THE BEPCII DCCT SYSTEM

Y. Zhao#, J.S. Cao

Institute of High Energy Physics, Chinese Academy of Sciences, Beijing 100049, China

Abstract

A DC Current Transformer (DCCT) as a standard diagnostic system for beam current plays an important role in BEPCII, the upgrade project of the Beijing Electron Positron Collider. Two DCCTs are operating now, separately in the electron and positron rings, to monitor the beam current, the beam injection rate, the beam loss rate and the beam lifetime. In this paper, the mechanical structure design, readout system and data processing are presented. The progress of DCCTs on each step of BEPCII commissioning, such as improving the beam lifetime and reducing the background noise, are also included.

INTRODUCTION

DCCT systems usually consist of three parts: sensor, electronics and the DAQ & control. The sensor is always affixed on the linear tube, for it is sensitive to the parasitic magnetic field caused by RF cavity, quadrupole magnet and the power cable, and must be far from those parts. Figure 1 shows the layout of the DCCT.

In BEPCII, two DCCT sensors are fixed in each outer ring, symmetrically around the south interaction points. The two sensors are individually used for the electron ring and positron ring when BEPCII operates in the collision mode. In dedicated synchrotron radiation mode, both of them are used for the electron ring. The sensor and electronics are made by the Bergoz Instrumentation Company. DCCT is an integrative system, so it works in single bunch or multiple bunch operation.

Tabel 1 gives the main technical parameters.

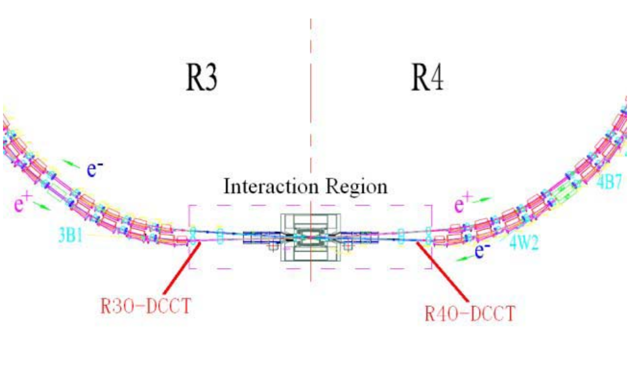


Figure 1: Layout of DCCT

#zhaoying@ihep.ac.cn

Table 1: The main technical parameters of DCCT

Parameters	Value
Dynamic range	0.0~1.5A
Linearity	0.1 %
Zero drift	<0.05mA
Remarks	shielding needed
Detector size	350 mm with flange
Location	far from RF cavity

THE MECHANICS & INSTALLATION

A vacuum chamber with a ceramic gap has been used for avoiding the parasitic current caused by the chamber's electrical conductivity. Considering the 30 kHz bandwidth of the DCCT's signal, we decided to enhance the high frequency pass band to prevent the bunch frequency component from leaking from the gap when BEPCII operates in the single bunch mode. Thus the cut-off frequency could be lower than the bunch frequency but higher than the pass band of the DCCT. After calculation and simulation in the lab, the preparatory configuration of the system was confirmed. Figure 2 shows the structure and the parameters[3]. Copper foil and a layer of polyester film were used over the gap, to reduce the low-frequency signal leakage. Two magnetic shielding layers were adopted to protect the sensor from unorderly magnetic fields. The outer layer is electrostatic shielding against RF and for circulation of wall current.

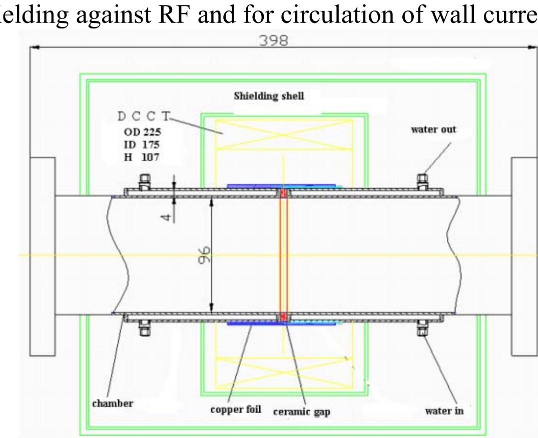


Figure 2: Structure of DCCT tube.

THE ELECTRONICS & DAQ

The electronics and the DAQ system of DCCT are in the local stations of beam instrumentation, and consist of 2 cassettes, 2 DVMs and an IPC. The sensors in the tunnel are connected to the electronics by 120 m of cable. Figure 1 shows the structure. In the earlier design, a low pass filter had been put between electronics and DVM to decrease 50 Hz interference; it has since been removed.

The operating modes and ranges can be changed in the local station manually, according to the BEPCII working mode.

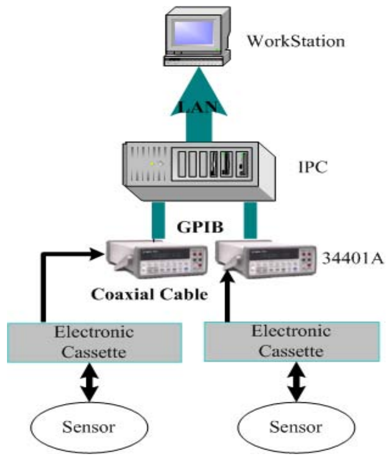


Figure 3: DCCT system structure

The DAQ system is based on DVM Agilent 34401A and GPIB. Programs running in the IPC complete data acquisition, processing and transmission. The program works as an EPICS soft IOC. Authorized users can access and acquire the data to calculate the beam injection rate and the beam loss rate. The historical data are not stored in the local IPC but can be checked in the Archive Database. Figure 4 shows the software structure and Fig. 5 shows the program interface.

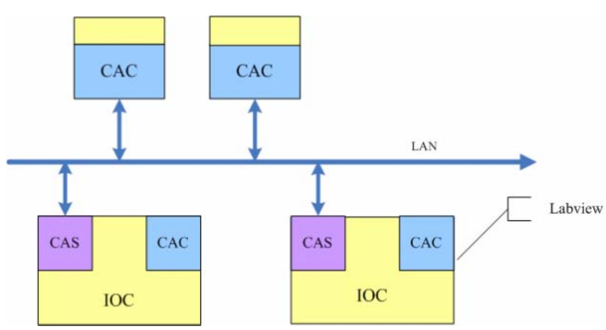


Figure 4: Software structure.

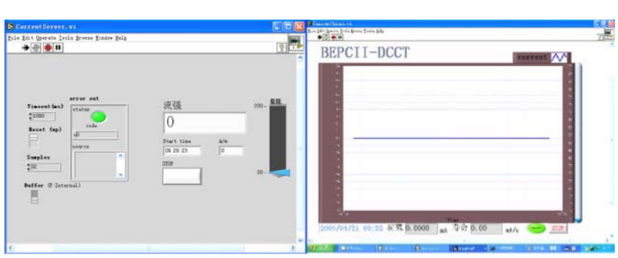


Figure 5: Program interface.

DATA ANALYSIS

The DCCT system in the electron ring played an important role since the first commissioning stage, running in dedicated synchrotron radiation mode.

The discrete lifetime solved

We found when the electron beam current was below 60 mA, the beam life time was somewhat "discreted." The beam lifetime often was related to the degree of vacuum, equipment state and closed orbit distortion, etc., and usually rises as current diminishes. Figure 6 shows the details of the waveform. [2]

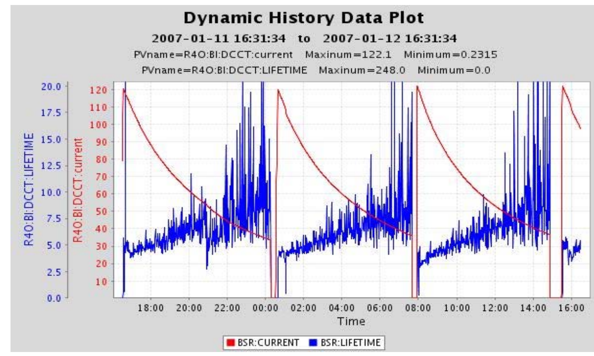


Figure 6: The details of the lifetime wave

The smooth red curve is what would be expected if all parameters of the storage ring were normal. The blue lifetime curve was abnormally shaped as current decreased. The lifetime discrete range was 7% when the current was 120 mA, 30% at the beginning. We thought the issue was noise dither and tried to solve it in the DAQ program. But the result was not satisfactory; even the readout rate was negative impacted.

We analysed the data again and tried to increase the sampling rate and improved the arithmetic for calculating lifetime. By changing the sampling rate of beam current from 5/s to 100/s, added the fitting spot and extended sampling range. The result was much better.

The magnetic field effect

We also found the sensors are sensitive to the magnetic field even with shielding. Figure 7 was the background data record from a machine study time. An obvious fall of current, about 0.3 mA, can be seen. The log showed that only the octupole magnet nearby was adjusted.

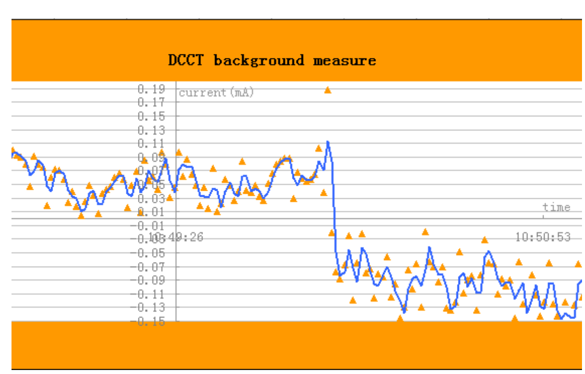
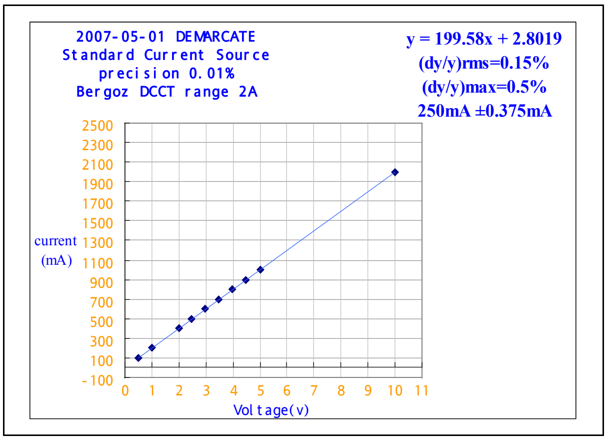


Figure 6: Intercepted from background data record.

So calibration was done periodically to insure the whole system's reliability. We used the standard current source (precision 0.01%) as the input signal entered the electronics. The readout voltage signal was nearly linear with the current input.

Table 2 gives one of the calibration results. It shows the linearity of the beam current. When the current was 250 mA, the variance between experimental data and real current was about 0.15%. It completely met the demand.

Table 2: One of the demarcation results.



Troubleshooting

In the phase two commissioning, BEPCII was operating in collision mode. The DCCT system in the positron ring showed abnormal background drift from the beginning, comparing to the power of RF cavity; the read out data was incorrect. After calibration, we found that the linearity coefficient was changed 35%.

We did all-around examination and discovered that a signal wire's insulating layer in the cable head was torn and touched another pin, which affected the sensor's demagnetizer function. The tear may be due to careless installation. It was repaired and soon the whole system worked normally.

SUMMARY

BEPCII is undergoing maintenance and we are preparing for the next operation stage. Although the DCCT system is basically running well, there is still a lot to do and opportunity to make progress. As the heating problem of the DCCT sensor when beam current is higher than 500 mA, the automatic adjustment of the measurement range and the automatic adjustment of offset base on the BPM signal, and so on.

ACKNOWLEDGEMENT

I appreciate Dr Jianshe Cao, Dr Li Ma and Dr Chuang Zhang from IHEP for helping me a lot through the whole system. Special thanks to Dr Baogen Sun and Dr Ping Lu from NSRL for the support on the Epics. And The Bergoz Instrumentation Company give technical supports. Also thanks to all the group members from IHEP Acc-center for giving me a lot of useful advises.

REFERENCES

[1] Y. Zhao, J.S.Cao, The summarizing and analysis of the DCCT system, 2007.

[2] C. Zhang, The discussion of beam lifetime in BEPCII, 2007

[3] J.S. Cao, L. Wang, The report of the machine study of new and old DCCT, 2005