Construction of new amplifiers for RILAC†

K. Suda,*1 E. Ikezawa,*1 N. Sakamoto,*1 K. Yamada*1 Y. Touch,*2 T. Ohki,*3 K. Oyamada,*3 K. Kaneko,*3 M. Tamura,*3 H. Yamauchi,*3 A. Yusa,*3 and O. Kamigaito*1

RILAC consists of six variable frequency cavities (tanks) constructed in 1978[1)]. The first amplifier was constructed in 1977 as a prototype for tank #1. Five other amplifiers were constructed the next year. The #5 and #6 amplifiers were upgraded in 1999 for experiments super heavy element synthesis. Three final-stage plate DC power supply (plate PS) were upgraded at the same time; one PS supplies DC voltage to two amplifiers.

In recent years, several issues related to amplifiers #1 to #4 were encountered, such as water leaks from cooling pipes and damages to the socket for the tetrode caused by insufficient contact. The contact between the socket and tetrode is shallow and a careful alignment is necessary. In particular, the design of the #1 amplifier was the oldest, so it became difficult to maintain it. Therefore, the amplifier #1 was upgraded in FY 2013 along with #2, because the plate PS was common for #1 and #2, and its control system had to be upgraded at the same time.

The new amplifier, as well as those for #5 and #6 are based on a tetrode RS2042SK coupled with a RS2012CJ from THALES/SIEMENS with a grounded grid circuit, that were originally designed for RRC[2)]. The maximum RF signal of 0.01 W (10 dBm, 18 to 40 MHz) is amplified by pre-, driver- and, final-stage amplifiers up to 150 kW. In 14 years of operation of the RILAC #5 and #6, we have experienced several parasitic modes, which might damage the tank and/or the amplifier itself. One is caused by a coupled oscillation between the 99-MHz G1-G2 resonance of RS2042SK and the output circuit including a feeder line to the tank. The other example is the 7th harmonic mode observed in RILAC #5. In order to avoid such parasitic modes, a 50 kW dummy load was installed at a plate stub.

In a factory, matching conditions for input and output circuits of driver- and final-stage amplifiers were measured and/or tuned. (1) The gain of the input circuit for a driver amplifier called as “All Pass Network” was measured and confirmed to be sufficient. (2) An input circuit for the final amplifier was tuned by a vacuum variable capacitor (INCAP) and a movable shorting stub located at a cathode input. The following was performed after installation in an accelerator hall: (3) An output impedance of the final amplifier was matched by changing a plate stub and a capacitor (OUTCAP). Details are described in Ref.[3)].

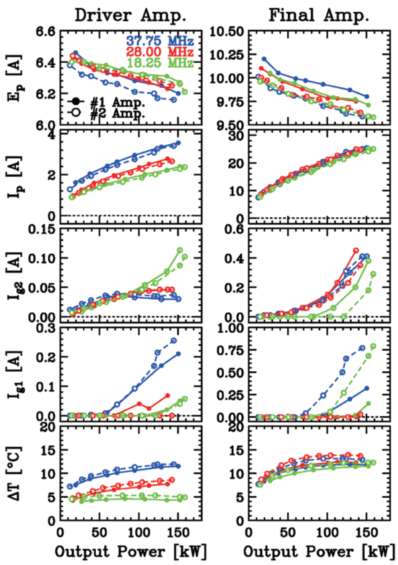

Fig. 1. Result of dummy load tests for two amplifiers (#1, #2). Voltages of plate (E_p), currents of plate (I_p), screen (I_{g2}) and control grids (I_{g1}), and the increase in temperatures of the cooling water (ΔT) for the driver and final amplifiers are shown.

The old amplifiers were removed in December 2013, and the new ones were installed in January 2014. Dummy load and power tests were performed in February 2014. In dummy load tests, a water-cooled 250 kW dummy load was connected to the output of the amplifier. It succeeded in obtaining an output power of 150 kW at three frequencies (Fig. 1). Then, load tests were performed at 36.5 MHz. The required acceleration voltages of RILAC #1 and #2 were successfully obtained. Beam service using the new amplifiers started on schedule on March 10th, 2014. A few problems occurred during operations. One was the leakage of cooling water from a rf power feeder of #1[4)]. This was partly due to heating at the output flange of the amplifier. The parameters of the amplifier were tuned, so that the temperature of the flange decreased. The other problem was that an automatic tuning control system stopped its sequence abnormally. This happened in both amplifiers in some cases since May 2014. The PLC program was corrected in October 2014.

References
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*1 RIKEN Nishina Center
*2 Sumitomo Heavy Industries
*3 SHI Accelerator Service Ltd.