THE BEAM ENERGY FEEDBACK SYSTEM IN BEIJING ELECTRON POSITRON COLLIDER II LINEAR ACCELERATOR

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Abstract

The beam energy feedback system in Beijing electron positron collider II (BEPCII) linear accelerator consists of three parts. They are the beam energy measurement Input/Output Controller (BEM IOC), the Graphical User Interface (GUI) based on Qt platform and the phasing system. This article describes the implementation of this system and the online testing which has been passed on March 16th, 2016. By using this feedback system, the injection rate and the energy fluctuation of the injection beam has been improved a lot. Now this system is steady running in the control room of BEPCII linear accelerator.

Introduction

Beijing electron positron collider has been upgraded into Beijing electron positron collider II. Its storage ring has the higher demand on the quality of the beam at the exit of the linear accelerator. While in the long time operation of the linear accelerator, the drift of the center energy cannot be avoided. To suppress the fluctuation of the beam energy at the exit of the accelerator, a beam energy feedback system has been developed. Because the klystrons are working on the saturation condition, we choose the accelerating phase of the last klystron at the end of the linear accelerator as the controlled quantity.

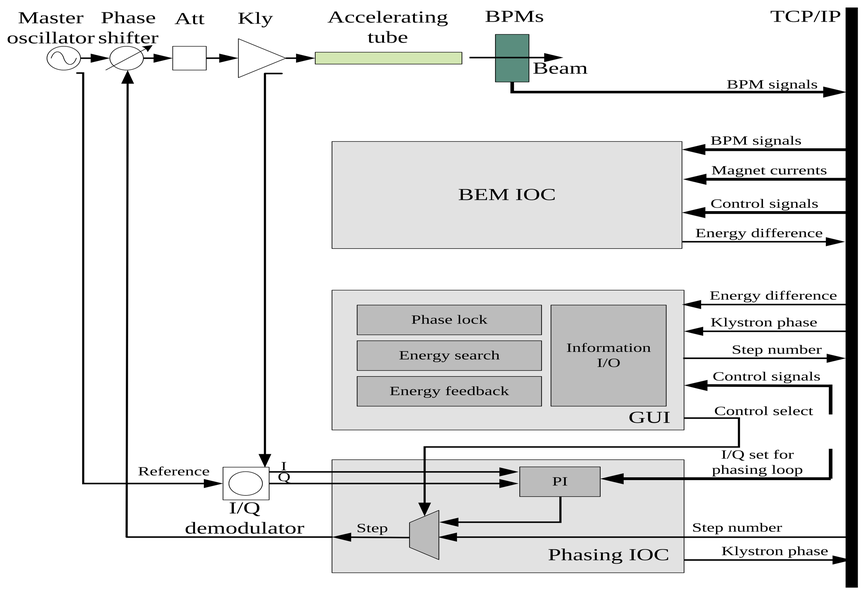

Figure 1: The diagram of the beam energy feedback system in BEPCII LINAC.

Composition

The system consists of the beam energy measurement (BEM) IOC, the GUI application and the phasing system.

The BEM IOC measures the difference between the beam center energy and the nominal one by using 3 BPMs (TCBPM1, TCBPM2 and TE/PBPM1, Fig. 2). The data sampling rate of the BEM IOC is set to be 10 Hz (maximum beam repetition 50 Hz). Though it is not a pulse to pulse system, considering the phasing system is the combination of stepping motors and phase shifters, it meets the requirements of phase adjustment and center energy fluctuation suppression.

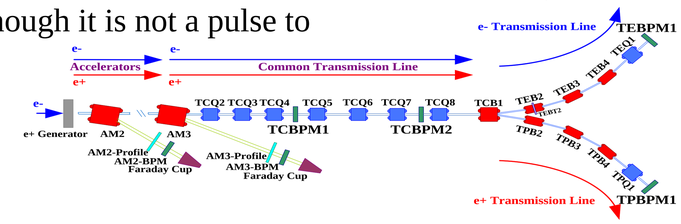

Figure 2: The layout diagram of the BPMs and the magnets at the end of BEPCII LINAC.

The GUI application (Fig. 3) has two significant functions: communicate with the users and calculate the controlled quantity. It is set to be easy to use and its interface is also very visual (its language is Chinese for its users are all from China). To realize the function of beam energy feedback, it runs the phase locking algorithm, energy searching algorithm and energy feedback algorithm in background. The control logic during the injection is shown in Fig. 4. When there is no beam, phase locking algorithm is activated. Both the phase locking algorithm and the energy feedback algorithm take the return difference of the phase shifter into account.

The phasing system has worked in the linear accelerator for nearly ten years. It is used by the energy feedback system to adjust the accelerating phase of the klystron. We redesigned its control speed and control priority to fit the new task.

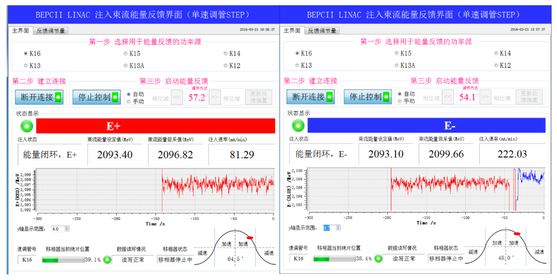

Figure 3: The screenshot of the system in collision mode (left is for positron injection and right is for electron injection).

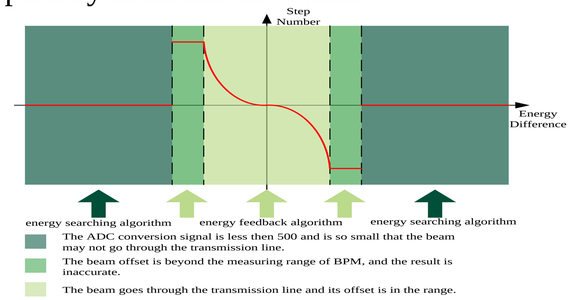

Figure 4: The control logic during the injection. In energy feedback algorithm, the control is nonlinear because of the nonlinear relationship between phase and energy gain.

Performance

The beam energy feedback system passed the online testing on March 16, 2016 and came into use from then on. It can suppress both the fluctuation of the beam energy and the injection rate effectively. The peak-to-peak value of the injection rate is less than 10 mA/min with the system and 20 mA/min without it. The energy fluctuation of both positron and electron is less then 1‰ by using this system.

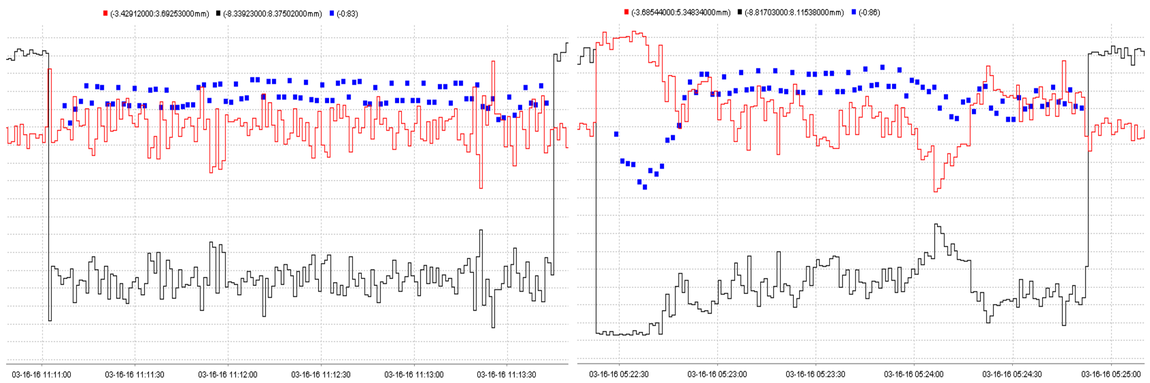

Figure 5: The comparison of the injection with the beam energy feedback system (left) and the injection without the beam energy feedback system (right). The blue points are the injection rate values recorded by Archive Database. The red line and the black line are the measurement results of TPBPM1 and TPBPM3, respectively. They indicate the fluctuation of the beam energy to some extent.

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