# PROGRESS OF TPS CONTROL APPLICATIONS DEVELOPMENT

Y. S. Cheng, Jenny Chen, C. Y. Liao, P. C. Chiu, C. H. Huang, C. H. Kuo, K. T. Hsu
National Synchrotron Radiation Research Center, Hsinchu 30076, Taiwan

## Abstract

The TPS (Taiwan Photon Source) is the latest generation 3 GeV synchrotron light source which is in installation phase. Commissioning is estimated in 2014. The EPICS is adopted as control system framework for the TPS. The various EPICS IOCs have implemented for each subsystem at this moment. Development and integration of specific control operation interfaces are in progress. The operation interfaces mainly include the function of setting, reading, save, restore and etc. Development of high level applications which are depended upon properties of each subsystem is on-going. The archive database system and its browser toolkits gradually have been established and tested. The Web based operation interfaces and broadcasting are also created for observing the machine status. The efforts will be summarized at this report.

## INTRODUCTION

The TPS [1] is a latest generation of high brightness synchrotron light source which has been under construction at the National Synchrotron Radiation Research Center (NSRRC) in Taiwan since February 2010. The civil construction works are approximately finished in half of 2013. The TPS consists of a 150 MeV electron Linac, a 3 GeV booster synchrotron, and a 3 GeV storage ring, and the accelerator system installation and system integration will be proceeding from later 2013. Commissioning is scheduled in later 2014.

The EPICS (Experimental Physics and Industrial Control System) is a set of open source software tools, libraries and applications developed collaboratively and used to create distributed soft real-time control systems for scientific instruments such as the particle accelerators, telescopes and other large scientific experiments [2]. In the field of accelerators, many facilities have good practical experiences for EPICS and adopt it as the accelerator control systems. Many resources and supports are available as well as numerous applications for accelerator have been developed.

As a result, the EPICS framework was also selected as control system infrastructure for the TPS project. The EPICS platform has been gradually built and tested to control and monitor the subsystems of TPS. The various database records can be created for accessing the I/O data and setting parameters at the IOC (Input Output Controller) layer. Adopting the EPICS channel access mechanism with specific toolkits, the data can be accessed between the IOCs and the clients.

During the implementation process of the EPICS support for various subsystems, the operation interfaces of each subsystem are also developed according to the different operation methods. To simulate the operation process, the various operation interfaces are needed to integrate. The centralized management of the EPICS related files is also adopted, and the mechanism of save and restore will be continuously developed. The efforts will be summarized as following.

## SOFTWARE ENVIRONMENT

The client consoles are adopted the Linux operation system. All of the EPICS base, modules and extensions are installed at the Linux system. The software versions are shown as Table 1 where most of applications are developed base upon this software environment.

Table 1: Software Environment of the Control Consoles

|  | Version |
|---|---|
| OS | RHEL 5.x (32-bit) (kernel 2.6.18.x) |
| EPICS | base-3.14.11 |
| Extension | edm-1.12.8x |
|  | labCA-3.3 |
| CSS | 3.1.6 |

All EPICS related files at control consoles are mounted from the file server by using the NFS service to simplify software version control. Various directories are created and saved into various versions of related files for various hosts and purposes. Various directories provide a mount point for hosts mounted according to various purposes. The directories include EPICS base, modules, extensions, saved data, temporary data and etc.

Several file servers are established to share the loading of NFS file service. The hosts mount specific file server according to its location and purpose. By loading testing, the NFS file service is divided into three parts. Two servers provide the NFS service for hosts of all cells; the other server is for engineer development.

## SAVE AND RESTORE MECHANISM

To readily restore a set of the machine parameters for subsystems during operation as well as to optimize and record working points for different machine conditions, the mechanism of save and restore is developed. The save and restore function is initially established by using the MATLAB with the labCA [3]. The various files of grouped PVs (Process Variables) list are created for saving the respective parameter values of each subsystem. The file with PVs and saved parameters is also selectable for resume the settings. The graphical operation interface of save and restore mechanism is created as shown in the Fig. 1.

Figure 1: The operation interface of save and restore.

# SUBSYSTEMS CONTROL PAGES

At the development phase, the GUI of TPS control system adopts the EDM (Extensible Display Manager) toolkit to develop main graphical operation interface. The EDM pages of various subsystems are created and saved into the NFS file sever for client console operation.

The EDM is an interactive GUI builder and execution engine, the EPICS documentation uses the term display manager, and maintained by the ORNL EPICS community [4]. All "objects" of EDM are loaded from shared libraries. The EDM administrator can add and remove objects from the list of available objects without recompiling EDM itself. The objects are versioned, carefully coded objects can be upgraded without impacting existing displays.

The main control page is built by the EDM toolkit shown as the Fig. 2. All control pages can be launched from this GUI. All control components are located at the foreground of the TPS accelerator illustration. For example, the LTB (Linac to Booster) dedicated control page is linked from the main control page for operation shown as the Fig. 3. The related control parameters or components are also located at the same page for tuning easily, such as the control page for the TPS timing as shown in the Fig. 4. These pages will be continuously refined and developed for the future commissioning.
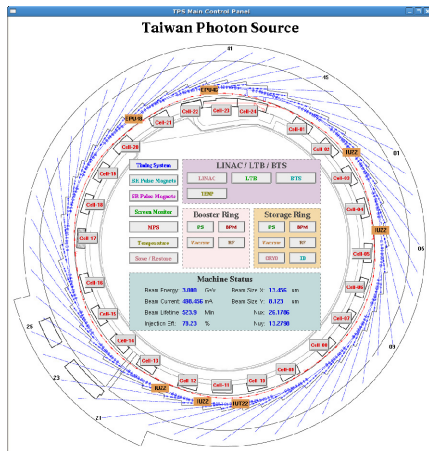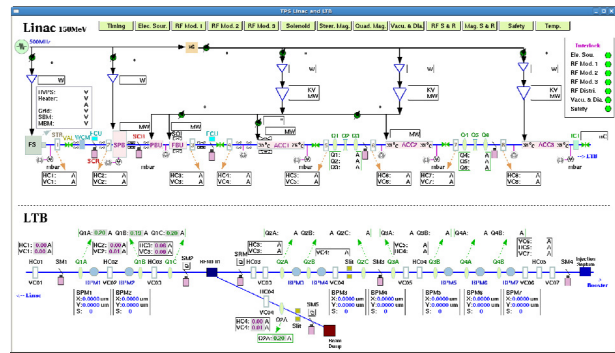


Figure 2: TPS main control page.



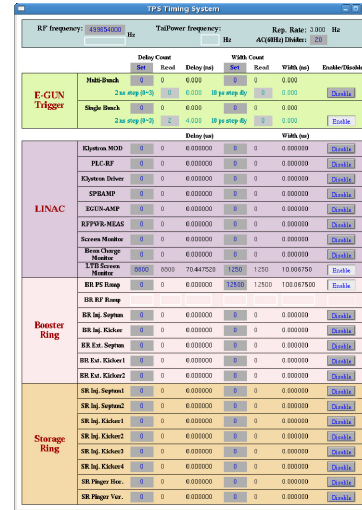Figure 3: The Linac and LTB GUI control page.



Figure 4: The overview control page for the TPS timing.

The EDM toolkit is also adopted to develop the operation interface of power supplies. The client console can operate the specific EDM page to access the data via PVs channel access. The preliminary GUI page of storage ring dipole, quadrupole and sextupole power supplies controls as shown in Fig. 5. The main control page was shown critical information for observing status easily, and the main operation process functions are also executed from the panel. The Fig. 6 shows the GUI page of one quadrupole power supply control for storage ring. The macro name method was regularly used to switch each display page. Fig. 7 shows GUI for booster 2 families of sextupoles and bending trim coil ramping waveform generation and download.
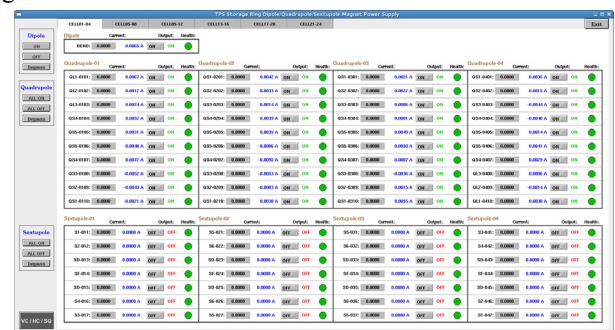


Figure 5: The control GUI of storage ring dipole, quadrupole and sextupole power supplies.
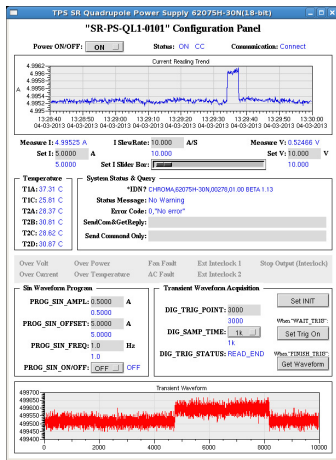
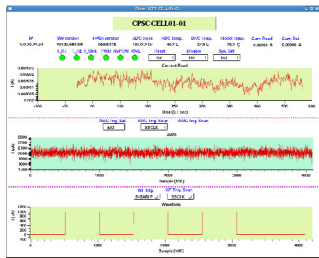Figure 6: GUI of one quadrupole power supply control.



Figure 7: EDM GUI page for booster corrector power supply controller (CPSC).

GigE Vision cameras are used to capture images. A dedicated EPICS IOC is used to acquire images and delivery waveform process variables (PVs) which represent the images. The image analysis IOC embedded MATLAB environment to perform image processing and analysis. The screen monitor analysis GUI as shown in Fig. 8, has been developing and has various features including specify region-of-interest (ROI), optional background subtraction, 3D image viewing, and software multiple exposure. It also can create a simulated beam image for the purpose of evaluating the fitting correctness. All fitted parameters will be stored as EPICS PVs such that clients can easily access it for further usage.

The LabVIEW GUI was developed for the gated ICCD control and display. The layout of the LabVIEW GUI is shown in Fig. 9. It contained an EPICS IOC by using the LabVIEW Datalogging and Supervisory Control (DSC) module which can create the PVs or communicate to PVs through the Server and Client I/O server functions.
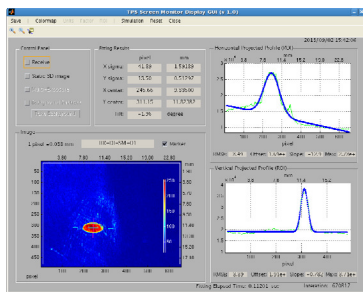


Figure 8: Layout of the Matlab analysis display GUI for screen monitor.
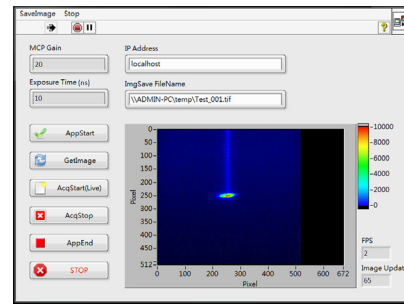


Figure 9: LabVIEW ICCD control/display GUI.

New generation digital BPM electronics is equipped with Ethernet interface for configuration and served as EPICS CA server with 10 Hz data rate. Another multi-gigabit interface will deliver beam position for fast orbit feedback purpose at rate up to 10 kHz. The BPM electronics will also provide post-mortem buffer for orbit analysis during specific event happened like beam loss. Post-mortem analysis can help to find the weakest point and provide information to improve system reliability. The BPM GUI has created to analyze by using MATLAB. Fig. 10 shows the main page for the TPS storage ring BPM system, and Fig. 11 shows main page for the TPS booster ring ramping orbit system.
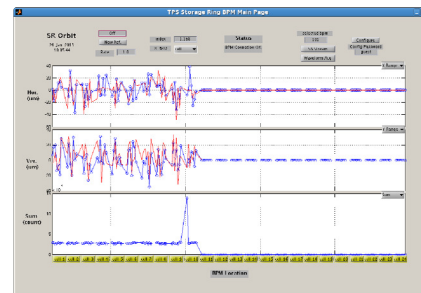


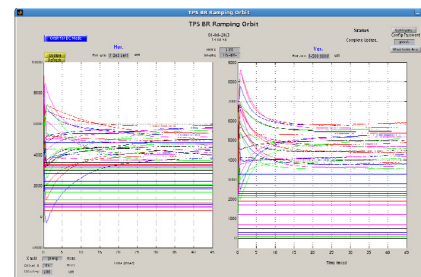Figure 10: Main page for TPS storage ring BPM.



Figure 11: Main page for TPS booster ring ramping orbit.

Due to the limited display resolution of the existed analogue CATV system, it cannot display all necessary information in one screen; and many channels are needed to deliver variety information for different users with different preference. Based upon the advanced of computer network and low cost high resolution display available, web broadcasting design can provide concise and comprehensive information in one page, and can satisfy most of users requirements. More display pages can be added if necessary. The Web broadcasting of the simulated TPS machine status is shown in Fig. 12. On the other hand, the WebOPI [5] function has been established

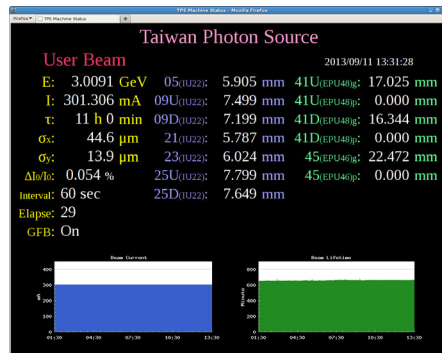to use CSS-created control GUI pages via Web browser. The WebOPI for controlling CPSC is shown in Fig. 13.



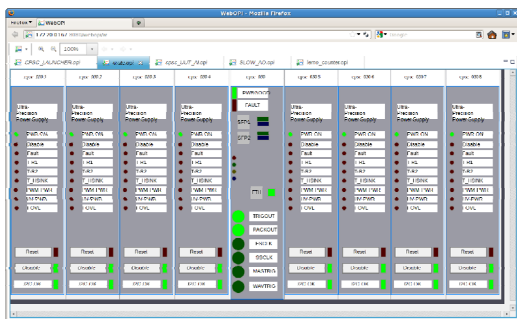Figure 12: Web broadcasting of the simulated TPS machine status.



Figure 13: CSS WebOPI for controlling CPSC.

## ARCHIVE SYSTEM

The historic EPICS data need to be recorded during the initial test phase for the TPS control system construction. Thus the EPICS data archive system needs to be established for saving the historic EPICS data of various subsystems. The archive system of CSS (Control System Studio) which named BEAUTY (Best Ever Archive Toolset, yet) [6] was built to be used as the TPS data archive system in 3rd quarter of 2012. Moreover this developed TPS archive system will be utilizing gradually during the installation and commissioning phases.

The CSS archive system can store data in an RDB (Relational Database). The CSS includes JDBC libraries for some databases (MySQL, Oracle, PostgreSQL), and the archive system includes example database definition (DBD) files to create the required tables for the database dialects. The PostgreSQL (EnterpriseDB) [7] RDB was used for the EPICS data archive system of TPS project. The PostgreSQL RDB can be a good compromise and bigger table sizes. Both the historic data of PVs and the Archive Engine configuration are stored in the same relational database. The engine configuration can be imported from an XML file format into the database.

To observe the temperature variation for in-vacuum insertion device baking, the specific monitor GUI was created by the CSS toolkit, and this page can be displayed the latest 30 minutes historic temperature data trend which retrieved from the database. The monitor GUI is shown as Fig. 14.
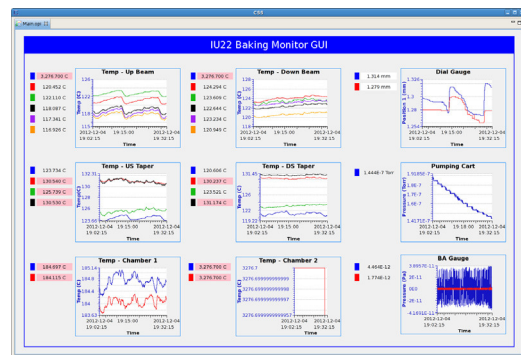


Figure 14: Archive data browsing GUI for ID baking.

The archive system of CSS (Control System Studio) which named BEAUTY (Best Ever Archive Toolset, yet) was built to be used as the TPS data archive system in 3rd quarter of 2012 [8]. The PostgreSQL RDB was adopted as the data storage for the BEAUTY. The archived data can be retrieved in a form of graphical representation using the CSS-based data browser. Taking the performance and redundancy into considerations, the storage servers and RDB table structures are tuned relatively. This developed TPS archive system will be utilizing gradually during the installation and commissioning phases.

## SUMMARY

The TPS control system adopts the EPICS framework as the control infrastructure. The EPICS supports of various subsystems are built gradually. The operation interfaces of various subsystems are also developed in the meantime. The various GUIs are designed according to the different operation methods. The management of the EPICS related files system is also established for maintaining files versions easily. The mechanism of save and restore are needed to apply parameters for operation process. Various operation interfaces will be integrated and improved continuously during the TPS control system construction. Adopt newly developed supports accompany with EPICS V4 will be included in deploy of the TPS control system includes directory service, high level applications, and etc.

## REFERENCES

[1] TPS, http://www.nsrrc.org.tw/english/tps.aspx
[2] EPICS, http://www.aps.anl.gov/epics/
[3] labCA, http://www.slac.stanford.edu/~strauman/labca/
[4] EDM, http://ics-web.sns.ornl.gov/edm/
[5] WebOPI, http://sourceforge.net/apps/trac/cs-studio/wiki/webopi
[6] CSS Archiver, http://ics-web.sns.ornl.gov/css/
[7] EnterpriseDB, http://www.enterprisedb.com
[8] Y. S. Cheng, et al., "Implementation of the EPICS Data Archive System for the TPS Project," Proceedings of IPAC2013, Shanghai, China, May 12-17, 2013.