EPICS BASED BEAM ORBIT MEASUREMENT SYSTEM FOR KEK PF-AR

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Abstract

A new beam position measurement system for KEK PF-AR was constructed employing EPICS(Experimental Physics and Industrial Control system). Two new record types were developed for this system. The EPICS database includes more than 3,500 records and SNL programs are used to operate electric relay switching beam position monitors (BPMs). Measured orbit data is agreed with the data which is taken by the existing HIDIC mini computer system. The measurement time is improved with the new system.

1 INTRODUCTION

The PF-AR (Advanced Ring), 6.5 GeV electron storage ring for pulsed X-rays, was originally constructed as an injection booster to TRISTAN [1] main ring, and had also been used as a synchrotron radiation source during the intervals of injection to the TRISTAN. The upgrading project of PF-AR [2, 3] which intend to reconstruct the ring as the SR light source, is under way.

Replacement of the control system with the system reliable and easy for machine operation is the part of the project. In order to minimize costs and loads of the replacement, device interface layer under CAMAC has not changed. We only replace the existing HIDIC minicomputer system with EPICS IOC (VME computer, CPU: Power PC 750, CAMAC Serial Driver: VSD 2992). In this study, an auxiliary crate controller, which is controlled from IOC, was installed on each CAMAC crate to ensure simultaneous controls from HIDIC and EPICS.

2 HARDWARE SETUP

The PF-AR has 83 sets of electrostatic beam position monitors (BPMs), each of which consists of 4 electrodes[4]. Electric signal of each electrode is selected by coaxial relay placed in the AR tunnel. And the output from the relay is fed to one of four local control rooms located on east, west, south and north part of the ring. Signals are processed by the detector located in each local control room and digitized by 12-bit CAMAC ADC for beam position calculation. Several kind of CAMAC modules are used to measure the beam position: AIO (Active Input/Output register) module to control the coaxial relay, SIG (Status Input Gate) to monitor the hardware status.

3 SOFTWARE DEVELOPMENT

3.1 New record type

Two new record types were created, one is to calculate the horizontal and vertical (X and Y) positions and a standard deviation of each electrodes, the other is to concatenate the single position values into a big array to be displayed in MEDM (Motif-based Editor and Display Manager). Both records are designed so that they can be applicable to the other EPICS based system easily.

bpmArRecord Then main purpose of the new record type bpmArRecord is to calculate out the beam position (X, Y). The CNAM field is used to specify a user defined conversion function name. The default conversion function implements the following algorithm:

- Apply correction factors for cable loss to each signal from four electrodes.
- Check the consistency
  - Calculate (X,Y) with picking up only three signals out of four for all possible combinations (abc/bcd/cda/dab) by using a fourth order polynomial for its own.
  - Calculate variances of result in the previous step, σ_x and σ_y.
  - compare the variance with the standard variance to check the consistency.
- Return the final beam position (X, Y) when status is normal, otherwise returns error code.

The record was created based on bpmKekRecord by adding about 60 fields, such as the fields of signal values from the four electrodes of a BPM, the correction ratios of the cable loss, size of elements for each set of coefficients, maximum variance, σ, specified by user, etc.

Values of these coefficients (mapping data and setting error of beam duct) is taken from the data stored in HIDIC system. We transferred these data on HIDIC system to the ascii file on UNIX workstation, then converted them to the form which can be directly downloaded to the IOC using a program written for it.

aConcatRecord In order to display all the calculated beam positions, X and Y, for each station and also for all stations, a new record type aConcatRecord was created. It has up to 12 input links to get input data and concatenate them into an array pointed by VAL field. The input links

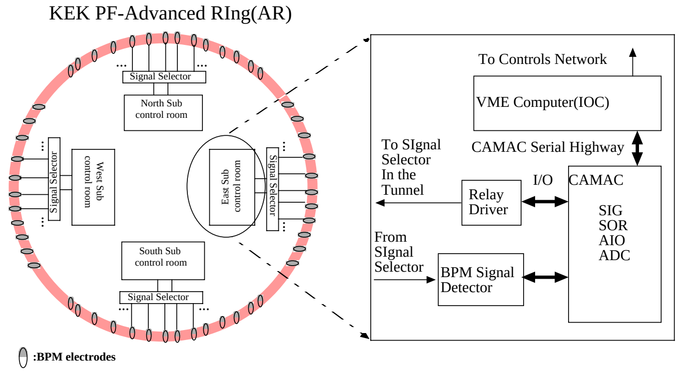

Figure 1: A block diagram of EPICS based beam position measuring system.

can be any record type of EPICS database including aConcat record, so data which has more than 12 elements can be concatenated using two or more aConcat records. The NELM field must be specified correctly when an aConcat record in the database is created.

3.2 Database

CapFast[1] is used to create most of the database logics for the AR BPM measurement system. Some logics are created by editing the ascii files of database.

The database logic of AR BPM measurement system can be classified into 4 types: 1) IOC read/write logics, 2) relay logics, 3) timestamp logics and 4) data concatenation logics. Four template files, bpm1.db, bpmrelay.db, time.db and wf.db, have been created corresponding these four kinds of logics.

The IOC read/write logic (bpm1.db) is the largest one, which contains the logic for each BPM to clear BPM_DONE and BPM_ERR flags, to enable CAMAC AIO module, to set time delay, and to get input data from the four electrodes one by one. Figure 2 shows a CapFast schematics for this logic. The four database parameter files for the BPM read/write logic of AR east, west, north and south were created from some parameter files of HIDIC control system.

For each station, four database parameter files were created. Taking AR east station as an example, the parameter files are bpmArEast.dbprm, relayArEast.dbprm, timeArEast.dbprm and wfArEast.dbprm. The EPICS command ”dbLoadTemplate” is applied to create run-time database from the template and parameter files. For example,bpmArEast.dbprm gives parameters for read/write logics of 20 BPMs in AR east station. By using the command ”dbLoadTemplate bpmArEast.dbprm > bpmArEast.db” the final run-time database file for AR east ”bpmArEast.db” is generated. In the similar way other database files for AR west, north and south stations are also created.

[1]Capfast^{TM} is the name of schematic editor, developed and sold by Phase Three Logic, Inc., Beaverton, Oregon, USA.

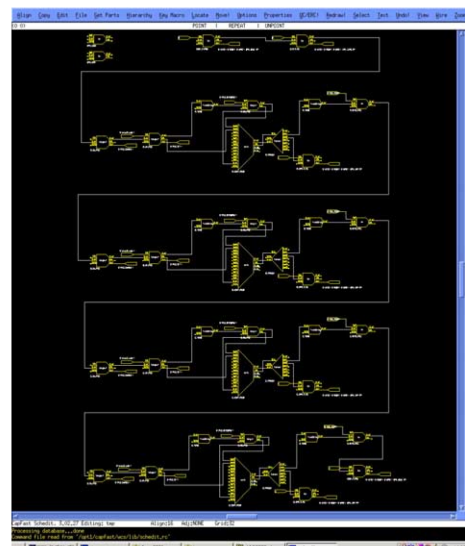

Figure 2: CapFast schematics for 1 BPM (4 electrodes).

Besides, there is a parameter file containing the parameters for timestamp records to get the timestamp information for all BPMs. And there is a run-time database ”wfArAll.db” to trigger the measurement of four stations concurrently, to concatenate all the X and Y position data from four stations into two arrays separately to be displayed graphically. So altogether there are 4 database template files, 17 database parameter files, and 18 final run-time database files which can be loaded into IOC memory.

3.3 SNL

The layers of SNL logic are used to achieve the measurement. One is for the measurement in a single station. The other manages the concurrent measurement over the four stations. In each station, a SNL program is used to do the following tasks:

- start the measurement,
- switch the measurement from one BPM to the next one,
- set the starting and ending timestamps,

- reset relay drivers when all BPMs in one station have been tested,
- trigger the aConcat records to be processed when all bpmAr records in one station have been processed.

The BPM_DONE and BPM_ERR flags are monitored in the SNL programs for each BPM. In the database logic, BPM_DONE is set to ”1” when the four electrodes of the BPM have been read, and BPM_ERR is set if something wrong. Therefore when any of them is set to ”1” the SNL programs switches the measurement to next BPM.

Another layer of SNL logic is to deal with all BPMs of the four stations. These logics are running on AR east IOC.

3.4 Display

MEDM is used to create graphical user interfaces to control the measurement and monitor interested results for this measurement system as shown in Fig. 3. For each station there are two kinds of MEDM adl files created, one is to enable the measurement, display some key information. The contents are summarized as:

- buttons to enable the power and start the measurement
- label to display the status of the relay power: ”enabled” or ”disabled”
- labels to display the start_measuring timestamp, the end_measuring timestamp and the time ”elapsed”
- labels to monitor the BPM_DONE flag, BPM_ERR flag and the four electrodes’ write-out, read-in for each BPM
- labels to display the calculated X position and Y position for each BPM

Another kind of adl file is to plot sets of values of the calculated X and Y positions in a graph, for the east, west, north, south stations separately and for all BPMs, too. The button to start the measurement of all BPMs in the four stations is created in the bpmArEast.adl, which is also used to control and monitor BPMs for the east station.

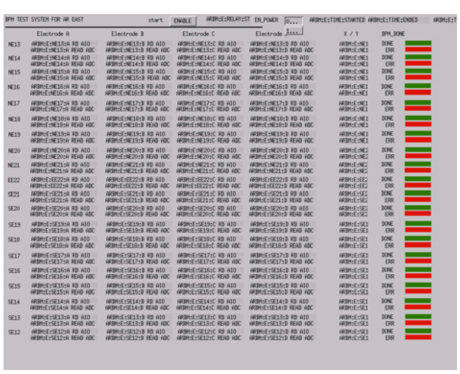

Figure 3: Editing the panel for one local control room.

4 RESULTS AND CONCLUSION

All the measurement can be done in 12 seconds, including getting signals from the four electrodes of each BPM and calculating X/Y positions and SIGMAs of BPMs and concatenating them into 10 arrays (2 arrays for each station, and 2 arrays for all BPMs). Most of measurement time is spent to wait ready signal from relay switch. This was mainly achieved by doing the measurements for the four stations concurrently.

Python scripts and MatLab are used to plot and compare 15 sets of date from the HIDIC system (the original one) and the result from the new BPM measurement system using EPICS as shown in Fig. 4. Measured data seems to

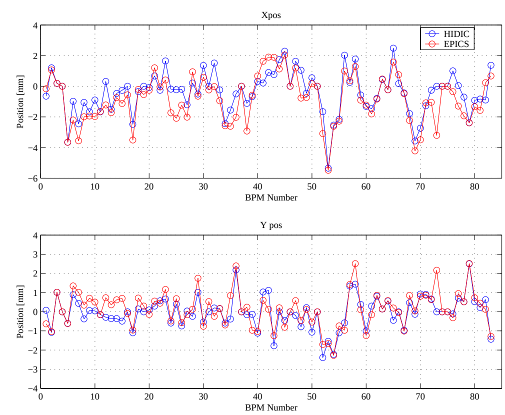

Figure 4: Beam position measured by HIDIC and EPICS.

agree with each other, however, there is a slight difference between two systems. The possible reasons are a reliability of coaxial relay or a difference of average function. HIDIC system use 8 channels of scanning ADC, whereas EPICS used only one channel at this time. Because the coaxial relay (mechanical switch) will be replaced by mercury relay switches during the shutdown period, reliability of the relay will remarkably be improved.

Commissioning with the electron beam will start at the beginning of January 2002. We will investigate the system further before commissioning. In order to achieve the more fast data acquisition, we are planning to build a new detector circuits and switching system.

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6 REFERENCES

[1] Shin-ichi Kurokawa, *et al.*, “The TRISTAN Control System”, Nucl. Instr. and Meth., A247, (1986) pp. 29-36 and references therein.

[2] “Design Report on Advanced Ring for Pulse X-rays (PF–AR)”, KEK Report 97-2 (1997).

[3] Photon Factory Activity Report **17**(1999)114

[4] T.Ieiri,*et al.*, “Performance of the Beam Position Monitors of the TRISTAN Accumulation Ring”, Proc. 5th Symposium on Acc. Sci. Tech., Tsukuba (1984)154