THE UPDATED BPM SYSTEM OF HLS*

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Abstract

The operation of the updated BPM system of HLS and VXI-based application of LabVIEW as well as Network technic in NSRL phase II project, are introduced here. Bergoz BPM modules and modular VXI measurement instruments are adopted for data measurement and acquirement, in order to provide stable and credible performance. The LabVIEW development environment of VXI-based, which is adopted in our project, not only provides good hardware controls, but also promotes the development efficiency. Measured data is fed back to correct closed orbit of the storage ring in constant time interval. At the same time, another copy of the measured data is sent to an independent data-server to be recorded. The BPM system now works with a precision not greater than 10μm, and a resolution about 1μm.

1 INTRODUCTION

HLS is a dedicated electron synchrotron radiation instrument, which works with 800MeV operation energy, 100-300mA current and 204.035MHz RF frequency. During the machine physics studying, Upgrade of components and Commission of inserted devices, the online running of the close orbit measured system is an indispensable diagnostics tool. In 1995, we rebuilt the key parts of the BPM system and achieved operation with a 50 μm precision and a 10μm resolution[1]. The average orbits measurement after damping and local bumped orbit primary correction had been carried out after rebuild BPM system. To advance measurement precision of BPM, upgrade of BPM system is brought forward as an important task during NSRL Phase-II project. This time we reconstruct the whole system from front-end electronics to post end data processing and maintain a fine performance.

2 ARCHITECTURE AND SIGNAL PROCESSING OF THE BPM SYSTEM

2.1 Architecture of the BPM system

HLS storage ring, circumference is 66m, has 27 capacitance button BPMs. Each BPM with 4 button pick-ups (25mm diameter) mounted at the skew azimuth. Single BPM's figure and its distribution on the ring is shown in Fig.1.

HLS transverse tune is ν_x=3.54, ν_y=2.61, giving 6-7 points per period of tran-oscillation, 22 BPMs are enough for this measurement. The BPMs are distributed according to dispersion function along the ring.

Since the multiplexer, which were adopted in BPM system formerly, bring the complex and uncredibility into close orbit measurment, we adopt to process each BPM in parallel now. For the analogy signal detection, we choose commercial available Bergoz BPM modules[1] which work on heterodyne receiving with up to 75dB dynamic range and 1μm resolution. The parameters of modules can be customized, in our case, we got 204MHz center frequency which is RF of HLS and ±200kHz band pass. And the Δ-Σ is internally completed and outputs V_x and V_y which proportional to x and y position. The relation of Beam position and module outputs is:

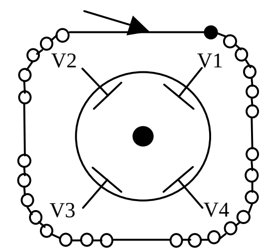

Fig.1 BPM figure and distribution

$$X(mm) = \frac{V_x}{G_x} = K_x * U = \frac{U}{S_x} = \frac{V_x}{S_x * G_{ex}}$$

$$Y(mm) = \frac{V_y}{G_y} = K_y * V = \frac{Y}{S_y} = \frac{V_y}{S_y * G_{ey}} \qquad (1)$$

where S_x,S_y*[%/mm]* are the mechanical sensitivity, Gex,Gey are the electronics gain and Gx,Gy are the total gain: *Gx [V/mm]= Gy [V/mm]=*S *[%/mm] × Modu le Ge(V/%).*

In the bench test we found the Gex,Gey have departure rating slightly for each modules and even the *x* and *y* channel in one module. To assure the accuracy, we measured and corrected each module.

2.2 Signal processing of the BPM system

Signals from pick-ups of 22 BPMs transmitted by GX03272 cable with variable lengths are fed into 2 units of BPM module chassis, each contains 11 modules serving 11 BPMs and giving 22 x and y outputs. The total of 44 outputs are then fed into VXI SC1102B signal conditioning module which incorporating a 200Hz LPF to cleaning unwanted components. After that, signals are digitized by a 16bit, 64Channel VXI MIO module and then data packages are sent to VXI bus and Epics Data bus for beam position monitoring and closed orbit correction.

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1 Bergoz BPM module user manual

BPM module, VXI chassis, Controller IPC as well as other beam diagnostics instruments such as beam monitor and photo position detection are mounted inside a local rack inside the storage ring. The architecture and signal processing, as well as software realization are shown in Fig2 and Fig3.

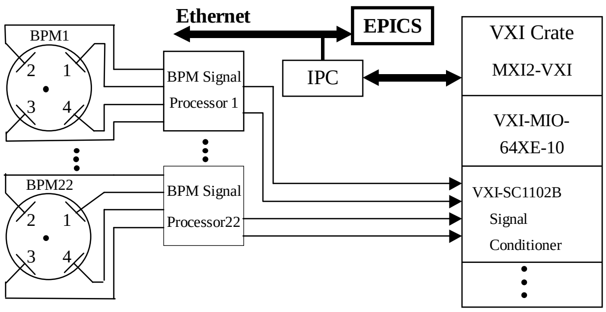

Fig.2 BPM hardware Architecture

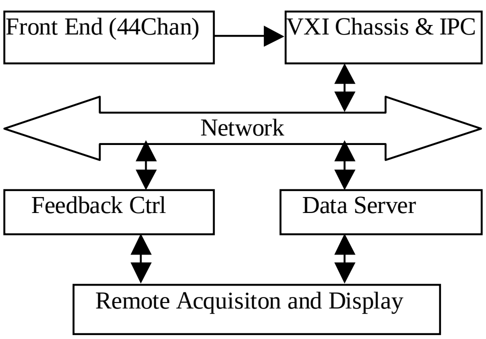

Fig.3 BPM software Architecture

2.3 Data acquisition and control

Data acquisition is supported by VXI modules and NI LabView Measurement technic. VXI chassis is Tek intelligence 13 slots VX4101 with MXI-2 BUS MODULE & CONTROLLER. Beam diagnostics instrument like BPM acquisition (NI VXI-MIO-64XE-10), DCCT monitor (Tek4101 multimeter), photo position detection as well as other tools are incorporated in the single chassis. Except for the front end electronics, all components are bus& network connection, Data are sent to independent data server for feedback and open access. All kinds of data and control are via Ethernet local area network of the EPICS system.

3 MEASUREMENT RESULTS OF UPDATED COD AND DATA ANALYSIS

3.1 Measurement data record

Fig.4 trace out the record from 1# BPM history data of beam orbit which one time/two second. From the history record we can see that orbit deviation varying below a quantity as small as 10µm. In other words, the total system error is limited below 10µm. Variation of particle momentum, beta tune, magnet power as well as electronics noise all make contributions to it.

$$\Delta\chi = \Delta x_\beta + \Delta x_\varepsilon + \Delta x_c + \Delta x_n \qquad (2)$$

Δx_β - deviation of betatron ososcillatory, Δx_ε - distracting from particle momentum, Δx_c -Closed orbit distorse, Δx_n - deviationof of BPM electronics noise.

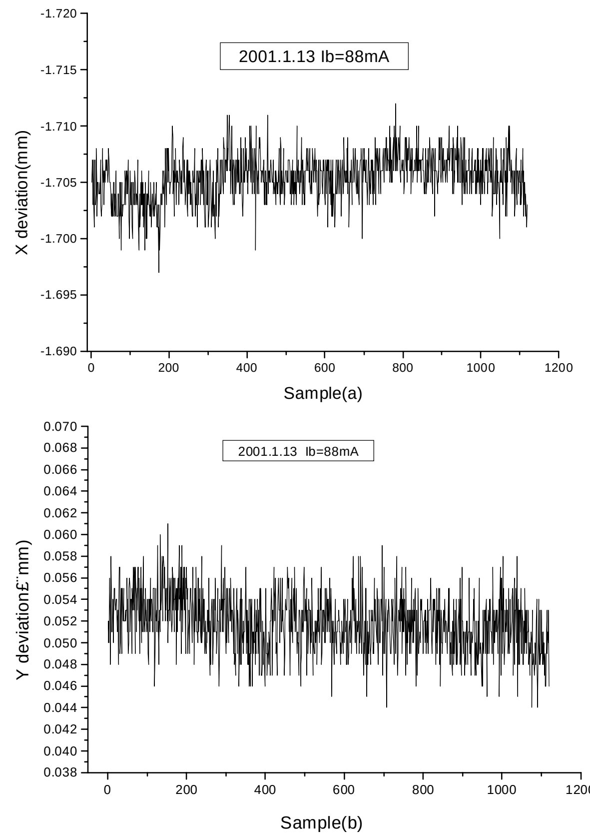

Fig.4 1# BPM Operation History Curve

3.2 Noise Caused Position Error

First we estimate the effect of thermal noise here. Button induced voltage is expressed like[2]:

$$V_b = \frac{2\pi a^2}{b\beta c} Z A_m f_b I_{avg} \qquad (3)$$

where: b-beam pipe radius, a-button electrode radius, Z-coaxial impedance, f_b- bunch frequency, I_{avg} -average current and A is a coefficient relating to bunch shape and harmonics. Given I_{avg} =100mA, the estimating inducted signal power for HLS is:

$$P_s = \frac{1}{2}\frac{V_b^2}{Z} = \frac{2\pi^2 a^4}{b^2 \beta^2 c^2} Z A_m^2 f_0^2 I_{avg}^2 = 6\mu W = -22.22dBm \qquad (4)$$

Because the measurement bandwidth is 400KHz, the corresponding thermal noise power is:

$$P_N = 4K_B TB = 66.56\times 10^{-16} W = -111.8 dBm$$

And $SNR = \dfrac{p_s}{p_N} = 89.8dB$ (5)

The induced position deviation:

$$X = \frac{b}{2}\times\frac{V_1+V_2-V_3-V_4}{V_1+V_2+V_3+V_4} = \frac{b}{2\sqrt{2}}\times\frac{1}{\sqrt{SNR}} = 0.5\mu m \quad (6)$$

The result shows that noise induced position deviation is a far small quantity. In fact, the other electronics noise, like 1/f noise, device distribution noise contribute more to the final output. Our bench top tests give a rms level of 3mV, corresponding to a 5μm variation.

3.3 Application of BPM system

The newer version BPM system has been in operation now. With it we made fine measurement of dispersion function[3]. When changing the RF frequency slightly and recording the orbit changes we get dispersion function[4]:

$$\eta(s) = -\alpha_c \frac{\Delta x(s)}{\Delta f_{rf} / f_{rf}} \quad (7)$$

The compare of the dispersion function for measurement with one of theoretical calculation been shown in Fig.5[4].

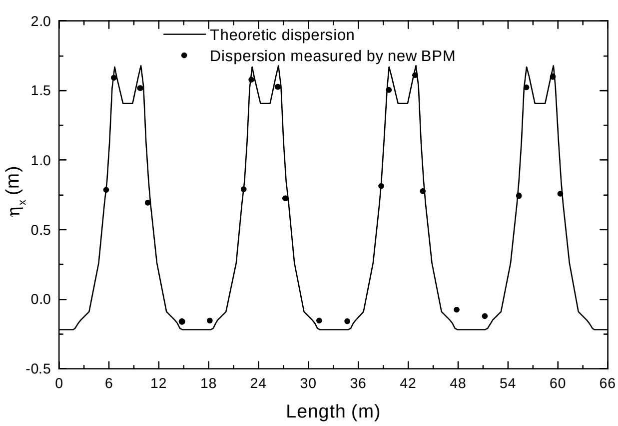

Fig.5 The compare of horizontal and theory dispersion function

From Fig.5, we got measurement and theoretical calculation are in well agreement. With the precision BPM system, we have accomplished the measurement of quadrupole centering using the local bump method. The new BPM(COD) system also plays an import role in the ring closed orbit correcting and wiggler commissionsing now.

6 REFERENCES

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