

EPICS BASED BEAM ORBIT MEASUREMENT SYSTEM FOR KEK PF-AR

T. Obina, J. Odagiri, N. Yamamoto, KEK, Tsukuba, Japan
Ge Lei, Institute of High Energy Physics, Chinese Academy of Sciences, Beijing, China
Zheng Lifang, Shanghai Synchrotron Radiation Center, Shanghai, China

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 mini-computer 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

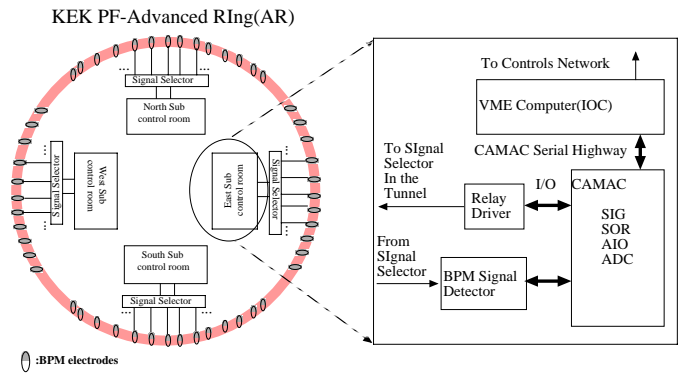


Figure 1: A block diagram of EPICS based beam position measuring system.

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

CapFast¹ 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.

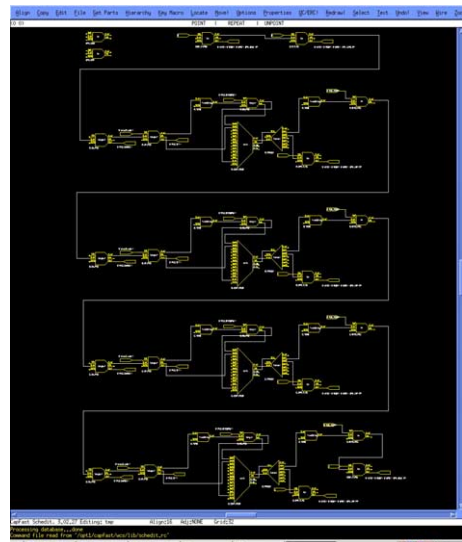


Figure 2: CapFast schematics for 1 BPM (4 electrodes).

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,

¹CapfastTM is the name of schematic editor, developed and sold by Phase Three Logic, Inc., Beaverton, Oregon, USA.

- 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.

BPM TEST SYSTEM FOR EAST	Electrode A	Electrode B	Electrode C	Electrode D	X / Y	BPM_DONE
M01	AMPH01A01 RD ADI	AMPH01B01 RD ADI	AMPH01C01 RD ADI	AMPH01D01 RD ADI	AMPH01E01	OK
M02	AMPH01A02 RD ADI	AMPH01B02 RD ADI	AMPH01C02 RD ADI	AMPH01D02 RD ADI	AMPH01E02	OK
M03	AMPH01A03 RD ADI	AMPH01B03 RD ADI	AMPH01C03 RD ADI	AMPH01D03 RD ADI	AMPH01E03	OK
M04	AMPH01A04 RD ADI	AMPH01B04 RD ADI	AMPH01C04 RD ADI	AMPH01D04 RD ADI	AMPH01E04	OK
M05	AMPH01A05 RD ADI	AMPH01B05 RD ADI	AMPH01C05 RD ADI	AMPH01D05 RD ADI	AMPH01E05	OK
M06	AMPH01A06 RD ADI	AMPH01B06 RD ADI	AMPH01C06 RD ADI	AMPH01D06 RD ADI	AMPH01E06	OK
M07	AMPH01A07 RD ADI	AMPH01B07 RD ADI	AMPH01C07 RD ADI	AMPH01D07 RD ADI	AMPH01E07	OK
M08	AMPH01A08 RD ADI	AMPH01B08 RD ADI	AMPH01C08 RD ADI	AMPH01D08 RD ADI	AMPH01E08	OK
M09	AMPH01A09 RD ADI	AMPH01B09 RD ADI	AMPH01C09 RD ADI	AMPH01D09 RD ADI	AMPH01E09	OK
M10	AMPH01A10 RD ADI	AMPH01B10 RD ADI	AMPH01C10 RD ADI	AMPH01D10 RD ADI	AMPH01E10	OK
M11	AMPH01A11 RD ADI	AMPH01B11 RD ADI	AMPH01C11 RD ADI	AMPH01D11 RD ADI	AMPH01E11	OK
M12	AMPH01A12 RD ADI	AMPH01B12 RD ADI	AMPH01C12 RD ADI	AMPH01D12 RD ADI	AMPH01E12	OK
M13	AMPH01A13 RD ADI	AMPH01B13 RD ADI	AMPH01C13 RD ADI	AMPH01D13 RD ADI	AMPH01E13	OK
M14	AMPH01A14 RD ADI	AMPH01B14 RD ADI	AMPH01C14 RD ADI	AMPH01D14 RD ADI	AMPH01E14	OK
M15	AMPH01A15 RD ADI	AMPH01B15 RD ADI	AMPH01C15 RD ADI	AMPH01D15 RD ADI	AMPH01E15	OK
M16	AMPH01A16 RD ADI	AMPH01B16 RD ADI	AMPH01C16 RD ADI	AMPH01D16 RD ADI	AMPH01E16	OK
M17	AMPH01A17 RD ADI	AMPH01B17 RD ADI	AMPH01C17 RD ADI	AMPH01D17 RD ADI	AMPH01E17	OK
M18	AMPH01A18 RD ADI	AMPH01B18 RD ADI	AMPH01C18 RD ADI	AMPH01D18 RD ADI	AMPH01E18	OK
M19	AMPH01A19 RD ADI	AMPH01B19 RD ADI	AMPH01C19 RD ADI	AMPH01D19 RD ADI	AMPH01E19	OK
M20	AMPH01A20 RD ADI	AMPH01B20 RD ADI	AMPH01C20 RD ADI	AMPH01D20 RD ADI	AMPH01E20	OK
M21	AMPH01A21 RD ADI	AMPH01B21 RD ADI	AMPH01C21 RD ADI	AMPH01D21 RD ADI	AMPH01E21	OK
M22	AMPH01A22 RD ADI	AMPH01B22 RD ADI	AMPH01C22 RD ADI	AMPH01D22 RD ADI	AMPH01E22	OK
M23	AMPH01A23 RD ADI	AMPH01B23 RD ADI	AMPH01C23 RD ADI	AMPH01D23 RD ADI	AMPH01E23	OK
M24	AMPH01A24 RD ADI	AMPH01B24 RD ADI	AMPH01C24 RD ADI	AMPH01D24 RD ADI	AMPH01E24	OK
M25	AMPH01A25 RD ADI	AMPH01B25 RD ADI	AMPH01C25 RD ADI	AMPH01D25 RD ADI	AMPH01E25	OK
M26	AMPH01A26 RD ADI	AMPH01B26 RD ADI	AMPH01C26 RD ADI	AMPH01D26 RD ADI	AMPH01E26	OK
M27	AMPH01A27 RD ADI	AMPH01B27 RD ADI	AMPH01C27 RD ADI	AMPH01D27 RD ADI	AMPH01E27	OK
M28	AMPH01A28 RD ADI	AMPH01B28 RD ADI	AMPH01C28 RD ADI	AMPH01D28 RD ADI	AMPH01E28	OK
M29	AMPH01A29 RD ADI	AMPH01B29 RD ADI	AMPH01C29 RD ADI	AMPH01D29 RD ADI	AMPH01E29	OK
M30	AMPH01A30 RD ADI	AMPH01B30 RD ADI	AMPH01C30 RD ADI	AMPH01D30 RD ADI	AMPH01E30	OK
M31	AMPH01A31 RD ADI	AMPH01B31 RD ADI	AMPH01C31 RD ADI	AMPH01D31 RD ADI	AMPH01E31	OK
M32	AMPH01A32 RD ADI	AMPH01B32 RD ADI	AMPH01C32 RD ADI	AMPH01D32 RD ADI	AMPH01E32	OK
M33	AMPH01A33 RD ADI	AMPH01B33 RD ADI	AMPH01C33 RD ADI	AMPH01D33 RD ADI	AMPH01E33	OK
M34	AMPH01A34 RD ADI	AMPH01B34 RD ADI	AMPH01C34 RD ADI	AMPH01D34 RD ADI	AMPH01E34	OK
M35	AMPH01A35 RD ADI	AMPH01B35 RD ADI	AMPH01C35 RD ADI	AMPH01D35 RD ADI	AMPH01E35	OK
M36	AMPH01A36 RD ADI	AMPH01B36 RD ADI	AMPH01C36 RD ADI	AMPH01D36 RD ADI	AMPH01E36	OK
M37	AMPH01A37 RD ADI	AMPH01B37 RD ADI	AMPH01C37 RD ADI	AMPH01D37 RD ADI	AMPH01E37	OK
M38	AMPH01A38 RD ADI	AMPH01B38 RD ADI	AMPH01C38 RD ADI	AMPH01D38 RD ADI	AMPH01E38	OK
M39	AMPH01A39 RD ADI	AMPH01B39 RD ADI	AMPH01C39 RD ADI	AMPH01D39 RD ADI	AMPH01E39	OK
M40	AMPH01A40 RD ADI	AMPH01B40 RD ADI	AMPH01C40 RD ADI	AMPH01D40 RD ADI	AMPH01E40	OK

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 data 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

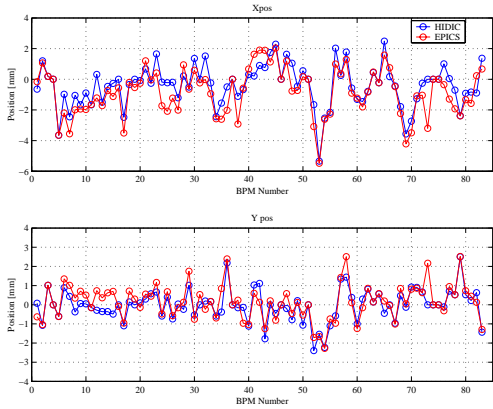


Figure 4: Beam position measured by HIDIC and EPICS.

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.

5 ACKNOWLEDGMENTS

The authors are greatly indebted to M. Tejima, S. Yoshida and other members of the KEKB control group for their great support to this work.

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