Performance of RF Amplitude and Phase at Linac

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In the J-PARC linac, the beam-energy upgrade from 181 MeV to 400 MeV was successfully achieved in 2014 by the installation of new twenty-five cavities, Annular-ring Coupled Structure (ACS). The resonant frequency of the ACS cavities becomes 972 MHz whereas that of the upstream cavities was 324 MHz. Therefore, we had developed a 972 MHz low-level RF (LLRF) system and a 3-MW klystron of 972 MHz. The twenty-five sets were installed in the shutdown of 2013 and properly operated.

The amplitude and the phase stabilities of the RF systems play an important role for a high intensity proton accelerator due to suppress the beam loss. For the J-PARC linac, the requirement of the accelerating field ambiguity is maintained within ±1% in amplitude and ±1 degrees in phase due to the momentum acceptance of RCS (requirement: $\Delta p/p<0.1\%$)[1]. To realize these requirements, a digital feedback (FB) control and a feed-forward (FF) technique are used in the LLRF control system. When the previous structure just consisted of the 324 MHz RF systems, the amplitude and the phase stabilities were less than ±0.2% and ±0.2 degrees in the beam condition of the peak current 16 mA (300 kW equivalent at MLF), respectively [2]. On the other hand, the highly accurate control of the new 972 MHz system was predicted to be harder because of the three times higher resonant frequency and the lower quality factor (Q_L~8,000) of the ACS cavity. However, we achieved the stabilization of ± 0.15% in amplitude and ±0.15 degrees in phase without the beam condition. At the beam peak current of 16 mA, the ambiguity of the amplitude was obtained to be about ±0.3% and that of the phase was less than ±0.2 degrees.

We would like to introduce the LLRF systems and mention the performance at the J-PARC linac.

References

[1] Y. Yamazaki, et al., KEK Report 2002-13 and JAERI-Tech 2003-44.
[2] T. Kobayashi, et al., Proc. of PAC07, pp. 2128-2130 (2007).