Renewal of automatic tuning systems for RILAC cavities

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The RIKEN Linear Accelerator (RILAC) plays an important role with an injector to the RIBF for heavy-ions up to krypton as well as solo acceleration for super-heavy element synthesis. The resonance frequency of RILAC cavities is conserved by moving a large compensator using a feedback system, which mainly varies according to the capacitive reactance of cavity, because the frequency is fluctuated by disturbances such as heat or pressure. The basic principle of a frequency tuning system is that a relative phase difference between rf signals from a cavity pickup and an amplifier input is detected and the compensator is moved so as to keep the phase difference constant. The previous frequency tuning system caused much interruption of the machine time, because the inert response of feedback led to tripping of amplifier, and the drift of phase reference during a long-term operation had to be adjusted locally by stopping the beam acceleration. Therefore, a new frequency tuning system has been developed to realize long-term operation without interruption.

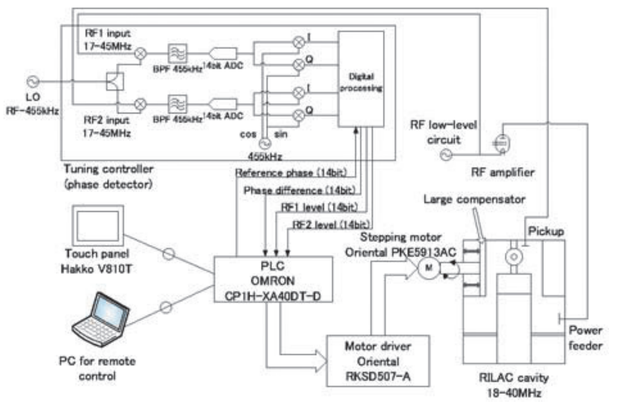

Fig. 1. Block diagram of the new frequency tuning system for RILAC cavities 5 and 6.

We replaced the tuning system for RILAC cavities 5 and 6 at first, because their rated voltage was higher and they experienced frequent trips. Figure 1 shows a block diagram of the new frequency tuning system. Although the basic principle is the same as the old one, much improvement was achieved, as follows.

A tuning controller (phase detector) was newly developed based on the concept of digital signal processing. Since the requied responce speed of the feedback is not very high (it includes a mechanical system), the two input rf signals are reduced to an intermediate frequency (455 kHz) by a double-balanced mixer with a local-oscillator signal, and converted to a 14-bit digital signal. Each digital signal is translated to in-phase (I) and quadrature-phase (Q) signals and the phase difference is determined by digital processing in a field-programmable gate array. The phase difference data is corrected by an applied reference phase to produce the phase deviation from the reference phase and output to a digital interface. The reference phase can be set to an arbitrary value or the present value of the phase output by a local and remote one-push button.

The old tuning system used a geared print motor, which was a DC motor whose rotation speed could not be controllable accurately. By fabricating a mounting plate and driveshaft coupling, the motor was replaced by a new stepping motor. The stepping motor is controlled by a programmable logic controller (PLC) with the principle of proportional speed control feedback based on the phase difference data. The maximum moving speed, feedback gain, and neutral zone can be accurately set locally and remotely.

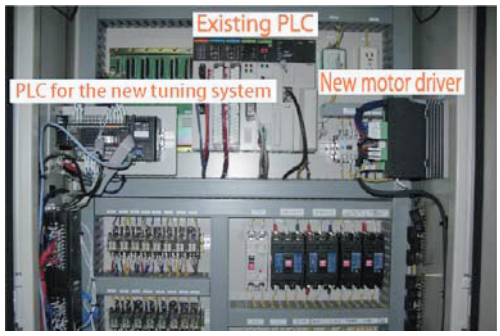

Fig. 2. Control unit of the new tuning system built in the existing RF control system for RILAC cavity 5.

Figure 2 shows the control unit of the new tuning system built in the existing RF control system for RILAC cavity 5. Since the existing PLC was discontinued, we introduced an additional PLC only for the tuning system. A touch panel for the local operation of the tuning system is shared with that for the RF control system. The new tuning system was successfully commissioned in Dec. 2012 on cavity 5, and the replacement for cavity 6 was carried out in Feb. 2013. Owing to the renewal, the stability of feedback was significantly improved and work on its availability during long-term operation is currently in progress.

At the time of the renewal of amplifiers for RILAC cavities 1 and 2 in the winter of fiscal year 2013, the new tuning controller was introduced for these cavities. The residual tuning system for cavities 3 and 4 will be replaced in parallel with the renewal of amplifiers in the future.

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