UPGRADE OF THE BPM SYSTEM FOR THE BEPC STORAGE RING

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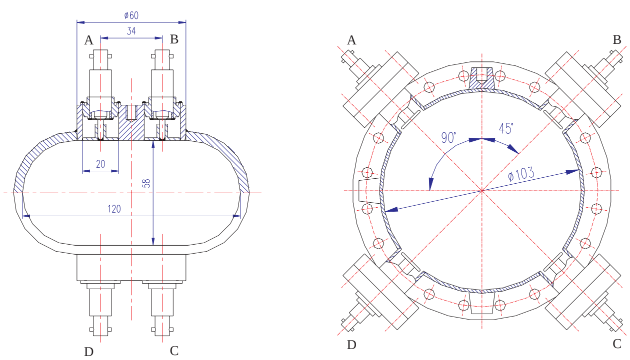
Abstract

The Beijing Electron Positron Collider (BEPC) is a machine with a designing energy up to 2.8 GeV. Thirty-two button-type beam position monitors (BPMs) are used for the position measurement of the colliding e^+ e^- beams in the storage ring. In order to improve the measurement resolution and reduce the measurement time, the hardware and the software of the BPM system have been partially modified at last year and have been tested with beams. The BPM processing electronics and the measurement behavior can be fully controlled by a personal computer (PC) in the local control room. The measured beam position data are stored in the memory on another PC, which serves as a communication server. These data can be accessed by the main computer in the central control room through the network. The short-term reproducibility of the measurement is better than 10 microns. The measurement time for scanning all 32 BPMs is about 11 seconds. The reliability of the measurement is assured by the self-consistency check. The dynamic rang of the system is over 81 dB and the minimum measurable beam intensity is less than 0.5 mA. This paper will describe the hardware and the software of our upgraded BPM system. The performances of the BPM system are also given in the paper.

1 GENERAL DESCRIPTION

The BEPC currently has 32 BPMs spaced around the ring. Each BPM consists of four button-type electrodes, labeled A, B, C and D. The button mounted on a BNC-type feedthrough has a 20-mm diameter. The structures of all BPMs can be divided into two types as shown in Figure 1. The type with a race track cross-section (Figure 1-(a)) is used in the bending sections of the storage ring and their pick-up connectors are directly welded on to the aluminum beam duck. The number of BPMs of this type is 24. The another type with a circular cross-section (Figure 1-(b)) is used in two long straight sections close to IPs of the ring. The four buttons with their feedthough connectors are mounted on a section of the circular stainless steel beam pipe with flanges for the button or the feedthough exchange. The number of this type BPMs is 8.

A set of four RG223/U coaxial cables bring up pick-up signals of each monitor to the local control room where the signal processing electronics is located. So, for 32 BPMs with 4 buttons each we have 128 cables. The lengths of cables vary from 60 to 90 meters depending on locations of monitors in the ring.



(a) (b)

Figure 1: BPM structures for the BEPC storage ring

2 SIGNAL PROCESSING

Before upgrading, the short-term reproducibility of the BPM system for the BEPC storage ring is larger than 20 μm (average), mainly due to the noise of the wide-band processing electronics. The purpose of the upgrade is to improve the reproducibility of the measurement without increasing the measurement time. To attain this purpose, the simplest way is to increase the number of ADC readings per button with high speed ADC modules, and then average the readings to improve the S/N ratio. Reference [1] can be referred for the more detailed description about the hardware and the software of our upgraded BPM system.

2.1 Hardware Electronics

Figure 2 shows a schematic block diagram of the BPM signal processing electronics. There are several modifications in the hardware electronics.

First of all, two 25-μs ADC (12 bits) modules are used to replace the original 120-ms ADC (14 bits) module. The measurement time can be reduced from 50 seconds to 11 seconds while the number of ADC readings per button increases from 1 to 500 (default value).

Secondly, the CAMAC serial crate controller (SCC), which was designed especially for the SLC control system by SLAC people, is replaced by the parallel crate controller Model CCU-2-80B with a PC interface card developed by the Electronics Division of our institute. All 21 BPM modules in two CAMAC crates then can be controlled by a PC or compatible processors as the host.

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Finally, the computer network is used for data communications between PCs and the BEPC main control computer, VAX4500A.

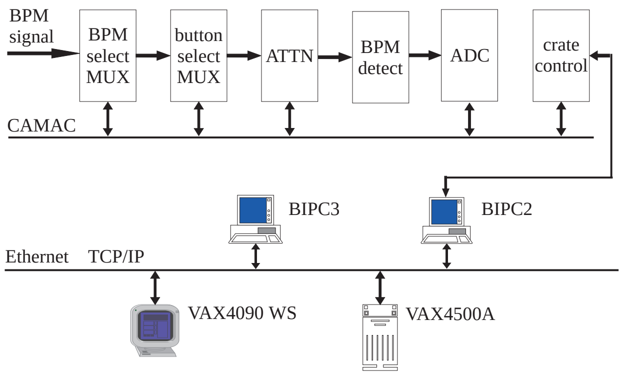

Figure 2: The BPM signal processing electronics after upgrading

2.2 Software Program

The graphical user interface panel on the VAX4090 workstation is kept the same after and before upgrading. Only the data acquisition program was modified and moved from VAX4500A to the PC named BIPC2. The program on BIPC2 was developed on the platform of the Microsoft Windows 95 and the Microsoft Visual C/C++ 2.0. The measurement control parameters, such as the number of ADC readings per button, and the measured beam position data are stored in the server, BIPC3.

When the BPM measurement program "WINBPM" on BIPC2 starts, it firstly initializes the electronics hardware of the system. Then the C function "BPMSCAN" of "WINBPM" begins to loop forever. In each loop, the function performs the following procedure: read the user specified measurement control parameters from BIPC3; adjust attenuation automatically according to the beam intensity; read the raw button voltage value of each button for *N* times, average them, and then compute x and y positions for each BPM; write button voltage values and positions to the database of BIPC3.

Operators can send the new measurement control parameters to and receive the latest measured beam position data from BIPC3 through the network, and to display the closed orbit distortion (COD) on the VAX4090 workstation. Communications between the main computer and PCs are based on the client/server model by using the TCP/IP protocol.

3 SYSTEM PERFORMANCE

3.1 Closed Orbit Measurement

The CODs can be measured simultaneously for e^+ and e^- beams. Though the scan time of the measurement for all 32 BPMs is about 11 seconds, the system response time to operators is much faster because the beam position data of the last measurement are always available in the memory of BIPC3 and can be accessed from the control console within a second through the network.

Figure 3 shows typical measured CODs for both e^+ and e^- beams. The horizontal COD is 2.2 mm rms while the vertical COD is 1.5 mm rms. The maximum measured position difference between the e^+ and e^- beams is around 0.5 mm and always appears with a few fixed monitors, such as BPM1. The reason is not yet very clear to us.

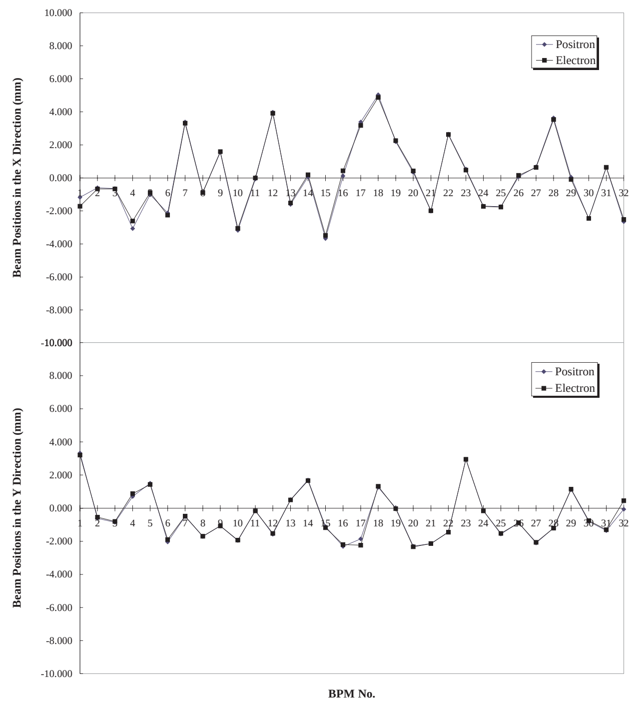

Figure 3: The closed orbit distortions for e^+ e^- beams

3.2 Short-Term Reproducibility

Ten-time consecutive measurements of the COD were performed during the beam storage to check the short-term reproducibility of the system. Table 1 lists the statistics of the standard deviation of measurements for all 32 monitors. The averaged standard deviations are 31(x)/21 (y) μm and 7(x)/8(y) μm before and after upgrading respectively. BPMs with the standard deviation being larger than 10 μm after upgrading basically belong to the type shown in Figure 1-(b). This type of monitor has a lower sensitivity due to the larger distance from the button to the axis of the monitor.

Table 1: A comparison of the standard deviation in 10 consecutive COD measurements before and after upgrading

	before upgrading			after upgrading		
σ (μm)	≤10	≤20	>20	≤10	≤20	>20
number (x)	5	13	14	27	3	2
number (y)	16	11	5	25	5	2

3.3 Beam Intensity Dependence

Figure 4 shows the beam intensity and the beam position measured at a test monitor during the beam storage in 8 hours. When the beam intensity changes, the measurement program automatically adjusts the setting values of programmable attenuators to keep the output level of the BPM detector in the useful range of the ADC. To prevent the BPM electronics from damage at high beam intensities, the minimum attenuation value is set at 5 dB when the measurable beam current is about 0.5 mA. The maximum attenuation is 81 dB in steps of 1 dB so that the dynamic range of the system is at least 81 dB without considering a 20-dB linear range of the BPM detector itself.

The peak-to-peak beam position drifts shown in Figure 4 are less than 50 μm in the horizontal direction and less than 40 μm in the vertical direction.

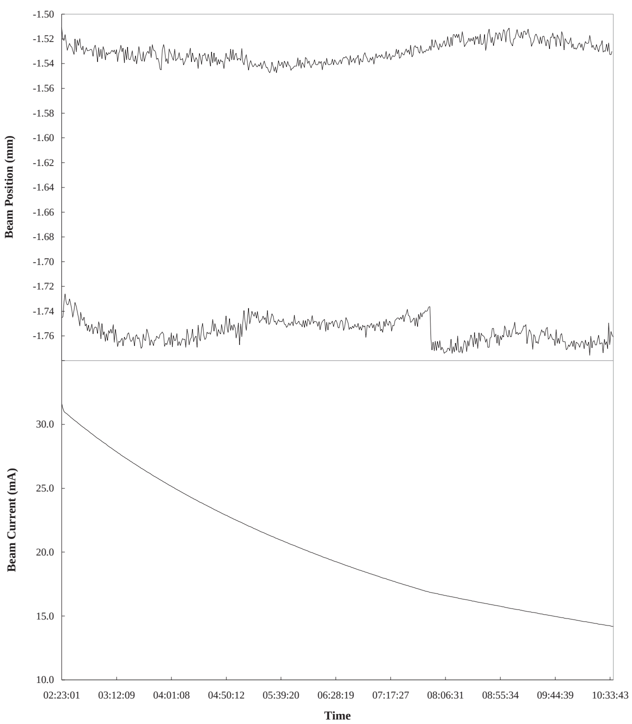

Figure 4: The long-term beam position drifts during the beam storage in 8 hours

3.4 Self-Consistency Check

As we know, the beam position at a BPM location can be computed by using any one of four 3-electrode normalizations and the 4-electrode normalization as well. Whenever we measure the COD, we will compare those five position values. If the maximum difference among those values for a BPM is larger than a small value δ in either x or y plane, we will mark the position of that BPM as a bad reading. Figure 5 shows the ratio of the number of bad readings to the total number of measurements performed in the period from November 1996 to April 1997 for all 32 BPMs. The total number of the measurements is about 9000.

When we began to use this self-consistency method to check the reliability of the beam position measurement, many of 32 monitors have higher bad reading ratios. Some of ratios even reach to 90%. We found that it is mainly caused by the relative attenuation change of the signal transmission cables and the channel to channel offset change of the PIN diode multiplexer. We remeasured these parameters carefully and replaced old parameters in the computer. At present, the differences between positions obtained from the 4-electrode normalization and other 3-electrode normalizations are usually less than 0.2 mm for most BPMs.

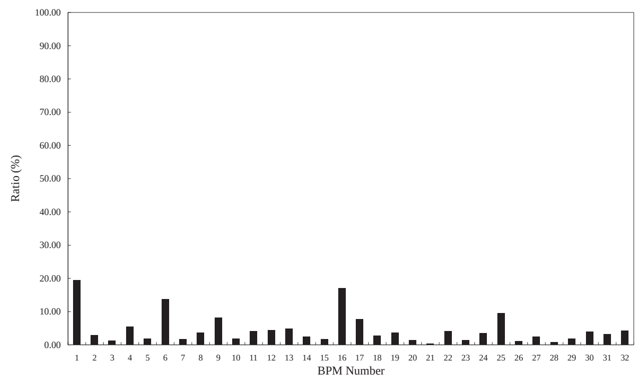

Figure 5: The ratio of the number of bad readings to the total number of measurements

4 SUMMARY

The beam position monitoring system of the BEPC storage ring basically satisfies the requirements for the machine operation and machine studies after upgrading. The short-term reproducibility of measurements is improved from over 20 μm to less than 10 μm. The measurement time for scanning all 32 BPMs is reduced from 50 seconds to 11 seconds with the default 500 ADC readings per button. The dynamic range of the system is over 81 dB and the minimum measurable beam intensity is less than 0.5 mA. The reliability of the measurement is guaranteed by the self-consistency check.

5 ACKNOWLEDGMENTS

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REFERENCES

[1] L.Ma, P.Shi, K.Ye and X.Geng, “Beam Position Monitoring System for the BEPC Storage Ring”, Proceedings of EPAC’96, Sitges, Spain, June 1996.