Test of Beam Position Control Logic with EPICS for Compensating the Remnant Bending Magnet Field in PEFP MEBT**

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1. Introduction

One of main purpose for Proton Engineering Frontier Project (PEFP) is developing a 100 MeV proton accelerator which will be installed in the Gyeongju site. It will provide 20 MeV and 100 MeV proton beams for scientific research of the materials and life sciences.[1,2,3] In order to switch the beam energy output, a Medium Energy Beam Transfer (MEBT) will be installed after the 20 MeV DTL tank. The MEBT includes a 45-degree bending magnet for 20 MeV beam extraction and two small DTL tanks for beam matching into the 100 MeV DTL. For switching to the 100 MeV energy output, we need to turn off the bending magnet. Due to the remnant magnetic field, the beam suffers the Lorentz force and will deviate from the desired orbit. So we studied a beam position control system to compensate the distortion by using the Experimental Physics and Industrial Control System (EPICS).[4,5,6] In this paper, we talk about the beam control system design and test it in a simplified situation.

2. The Design of Beam Position Control System

The basic layout of the beam control which is shown in Fig. 1. In this study, we considered the horizontal beam control only. The beam position control system uses two Beam Position Measurement (BPM) systems (BPM1, BPM2) and two steering magnets (kickers ST1 and ST2) to construct a feedback loop for changing the beam center positions so as to let beam coincide with the geometrical center. We use a beam control logic to drive the controller to aim the beam into the 100 MeV accelerators. The two BPMs can obtain the beam center positions and send the data to the EPICS controller. And the control logic calculates the appropriate steering angles for two steering.

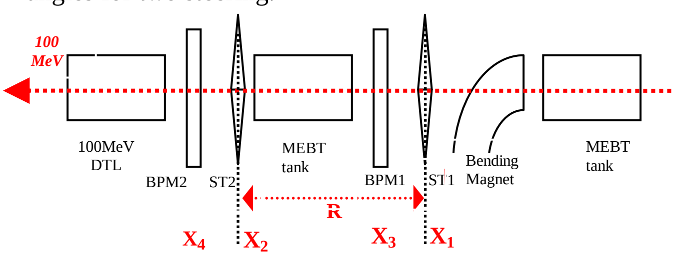

Fig. 1. The layout design of the beam position control system

The control system consists of beam measurement and magnet control system, the EPICS based controller, as well as the Operator Interface (OPI) client.

2.1 Control System Structure

The layout of beam control system is shown as Fig. 2. Now the EPICS controller is designed based on a Linux x86-PC, it can be conveniently convert to the Solaris platform in future. The controller is an EPICS Input/Output Control (IOC) server, and OPI client used for the monitor the control system.

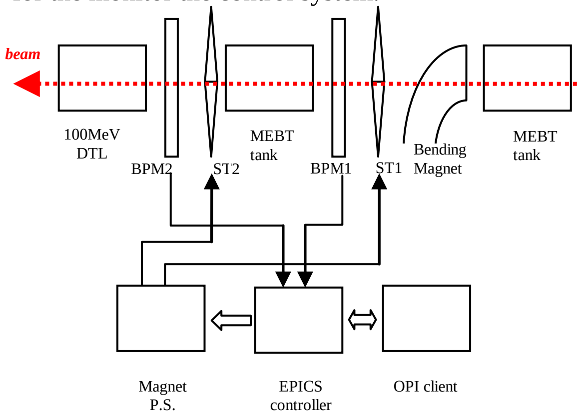

Fig. 2. The control system structure

2.2 The Schematic Design of the Control System

The software part of the beam control system is the essential. It includes the control logic and the data interfaces. Its structures are shown as Fig. 3. In this way we used the beam dynamics simulator to obtain the beam position information only.

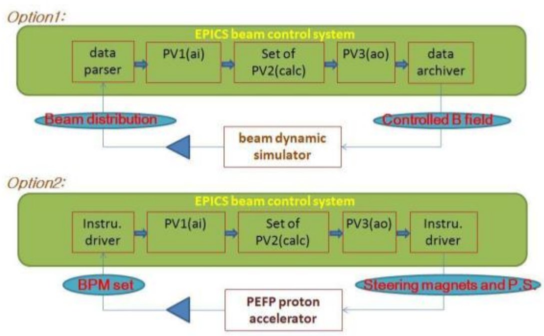

Fig. 3. the software design of the beam control system

And the simulator will be replaced to the beam position measurement system in future. The measured position data will be proceeding by the EPICS-based controller. Firstly it will go through the analog input record, and subsequently do the control logic in the calculation type record, finally use analog output record to write data file. The beam control algorithm was implemented using the record support and device support within an EPICS IOC server.

2.3 The Test of the Beam Control

We used control logic to test the EPICS beam control system. The system calculates the steering angles which are needed for the magnets.

The beam position information measured in two BPMs is converted into the (x_1, x_1') at the first steering magnet. From the transfer matrix M between two steering magnets, we can obtain the kick angles like [7].

$$\theta_1 = -\frac{M_{11}x_1 + M_{12}x_1^{'}}{M_{12}}$$

$$\theta_2 = -(M_{21}x_1 + M_{22}x_1^{'} + M_{22}\theta_1)$$

In this case, we neglected the RF field effect in the transversal direction and just care about the single particle tracking.

3. Result

Table 1 summarized the calculated beam positions at BPMs and the kick angles of the steering magnets.

Table 1: Test Results of the Beam Control

The measured beam positions (millimeter)	
x_3	1.54
x_4	0.70
The required beam center(millimeter)	
x_2	0
x_2'	0
The steering angles(m-radian)	
θ_1	-1.2
θ_2	1.2

The control result is shown in Fig. 4. The x-axis represents a device node. The y-axis represents the beam center deviations in millimeter. The blue line is calculated beam center position without kickers. The red line is the calculated beam center position as the control system is working. The result shows the control system works well.

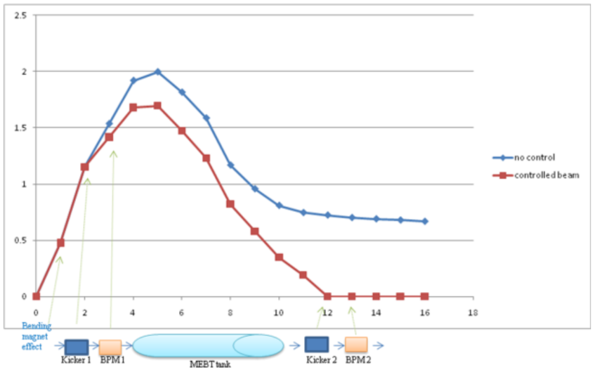

Fig. 4. The beam center positions in different stage before and after control

4. Conclusions

In this work, we studied beam control system as well as the software controller. Through a simplified test, the function of EPICS based beam control system was proved. It will include the real hardware interfaces in next step.

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