

such as beam load, temperature changes and frequency sources unstable would make cavity detuning, so it is necessary to use tuner for dynamic correction. Furthermore, the offset of cavity resonant frequency caused by mismachining tolerance and the welding deformation can also be compensated by tuner. Vacuuming port is located at the bottom of the cavity with the ion pump. The mechanical structure of buncher is shown in Fig. 2.

In June 2014, the fabrication of bunchers and their parts were completed and then passed high power condition test. The results agreed well with the design requirements. The test site is presented in Fig. 3. At present, the two bunchers are installed in MEBT1 for beam commissioning and work in good condition.

6 - 8 LLRF Control System for ADS Injector II

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The ADS Injector II is a linear superconducting accelerator, which is made up of the four vane type RFQ, MEBT and superconducting cavities. The amplitude and phase stability of all RF resonant cavities need to be controlled precisely by the low level radio frequency (LLRF) control system. Fig.1 is the block diagram of the LLRF control system, which is composed of the RF synchronous signal distributor, LLRF system and solide state RF high power amplifier.

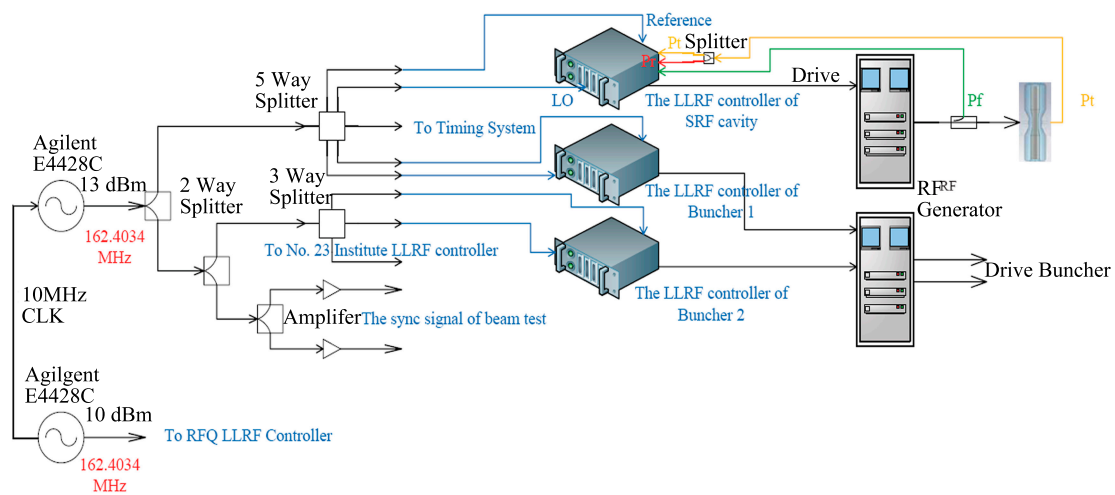


Fig. 1 (color online) The block diagram of the LLRF control system.

The LLRF control system which used to control buncher and superconducting cavity is developed by IMP, CAS. Fig.2 shows the system architecture of one LLRF system, which consists of cavity amplitude stability controller, phase stability controller and the cavity resonance frequency controller, and the operating frequency of it is 162.5 MHz. The system is an all-digital closed-loop feedback control system and based on the IQ quadrature sampling demodulation technique.

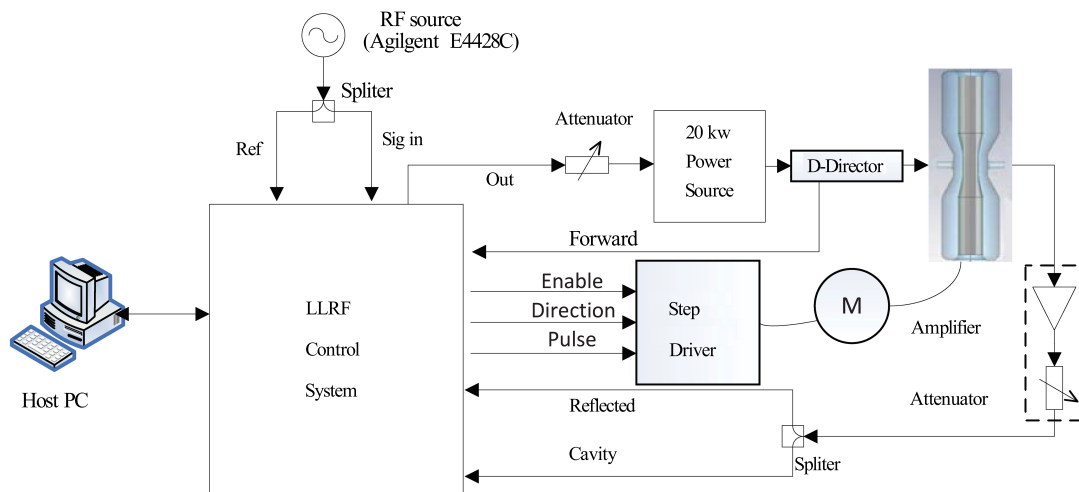


Fig. 2 (color online) The system architecture of one LLRF system.

The stability and performance of the LLRF control system had been tested on the superconducting HWR cavity, which operated in the temperature range of liquid helium. Figs. 3 and 4 show the test result, when the amplitude and phase of the superconducting cavity is locked by the LLRF system, the amplitude fluctuation is less than $\pm 3.4\%$ and the phase stability is better than $\pm 0.3^\circ$, and the cavity accelerating electric field reached to 25.1 MV/m which met the design requirement.

The long-term operation stability was also tested on the buncher which is part of MEBT, Figs. 5 and 6 show the performance data of 16 h running, the amplitude stability is 2.7%(Peak to Peak) and phase stability is $\pm 0.32^\circ$ (Peak to Peak).

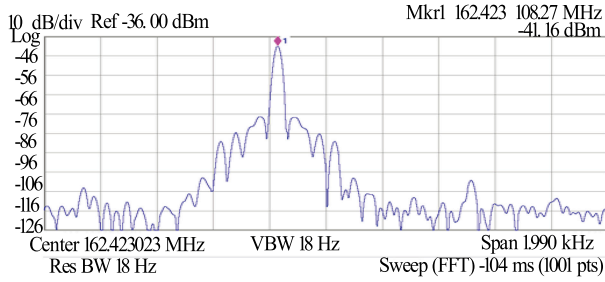


Fig. 3 (color online) The cavity pick up RF signal spectrum of the open loop state.

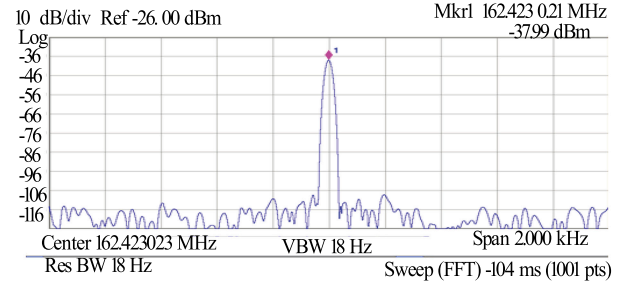


Fig. 4 (color online) The cavity pick up RF signal spectrum of the close loop state.

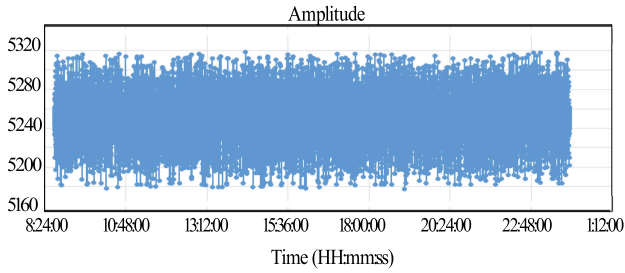


Fig. 5 (color online) Amplitude stability: 2.7%(Peak to Peak).

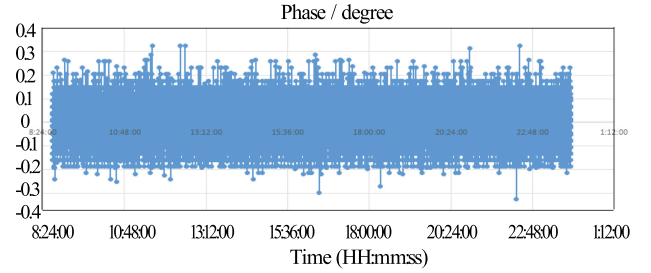


Fig. 6 (color online) Phase stability: $\pm 0.32^\circ$ (Peak to Peak).

After a long time of debugging, this LLRF control system can maintain stable operation for a long time. Base on this condition, beam commissioning proceeded smoothly, the ADS injector II achieved 3.6 mA CW operation for 3 h in November 2014, and successfully accelerated 11 mA proton beam in CW mode for 1 h in February 2015. The useful experience is accumulated for the future system upgrade, and the further system optimization will be proceeded.