# DESIGN STATUS OF THE TPS CONTROL SYSTEM

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*Abstract*

The Taiwan photon Source (TPS) control system is undergoing design and implementation phase. The control system is based on EPICS toolkits. Selection of hardware platform and software components are in proceed. Test-bed has set up and evaluate various selected hardware and software components. The control system will provide versatile environments for machine commissioning, operation, and research. The open architecture will facilitate machine upgrade, modification easily and minimize efforts for machine maintenance. Performance and reliability of the control system will be guaranteed from the design phase.

## INTRODUCTION

The TPS [1] is a latest generation of high brightness synchrotron light source proposed to build at the National Synchrotron Radiation Research Center (NSRRC) in Taiwan. It consists of a 150 MeV electron Linac, a booster synchrotron, a 3 GeV storage ring, and experimental beam lines. The control system consists of more than a hundred of CompactPCI (cPCI), MicroTCA (μTCA) and AdvancedTCA (aTCA) crates running the Experimental Physics and Industrial Control System (EPICS) [2]. Options of such kinds of hardwares provide us a chance to take advantages of local IT industry with better supports and low cost. Another proprietary IOCs are also possible to design provide by vendors. The cPCI IOC will be equipped with input/output modules to control subsystems. The power supply and fan module of the cPCI crate will be hot-swapped. The TCA IOCs can be interface to network attached devices and used as computation engine for demanding feedback applications. Consoles and servers are PCs running Linux. To achieve high availability of the control system, emphasis has been put on software engineering and relational database for system configurations. More than 300 K data channels will be serviced by the control system. Accessibility of all machine parameters through control system in a consistent and easy manner contributes to the fast and successful commissioning of the machine. Highly reliable Ethernet will be intensive used for field-bus. Superior reliability and high availability of TPS control system with reasonable cost and high performance are expected.

## CONTROL SYSTEM FRAMEWORK

Control system for the TPS is based upon EPICS toolkit framework. The EPICS toolkit provides standard tools for display creation, archiving, alarm handling etc, if users have found these tools to be inadequate and developed in-house alternatives. The big success of EPICS is based on the definition of a standard IOC structure, together with an extensive library of driver software for a wide range of I/O cards. Many users of the system report a steep learning curve and the need for significant development resources, but this is balanced by the large installation base and proven ability of this approach. The EPICS toolkits which have various functionalities will be employed to monitor and control all accelerator and beamline hardware. To meet budget restriction and gain better supports, a majority of hardware for IOCs is planned to be acquired from local manufactures. Control system special I/O modules (timing, event system modules, special transient digitizer, ..etc.) will procure from foreign countries.

### *Equipment Interface Level*

Monitor and control of equipments is via the direct connection to cPCI IOCs crates running EPICS. Standard I/O modules provide interfaces for analogue and digital input/output as well as serial line connection, scaler modules and position encoders. Ethernet will be heavily used as field-bus to connect many devices, such as power supplies, motion control, temperature monitor, oscilloscope, IP camera/phone/pager, …etc. The other input/output modules are mounted in the cPCI carrier boards. Operating for the IOC level is planned to adopt Linux. Adopting single operating system for all of IOCs, OPI, and various servers may minimize the efforts of the software development and is the current favorable proposal. The μTCA/aTCA platform will be used as EPICS IOC for some applications also and used as orbit feedback system platform.

### *Networking*

Mixed of Fast Ethernet, 1/10 Gbps switched Ethernet will be deployed for the TPS control system [3]. Most of devices will provide GbE connection. The backbone will be a 10 G links. There are several private Ethernets for devices control and GigE Vision camera applications. Isolation and routing are requested and ensure network security with necessary flexibility will be addressed. Some devices such as the file and database servers are on both the private and intranet network, allowing the exchange of data among them. Availability, reliability and security, and network management will be focus in the design phase.

### *Operator Interface Level*

The operator interface level consists of Linux PCs are used as consoles and servers. Consoles in the control room have multiple LCD screens. Two large screens high resolution LCD display (30") provides major user interface and four small LCD (21") just installed above of the large display might used for configure fixed display. Curved LCD technology might be adopted after it's mature and cost down. The computer for OPI will be installed at the computer system control room with optical PCIe extension to remoter display unit at control room, this can provide better cooling for the computer, reduce loudness at control room and provide clean control consoles. Large screen format displays hang on the roof at control room will be available for display of important parameters likes beam current, lifetime, vacuum distribution, synchrotron radiation image, …etc..

### *Applications and Physics Programming Interface*

Generic applications provided by the EPICS toolkit will be used from all kinds of applications. Standard tools such as the archiver, alarm handler and save-restore tools are supported. Channel Access is used as an interface to machine process variables (PVs), and simple tasks such as monitoring, alarm handling, display and setting of PVs are performed using EDM panels and strip tools. The accelerator physics tools for TPS includes extensively adopted Matlab Middle Layer (MML) and Accelerator Toolbox (AT) software packages. They are developed in parallel at the ALS and SPEAR3. It enables various developed applications of different machines be directly adopted for TPS applications. The MML has also provided a systematic way of managing machine data, and is easily extended to separate data from transfer lines, booster and storage ring. The Middle Layer communicates with the machine from within MATLAB using LabCA. To enable early testing of the physics tools through the control system, a virtual accelerator has been implemented by the help for Diamond Light Source to give simulation of the accelerators through the intended PV interface. It was developed by providing EPICS device supporting to interface and the model using the AT and MML.

## TECHANICAL SYSTEM INTERFACE

Some technical system interfaces which are plan used for the control system of TPS are summarized in this paragraph.

### *Power Supply System*

Control of the near 1400 sets of various power supplies of TPS is divided into three categories rather than a unify solution. Reason of this choice is to meet the real practical situation from manpower, budget and available vendors. The small power supply for corrector magnets in the range of 10 Amp categories will directly interface by analogue interface with 18 bits resolution. The intermediate power supply with current rating 250 Amp will equip with Ethernet interface. The main AC power supply of the booster synchrotron and the storage ring dipole DC power supply will be equipped with Ethernet interface also. The main AC power supply of the booster synchrotron will built in waveform support with external trigger capability. All of these power supplies will interface with the EPICS IOCs directly.

### *Insertion Devices Control*

The warm insertion devices will follow the TPS motion control standard, Ethernet based motion controller will be used. The IOC will be equipped with related I/O modules and connected to the motion controller via Ethernet. Absolute optical encoder with SSI and EnDat 2.2 protocol will be supported. Interlock signals from limit switches, tilt sensor, encoders will ensure the safe operation for the insertion devices. Trimming power supplies of the insertion devices will be controlled by the IOC also.

### *Timing System*

The event system was chosen for the TPS timing solution. Basic hardware includes event generator, event receiver and event receiver for gun trigger with fine delay functionality. These entire modules can installed various universal I/O mezzanine modules (UNIV I/O) to meet different input/output requirements. The mechanical form factor is 6U cPCI module. The 125 MHz event rate will delivery 8 nsec course timing resolution. Its high resolution and low jitter performance allow accurate synchronization of hardware signals and software across the TPS control system. Its usage simplifies the operation of the machine and allows complex sequences of events to be carried out by changing very few parameters. Prototype is setup in the lab. A large scale prototype system is planned to construction in 2011 for software development.

### *Diagnostics System Interface*

New generation digital BPM electronics is equipped with Ethernet interface for configuration and served as EPICS CA server with 10 Hz data rate. Another separated GbE interface for a small group of BPM electronics will delivery beam position for fast orbit feedback at rate up to 10 kHz. Data communication for the BPM group is via RocketIO interface with redundancy to improve reliability. Reliability and high performance can be achieved. High precision beam current reading and lifetime calculation will be done at a dedicated IOC. The GigE Vision digital cameras will capture images for diagnostic purposes. Counting type and integrating type beam loss monitors will be connected to the control system by counter or ADC modules installed at IOCs.

### *Feedback System*

The feedback system is planned to provide user service from day-one after dedication. Integrated global orbit feedback system by using slow and fast correctors in the same feedback loop is basic design. The orbit feedback system is also planned to adopt multi-gigabit link (Gigabit Ethernet grouping or Diamond communication controller or another approach) to acquire orbit data from BPM electronics at rate of 10 kHz to μTCA/aTCA crate. Either FPGA platform (preferred) or general purpose processor running real-time operating system as feedback engines installed at the μTCA/aTCA crate will perform computation. The correction command can be sent to the fast corrector with the remote high resolution DAC module for corrector power supplies control via dedicated fibre links (RocketIO or GigE links) interfaces. Diagnostic node will be used to capture fast orbit data and corrector setting, up to 10 sec at 10 kHz rate for feedback system diagnostic and performance study purpose. The capture can be triggered either software or hardware with post-mortem capability. The bunch-by-bunch feedback system will adopt the latest generation FPGA processor with build-in diagnostics.

### *Turnkey System*

There are many subsystems like linear accelerator, RF transmitter, insertion devices, etc. which will be delivered by industry as turnkey contracts. These systems will be delivered with an EPICS control system [3]. It will be easy to integrate with the TPS control system. The linear accelerator was contracted to the RI Research Instruments GmbH and will delivery in early 2011. RF transmitter already contracted to the Thales and will delivery in 2011 also.

### *PLC Solution*

Single PLC solution is an idea goal from many aspects. However, due to practical reasons of various subsystems, several different kinds of PLCs might be used, including Siemens S7-300 or compatible model from VIPA, Yokogawa PLC with embedded EPICS IOC, Safety PLC from Omron for personnel safety system.

### *Interlock*

Each subsystem will have build-in interlock and protection. The global machine interlock system will collect various interlock signals from local interlock of orbit, vacuums, front-ends, radiation dosage monitors to send the beam disable commands to trip beam or inhibit injection.

### *Relational Database*

Relational database is planned to use for system configuration and operational management. Features provided include generating configuration files, archiving, reporting of bugs and system failures, tracking the location of all hardware modules, and generating EPICS substitution files. Users interrogate and modify database tables via a web interface.

### *Reliability Issues*

Reliability of control system can be improved by adopting high availability hardware, operating system, intensive software test, and adopt various strategic. Loosely coupled between IOCs and some critical devices (e.g. power supplies) can improve system reliability also, even performed IOC reset. Hot redundancy cPCI/μTCA/aTCA power supplies and fans can eliminate most of the single point failure. Power supply and fan of the IOC crates and computers usually are the most frequently failure cases compare to another component. Hot swappable of various I/O modules and network modules can reduce system downtime also. Continue monitoring of the healthy conditions of IOC crates, computers, BPM information, temperature of various components will be very useful to fine precursor of the failure. Software daemon will be watch and analyze of the healthy condition automatically and report to the adequate persons.

### *Post Mortem Analysis*

The cPCI ADC modules support buffer to capture events for post-mortem analysis following a beam loss or other events. Power-supplies are expected to have internal data buffer with post-mortem capability. 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.

## SUMMARY

Design and implementation of the TPS control system is in proceed. Control system staffs cultivation were done in 2008~2009. Prototype is planned in 2010~2011. Construction will be start after the TPS building finished which is expected in later 2012. Detailed design and selection of various hardware and software components are continuously ongoing and revising. Procurement of the IOC components, servers, and various computers will perform in 2010~2012. Make decision at the last minute is the strategic to prevent to do the wrong investment. Adopt updated components for the TPS control system are continuously watched to take advantage of the recently technology in advanced. For the system which design don't need to be finalized at this moment, but will be finalized at adequate timing. More latest hardware and software technology will be advantages of the TPS control system to gain better performance, avoid quickly obsolesce and more economic.

## REFERENCES

[1] TPS Design Book, v16, September 30, 2009.
[2] http://www.aps.anl.gov/epics/index.php.
[3] Y.T. Chang, et al., "Preliminary Planning of Taiwan Photon Source Control Network", these proceedings.