For minimizing these frequency region and reducing the RF voltage in the liquid stub tuner system, the length of the transmission line between the antenna and the top of the stub3 needs to be changed, so two short coaxial lines at the U shaped link, in Fig.3, were inserted.

Practical experiment with the triple liquid stub tuner system shows good result. This system satisfies LHD needs, such as high power, steady state and wide frequency range.

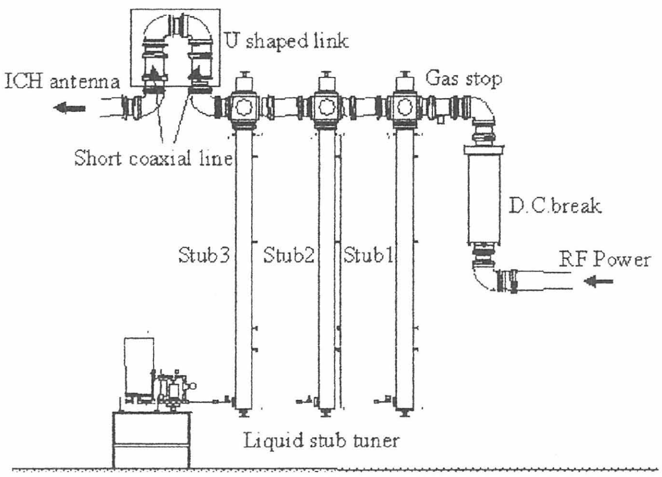

Fig. 3: Schematic drawing of the triple liquid stub tuner system.

Reference

1) Y.Zhao, et al., ICRF Waveform Controlling, NIFS-TECH-8(1999)

2) K.Saito, et al., to be published in Review of Scientific Instruments