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## Development of power combination system for high-power and long-pulse ICRF heating in LHD

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In the Large Helical Device (LHD), the development of high-power and long-pulse ICRF system is ongoing. Frequency was fixed at 38.47 MHz for the optimization of devices. At this frequency, plasma is heated with the minority ion heating of hydrogen and the second harmonic heating of deuterium. Field-Aligned-Impedance-Transforming (FAIT) antenna has the potential performance of high-power injection of more than 1.8 MW. In order to reduce the voltage in the transmission line, Ex-Vessel Impedance Transformer was also developed. However, the output power of the final power amplifier (FPA) is less than 1.2-1.3 MW for the stable oscillation in the LHD. In order to increase power into the FAIT antenna, a power combination system was developed. The target is injection power of 2 MW for 2-3 s and 1 MW for 10 min. By iterating the simulation of the electromagnetic field, optimized power combiner was designed. Then the combiner was fabricated and installed in the transmission system. The power combiner has two input ports and two output ports. Two FPAs are connected to the input ports. From one output port the combined power will be transmitted to the FAIT antenna. Another output port is connected to a dummy load. Air ducts for the air cooling are attached for the long-pulse operation. It was confirmed by the measurement with the network analyzer that the power combiner has almost perfect isolation between input ports and there are no reflections from these ports when there is no reflection at the output ports. Control of power and phase of forward waves into the input ports are important for the combination of the waves without power loss. Therefore, a real-time control system was developed and demonstrated. Step time of the control was less than 1 ms and power loss into the dummy load was successfully cancelled.

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