

VIRTUAL ACCELERATOR DEVELOPMENT FOR THE TPS

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Abstract

In order to help commissioning of TPS, control system based on a virtual accelerator model is constructed. The virtual accelerator has been created by AT toolbox and simulated beam behaviour; the Middle Layer providing high level accelerator application is also used. LabCA interfaces between Matlab and EPICS (Experimental Physics and Industrial Control System). Such a system could speed development of commissioning required software and examine the correction of all procedures.

INTRODUCTION

In order to control large-scale accelerators efficiently, a control system with a virtual accelerator model was constructed by many facilities [1][2][3][4]. The virtual accelerator (VA) is an on-line beam simulator provided with a beam monitor scheme. The VA could be designed based upon the specific control system such as Experimental Physics and Industrial Control System (EPICS) that most commonly employed in accelerators and is configured under the input/output controller (IOC) in parallel with a real accelerator. Thus, the machine operator can access the parameters of the RA through the client and then feed them to the VA, and vice versa. Such a virtual machine scheme facilitates developments of the commissioning tools; enable feasible study of the proposed accelerator parameters and examination of the measured accelerator data.

The concept of virtual accelerator is also introduced to develop beam control application programs in the TPS accelerator control system. The virtual accelerator is on computer process which simulates behavior of a beam of TPS and responds to the accelerator control program under development in the same way as an actual accelerator does. Users of the virtual accelerator can test their control algorithm and user interface without affecting the operation of the accelerator. EPICS (Experimental Physics and Industrial Control System) jointly developed by LANL and APS/ANL will be used as a basis of the TPS accelerator control system as well to control all devices, hardware, I/O components, instruments and etc. In the EPICS based control system, a device is represented as a collection of records in an EPICS runtime database. A control program on a host computer can access devices in the system only through names of record fields, called 'channels'. This abstraction allows us to construct a virtual accelerator control system. Channel access interfaces were implemented into the modeling program AT to realize this idea. A sample application of the method will be also presented.

High level physical applications will be also planned to develop by MATLAB which provides diverse functionalities and toolkits for further mathematical

analysis. Most of these physical applications will be developed and based on available accelerator toolkits including AT (Accelerator Toolbox), MML (Matlab Middle Layer) and LabCA (EPICS channel access interface for MATLAB) [5]. The VA will be built and configured as the EPICS channel and simulated to a real accelerator. It could facilitate developments of the procedure control of commissioning, operation interface and physical applications. This paper describes the VA buildup activities and the developed tools by using VA. Further development and future possible application are also described.

TPS EPICS PROCESS VARIABLE NAME CONVENTION

A Process Variable (PV) is representation of a single value within an EPICS host. The EPICS channel will be connected between clients and servers through which a single PV is accessed. (for EPICS system, everybody know that)The EPICS PV naming convention of TPS is based on the format: "*Machine-System-Subsystem (-Location): RecordName*" where *Location* is an optional description and it represents the geographic order of the subsystems and some subsystem having only one or two equipments could eliminate this notation. For example, SR-PS-HC-124:setI represents the 4th horizontal corrector power supply current setting values of cell 12 at the storage ring. The PV name of the virtual accelerator in the TPS will be identical to the real accelerator except for adding "TPSVA-" as a prefix: "*TPSVA-Machine-System-Subsystem(-Location): Record Name*". Taking the above mentioned corrector power supply as example, TPSVA-SR-PS-HC-124:setI represents the PV in the virtual accelerator.

VIRTUAL ACCELERATOR BASED ON ACCELERATOR TOOLKIT

The EPICS toolkits were chosen as the control system frameworks for the new 3 GeV synchrotron light source (Taiwan Photon Source, TPS). The virtual accelerator is therefore built and based on EPICS as well. Fig. 1 shows the virtual acceleration structure and the other related high level application. Accelerator Toolbox (AT) and a part of MML (Matlab Middle Layer) are used in the employ ready-developed functions to simulate the behavior of the TPS accelerator as the right below corner block. A soft EPICS IOC is created to EPICS channel access server and provides an interface to other clients, to develop the respective applications. For example, MML is a widely adopted application in many facilities. The GUI/OPI of the control system could be also refined and tested.

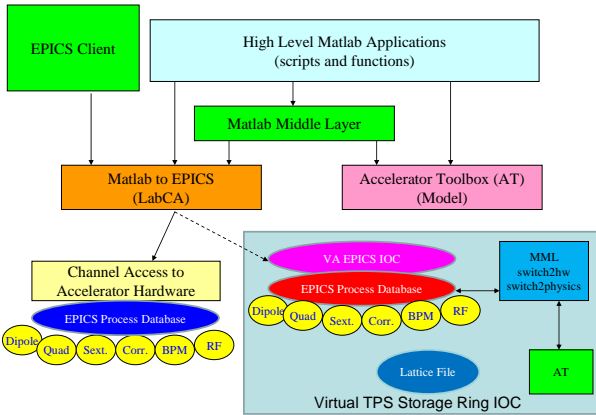


Figure 1: Functional block diagram of the virtual accelerator implementation.

DB FILE CONFIGURATION

Through LabCA packages, the Matlab high level application could be interfaced with EPICS channel access. The simulated EPICS IOC database (DB) is also created in the virtual accelerator platform. This DB file will list as many as possible EPICS PV channel name. For examples,

```
record(ai, "TPSVA-SR-PS-QL1-0101:setI") {}
```

The above description presents PV channel of quarupole family QL1 at cell 1 for current setting. The corresponding reading channel simulating with a small disturbance is as followed,

```
record(ai, "TPSVA-SR-PS-QL1-0101:getI") {}
```

The other related PV channel including ON, OFF, and RESET control will also be added to let it function as a real power supply.

AO OBJECT STRUCTURE

To build connectivity between accelerator physics and hardware component, the opinion of AO object in MML is also applied in VA according to the lattice THERING of AT. Fig. 2 depicts the AT link with AO structure. For examples, conversion of magnet field and current (B/I) could be performed by available function in MML. EPICS channel name could be also connected by using AO data structure.

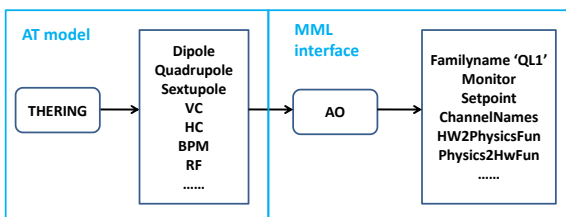


Figure 2: AT link with AO structure

USAGE OF THE VA FOR USER INTERFACE DEVELOPMENT

The virtual accelerator provides the necessary virtual channels to develop GUI control interface. Fig. 3 is the

draft control main page and Fig. 4 shows the corrector and quadrupole power supply control EDM page for the storage ring. These pages will be continuously refined and developed for the future commissioning.

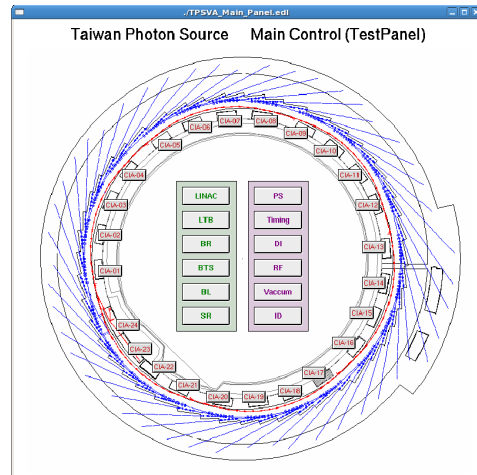


Figure 3: TPS main control EDM page

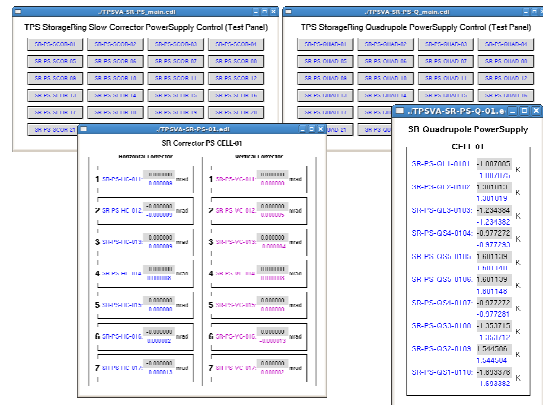


Figure 4: Storage ring corrector and quadrupole power supply control EDM page.

The core of the virtual accelerator is a simulator based on AT toolbox. The MML provides various applications access and GUI control pagefor commissioning with EPICS interface. MML could be configured as transport line, booster or storage ring. Fig. 5 shows the GUI interface of plotfamily in MML and is configured as the storage ring.

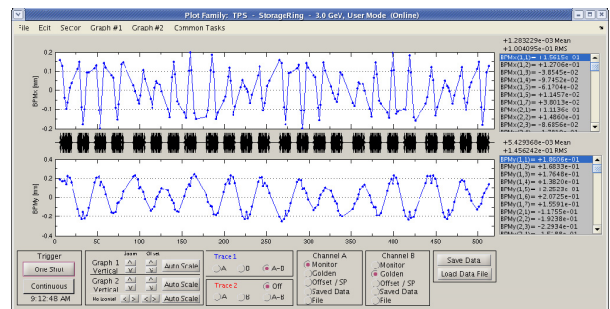


Figure 5: Plotfamily GUI used for displaying the horizontal and vertical storage ring orbit

Two applications will be used for the tune measurement. Beam excitation will be performed during injection or by pulse magnet or stripline. Each of the BPM electronics devices could record turn by turn data which is triggered by timing system and used for tune measurement. Fig. 6 & 7 depict the two related applications: turn by turn data, spectrum and phase space display. Try to increase setting of focus quadrupole family QL2 at cell one, we can reduce fraction of vertical tune and close to .25 resonant frequency as Fig. 7(b).

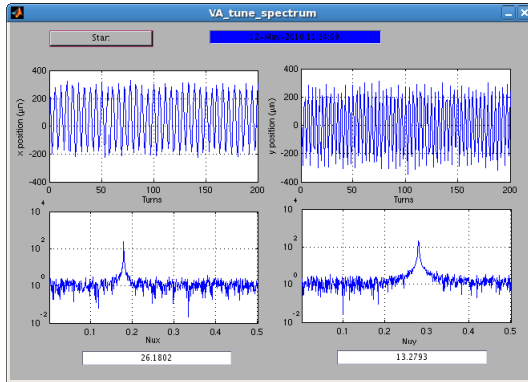
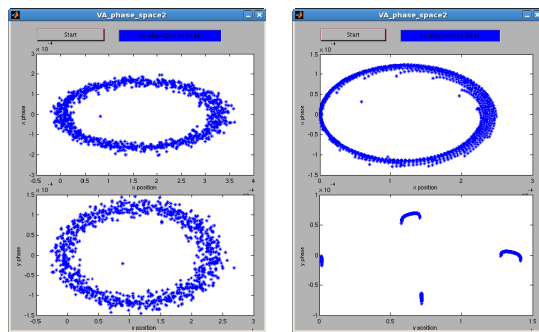


Figure 6: Tune measurement GUI: horizontal tune (left side) and vertical tune (right side).



(a) normal working tune (b) near 4th order resonance

Figure 7: (a) Phase space plotting for horizontal and vertical (b) Phase space plotting for horizontal and vertical plane when adjusts quadrupole setting to close the resonant.

FUTURE PLANS

To add more functionality to the virtual accelerator is under way. Most of the efforts will focus to integrate power supplies and diagnostics which is the most important related to the accelerator model.

SUMMARY

Since commissioning of the TPS will in late 2013, there are many high level applications need to be developed as early as possible. The EPICS based virtual accelerator is applied to instead of the real machine before TPS commissioning. It helps to provide an interface to facilitate the development of GUI, physics application, examination of user programs and etc. in the

early stage. The VA will continuously expand and grow to add new components/channels such that it can simulate a real accelerator as likely as possible.

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