DAQ SYSTEM OF BPM AND BCT FOR THE BEPCII LINAC

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Abstract

Following the BEPCII upgrade, total about 19 BPMs and 12 BCTs have been newly installed in the BEPCII Linac. Also, a set of distributed control system based on EPICS architecture has been built, and the BPM and BCT system are merged into the new control system for the data acquisition. In order to reduce the effects of RF noise, a special gated integrator was used for the BCT system. In this paper we will describe the DAQ system of BPM and BCT including calibrations in detail.

INTRODUCTION

The Beijing Electron-Positron Collider (BEPC) has been put into operation since 1989. As the second phase project of the BEPC, namely BEPCII, it will be upgraded to a double ring electron positron collider. The BEPC linac used working at 1.3 GeV. The beam from the linac is a single bunch of 2.5 ns width with 2856 MHz RF structure. The peak current of the injection beam is 600 - 800 mA for electron and about 3 mA for positron at the injection points of the ring. In order to meet the requirements of BEPCII, a very important requirement for the BEPCII linac is the injection rate of 50 mA/min at 1.89 GeV for the positron beam. Since there has no any BPMs in BEPC linac, it's very hard to know and control the beam quality for the normal operation, as well as high beam transmission. In the upgrade of BEPCII-Linac, total about 19 BPMs and 12 BCTs have been newly installed in the BEPCII Linac and a beam orbit correction loop will be used to partially cure the initial beam offset effects and machine alignment error effects on the beam emittance growth and orbit offset. Because the BEPCII storage ring will adopt 500MHz RF cavity instead of 200MHz cavity used at BEPC, So a new electron gun with 1ns full width at half maximum (FWHM) has been developed in order to match the 500MHz RF cavity. Also, the new BCT detector, which high frequency response can be reached up to 1.5 GHz, was manufactured and calibrated. In order to reduce the effects of RF noise, the SR250 gated integrator was adopted for the beam current measurement. Furthermore, in order to meet the requirements of the BEPCII Linac upgrade, a set of distributed control system has been built also, and the BPM and BCT system is being merged into the new control system for the data acquisition and data processing.

SYSTEM STRUCTURE

Beam-Position Monitors

The stripline-type BPM, which has a high sensitivity and a simple structure, is now most popular with pulsed beam in linac. So a conventional stripline-type BPM with orthogonal structure was designed. The stripline length is 150mm. The angular width of the electrode is 60 degrees in order to increase the signal sensitivity and avoid a strong electromagnetic coupling between the neighboring electrodes. For the reason of structure simply, a SMA - feedthrough is connected to the upstream side of each electrode, while the downstream ends are short-circuited to a pipe [1].

Beam-Current Monitors

The beam current monitor，which has fast frequency response and with a shielding structure, is designed for the 1ns length beam current measurement. Actually, the detector consists of a ceramic resistor ring, a toroidal ferrite core and an aluminum case [1]. The toroidal ferrite core with 10000 gauss initial magnetic permeability and the ceramic resistor of 16 Ohm were selected for the fast frequency response. An aluminum case is used for the shielding. In addition, the detector is designed as two half ring structures in order to the detector installation easily. The schematic drawing of the BCT monitor is shown as Fig. 1.

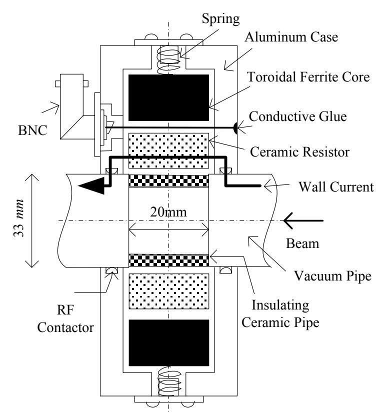

Figure 1: Schematic drawing of the BCT monitor.

Hardware Structure of DAQ

There are 5 monitor stations along the BEPCII linac gallery. All the BPMs and BCTs are connected to these monitor stations. Each monitor stations, consists of a VME computer (running VxWorks operation system), a gated integrator (for the beam current measurement), a log-ratio BPM and a signal-combiner box. The signal-combiner box is used for the signal multiplex and signal amplification (is mainly used for the weak positron beam). A DG535 is located at principal monitoring station and will offer the delay timing for the log-ratio BPM and gated integrator. Each monitor station has one unit BPM electronics and one unit BCT electronics, which can control 6 BPMs and 6 BCTs at best. The block drawing of the hardware Structure of BPM and BCT system is shown in Fig. 2. The pick-up signals of BPMs and BCTs

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are directly fed to a signal-multiplex box. In the signal-multiplex box, the signals from BPMs and BCTs are multiplexed, and then the BPMs signals are fed to the log-ration BPM electronics while the BCTs signals are fed to the gated integrator. At the end of the analog chain, there is a VME ADC module (IP330 in the AMVE9670 carrier board). The analog signals of BPMs and BCTs through the processing of BPM electronics and BCT electronics are fed into this ADC module for the converted of analog to digital.

Regarding the signal processing electronics, we adopt the LR-BPM signal processing electronics of the Bergoz Company for beam position measurement and model SR250 gated integrator to perform the beam current measurement, respectively. In the LR-BPM electronics, the signals from the BPM pickup electrodes are processed simultaneously thru four independent channels. Each channel consists of an input band-pass filter, followed by an amplification chain with logarithmic response. The LR-BPM principle of operation is that Log signals from opposite pickup electrodes are deducted from one another to obtain Log(A) - Log(C) = Log(A/C) which is said to be a very faithful representation of beam displacement between two pickup electrodes [2]. The SR250 Fast Sampler module is a gated integrator with four discrete user-selected gate widths from a few nanoseconds to 100 milliseconds. All of the necessary electronics are built into this high-speed module including an exponential averaging circuitry, A/D, D/A and a correction circuit to eliminate the inherent non-linearities in the sampling bridge [3].

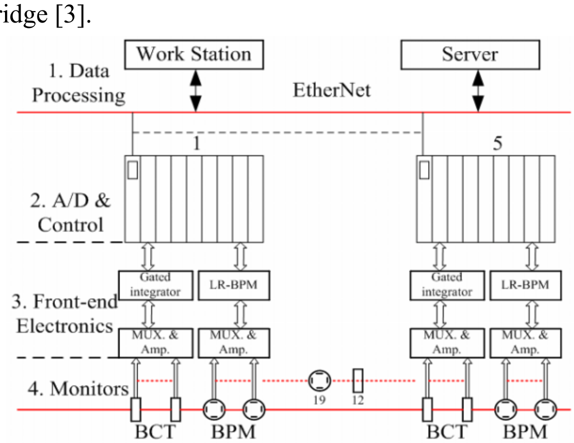

Figure 2: Block diagram of the DAQ structure.

The calibration of hardware

Before the installation of the BPM and BCT in the tunnel, all monitors must be mapped by using the calibration system. Test-bench calibration to the BPM detectors was carried out in the laboratory with a movable antenna in order to find out the offset value and BPM sensitivity. We determined the center of the BPM detectors by measuring the reference-plane of machining and then moved the antenna step-by-step over the desired area from the center of BPM assembly. We had a coarse calibration and a fine calibration. The measurement rang for each calibration is ±5mm with 0.5mm step or 0.1mm, respectively. The measurement is completely automatic. Once the calibration data are obtained, the curve fitting in MATLAB was used to extract polynomial coefficients by the least square root method. The test-bench calibration of BCT monitor consists of a tapered coaxial tube, an impulse generator and a digital oscilloscope. In order to increase the BCT calibration accuracy, we adopt the scheme of holistic calibration instead of the individual component calibration. At the same time, we also adopt the calibration of area integral instead of the calibration of peak value. Fig. 3 shows the schematic block diagram of BCT calibration set.

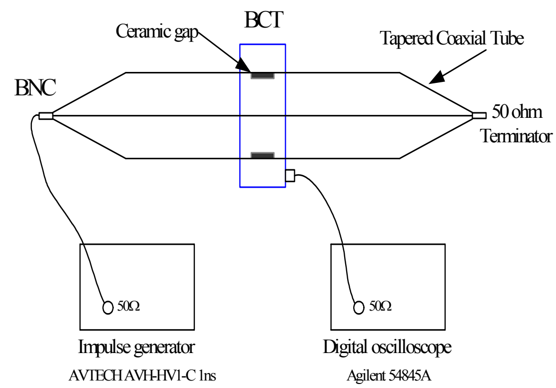

Figure 3: the schematic diagram of BCT calibration.

Control Structure

Because the BEPCII control system adopts the EPICS architecture, so the operating system running in the VME computer is VxWorks. The IOC is power PC 750 serial microprocessor MVME5100. The software structure adopts the principal and subordinate scheme based on the distributed control system. Total of five monitoring stations are divided into one principal station and four subordinate stations. The principal station could provide with CAN controller, GPIB controller and DG535, except that it has the function of subordinate station. The subordinate station could provide with the RF signal switching and ADC. The trigger-pulses synchronized with the linac beam through DG535 are provided to all of the subordinate stations. The DG535 is controlled by GPIB module in the VME crate. The signal switching is realized through the CAN controller in the signal-multiplex box. Both BPMs and BCTs could be measured simultaneously due to they two are independent. The signal switching speed at each monitoring station is about 100 Hz to 1Hz selected by the program. The DAQ processes are running concurrently at the front-end VME computers and at host computer located in the control room. The data transmission between the monitor stations and the control room is performed through Ethernet.

ON-LINE TESTS

The DAQ system tuning has been carried out in the laboratory. The beam tests are being performed by using single-bunch beams, electron or positron under the condition of 5Hz repetition rate at each monitoring station.

Table 1 and figure 4 show examples of the beam tests. At table 1 and figure 4, which show the both horizontal and vertical displacements of the beam from the center in table format and bar chart format, respectively.

Table 1: the beam position.

BEPCII Linac BPM Value

	Name	s (m)	x (mm)	y (mm)
1	BPM01	0.10	0.84	0.84
2	BPM02	3.00	0.91	-0.00
3	BPM03	5.00	0.14	-0.84
4	BPM1	8.80	-0.76	-0.91
5	BPM2	16.57	-0.96	-0.14
6	BPM3	18.74	-0.28	0.76
7	BPM4	24.29	0.66	0.96
8	BPM5	28.07	0.99	0.28
9	BPM6	32.79	0.41	-0.66
10	BPM7	37.52	-0.54	-0.99
11	BPM8	45.88	-1.00	-0.41
12	BPM9	56.81	-0.54	0.54
13	BPM10	67.13	0.42	1.00
14	BPM11	81.09	0.99	0.54
15	BPM12	95.06	0.65	-0.42
16	BPM13	102.18	-0.29	-0.99
17	BPM14	135.49	-0.96	-0.65
18	BPM15	162.44	-0.75	0.29
19	BPM16	188.54	0.15	0.96

commissioning. It's sensitivity is enough for the weak positron beam.

It needs to explain, in the signal-multiplex box, each pick-up signals of BCTs is firstly divided into two signals. One is fed to the gated integrator while other one is fed to a digital oscilloscope located in the control room for the conveniently use at the beginning commissioning stage. Now the software of BCT system has just carried out in the laboratory. The system will be on-line tested.

There has 2 BPMs (BPM01 and BPM02) before the buncher to determine the angle and offset of the beam entering the buncher. Unfortunately, because of the limitation of the tight space, these two BPMs have no any support to keep the relative position between the BPM electric center and the adjacent magnetic center unchanged. In addition, these two BPMs can not be aligned at now. This strongly affects the buncher beam commissioning. We are planning to solve this problem in this summer by the installation of alignment support. Generally to say, the DAQ system with principal and subordinate structure is simple and reliable.

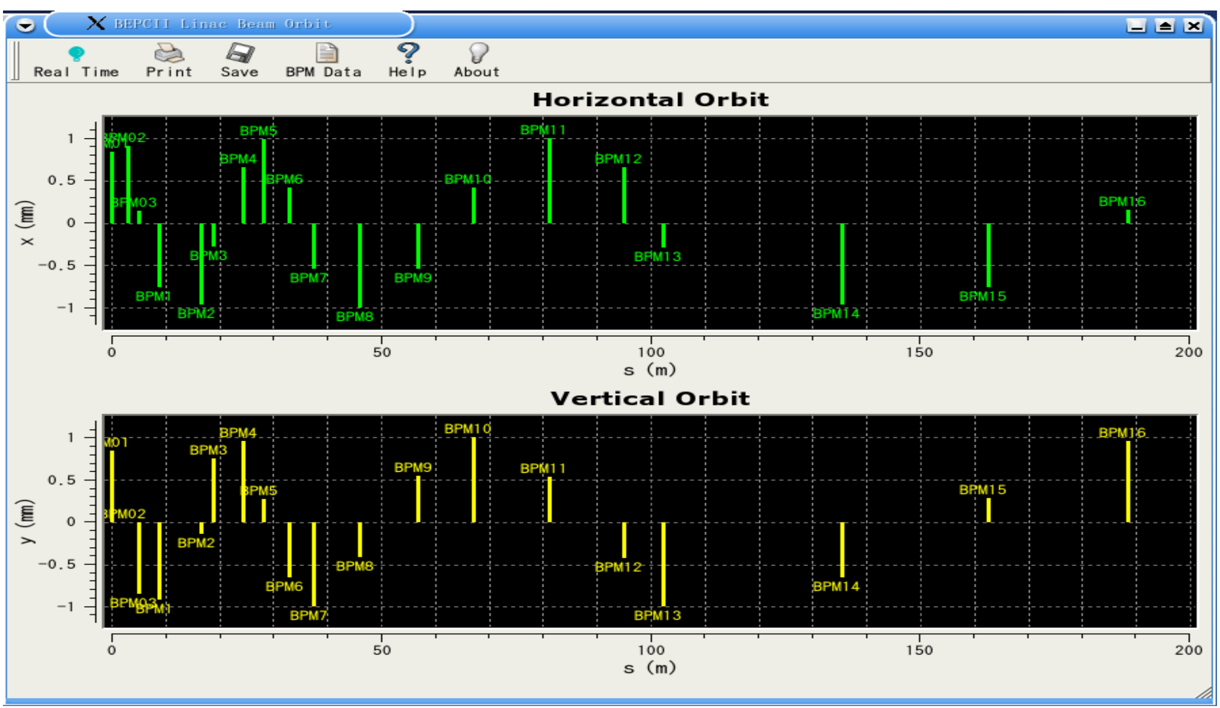

Figure 4: the beam orbit shown in bar chart format.

CONCLUSIONS

At the commissioning stage of the new DAQ system, we met a problem of electromagnetic interference. After we solved this problem by adopting the proper grounding scheme and RF shielding, the new DAQ system of BPM has on-line run smoothly about one month. The data-taking cycle speed at present is about 1Hz in order to prolong the lifetime of coaxial relay. The BPM system plays an important role when the positron beam

REFERENCES

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[3] Stanford Research Systems, Inc., "SR250 Specifications"