# CONCEPTUAL DESIGN OF THE TPS CONTROL SYSTEM

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*Abstract*

Baseline design of the Taiwan photon Source (TPS) control system of NSRRC is proposed. The control system design is based on EPICS toolkits. Guidelines for hardware platform and operating system choice will be addressed. The EPICS test bed will be setup to evaluate various selected hardware and software components. The TPS control system will provide versatile environments for machine commissioning, operation, and research. The open architecture will facilitate machine upgrade, modification without toil and minimized efforts for machine maintenance. Performance and reliability of the control system will be guaranteed from the initial 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 ~ 3.3 GeV storage ring, and experimental beam lines. The machine and beamline control system consists of more than a hundred of CompactPCI (cPCI) sets and/or Advanced Telecom Computing Architecture (aTCA) crates running EPICS [2] on Intel processors. Selection of such kinds hardware enable us have change to take advantage of local manufactureu in Taiwan. Another proprietary IOC are also possible design by some vendors, such as series IOC by using MOXA embedded computer, MicroIOC, D-TACQ solution or PC/Linux software IOC. The cPCI IOC will be equipped with input/output modules to control subsystems. Most hardware channels are directly connected to cPCI input/output cards. The cPCI input/output cards can be 'hot-swapped', and have circular buffers for inevitable failures and post-mortem analysis in case of beam loss. The aTCA IOC can be interface to network attached devices and used as computation engine for demanding feedback applications. The network is based on switched Fast Ethernet and 1G/10G Ethernet technology. Consolers 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 can be archived at high speed, and the resulting data is accessed through the Web. Accessibility of all machine parameters through control system in a consistent and easy to use manner contributes to the fast and successful commissioning of the machine. Highly reliable Ethernet will be intensive used for field-bus. Superior reliable and high availability system with reasonable cost and high performance are expected.

## CONTROL SYSTEM SELECTION

Three options for the control system were intensive study during pasting year: propriety design control system of 1.5 GeV Taiwan Light Source (TLS), TANGO of the ESRF/SOLEIL/ALBA collaboration, and EPICS toolkits. The conclusion was that each could deliver a working control system. A detailed analysis of further requirements showed that EPICS had advantages of its application to other accelerator projects, numerous developed drivers and no bad performance/functionality.

## CONTROL SYSTEM INFRASTRUCTURE

Experimental Physics and Industrial Control System (EPICS), which has various functionality 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 are planned to acquire from local manufactures in Taiwan. Accelerator related special I/O modules (timing, time-to-digital converter, special transient digitizer, ..etc.) will procure form United State, European, or Japan.

### *Equipment Interface Level*

Monitor and control of equipments is via the direct connection to cPCI or aTCA IOCs crates running EPICS. Standard I/O modules provide interfaces for analogue and digital input and output as well as motor control, temperature measurement, serial line connection, scaler modules and position encoders. Most interfaces are industry pack (IP) modules mounted on hot-swap cPCI carrier boards. Connection to signals is on the rear of the crate using 80mm deep transition modules. Operating for the IOC level is planned to adopt Linux, whether real-time or non real-time is still in evaluation. Adopt single operating system (Linux, non- real-time or reat-time and different distribution might acceptable) for all of IOCs, OPI, and various servers may minimize the efforts of the software development is the current though.

### *Networking*

Mixed of 100M/1G/10G bits/sec switched Ethernet will be deploy for the TPS control system. Most of devices will provide GbE connection. There are several private Ethernets for Ethernet enable devices and GigE Vision Camera applications. Necessary isolation and routing to 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, allowing the exchange of data among them.

### *Operator Interface Level*

The operator interface level consists of Linux PCs used as consolers and servers. Consolers in the control room have multiples of LCD screens. A number of single large screen consolers, which also act as boot servers, are located in the technical gallery or on beam lines. Large screen format display at control room will be available for display of important parameters likes beam current, lifetime, vacuum distribution, synchrotron radiation image, etc..

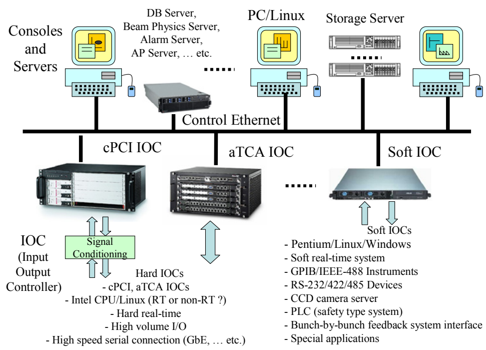


Figure 1: Proposed TPS control system architecture.

## EPICS TOOLKITS

The EPICS system has been widely adopted in the accelerator community. It has been used as primary software toolkits on many light sources control systems with great success. A considerable amount of works has been done around the world to port some aspects of the EPICS software to other platforms such as PCs running or Linux for consolers and cPCI/aTCA Intel processors for IOCs. Although EPICS provides standard tools for display creation, archiving, alarm handling etc, many 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 installed base and proven ability of this approach.

## MAJOR SYSTEM BUILDING BLOCKS

From the early deploy third generation synchrotron light source like TLS up to the latest generation synchrotron light source like TPS, technology for control system are quite different. Many new technologies will adopt for the control system of TPS. Highlight of various components of TPS control system are summarized in this paragraph.

### *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 striptools. However, for more complex accelerator physics applications, collections of scripts written in MATLAB and Python are utilized. The accelerator physics tools for TPS includes extensively adopted Matlab Middle Layer (MML) and Accelerator Toolbox (AT) software packages 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 either MATLAB Channel Access (MCA) or LabCA.

### *Power Supply System*

Control of the near 1000 sets of various power supplies of TPS is carried out by using individual fully digital power supplies. Very high stability of the electron beam from the experience of SLS and DLS confirmed the performance of digital power supply. Interface of the power supply controller is via a optical serial link to a power supply control interface box. This box is used as concentrator and equipped with GbE and RocketIO interface. The GbE interface will connect to the IOCs and the RocketIO interface to orbit feedback aTCA crate. All internal control parameters and readings can be read and set via this link and appear as standard EPICS process variables.

### *Timing System*

The timing system is a high performance design based on the APS/SLS/DLS event system. The only difference is the cPCI form factor rather than VME64x will be adopted. Its high resolution and low jitter performance allow accurate synchronization of hardware signals and software across the TPS control system. It usage simplifies the operation of the machine and allow complex sequences of events to be carried out by changing very few parameters. Its integration into the TPS control system means timing parameters can be treated just like any other control system variables.

### *Diagnostics System Interface*

New generation digital BPM electronics equipped with Ethernet interface for configuration and served as EPICS CA server for 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$^{TM}$ 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. FireWire or 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 will operate from day-one for user operation. Slow orbit feedback will be implemented by Matlab scripts running on control consoles. The feedback scripts by the aid of MCA can access BPM and control settings of the slow correctors at early operation. Dedicated fast orbit feedback system is also planned to adopt GbE link to acquire a group of BPM electronics at rate of 10 kHz orbit data to orbit aTCA crate. Compute blades installed at the aTCA crate will perform computation. The correction command can be send to the fast corrector via dedicated GbE links or RocketIO interfaces to the power supply controllers. Fast orbit data and corrector setting will be captured via a dedicated compute blade at the aTCA crate for diagnostics and further analysis. The bunch-by-bunch feedback system will adopt the latest generation FPGA processor with build-in diagnostics.

### *Turnkey System*

There are many subsystem like Linac, RF transmitter, insertion device, beamline monochromator, might be delivered by industry as turn key contracts. These systems will be delivered with an EPICS control system [3]. It will simplify integration into the global control system.

### *Beamlines Control System*

Beamline controls will be handled by the same hardware and software used for machine controls for which it reduces costs and development time, this has enabled control peoples to work on either system. The synApps [4] is a collection of software tools that help to create a control system for beamlines. Further development is needed to support various new devices and non-EPICS hardware. Data storage and handling will be addressed in the detailed design phase. Some turn-key beamline subsystem might delivery from the vendor equipment with EPICS control system.

### *Interlock*

Each subsystem will have build-in interlock and protection. The global interlock system will collect various interlock signals from local interlock of vacuum system, BPM electronics to send the trip beam commends the beam and/or to disable injection.

### *Relational Database*

ORACLE or MySQL relational database is planed 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 IOC and some critical devices (e.g. power supplies) can improve system reliability also, even performed IOC reset. Hot redundancy cPCI/aTCA power supply can eliminate the failed of a single unit failed. Hop swappable of various I/O module and network modules can reduce system downtime. How to design a system with high reliability will be address for the TPS control system.

### *Post Mortem Analysis*

Most of our I/O modules support buffers to capture events for post-mortem analysis following a beam loss or other events. The BPM electronics will also provide 16 k samples post mortem buffer for orbit analysis during specific event like beam loss. Post mortem analysis can be help to find the weakest point and provide precious information to improve system reliability.

## CURRENT STATUS

Conceptual design of the TPS control system ios ongoing in 2007. Detailed design and selection of various hardware and software components will be done in next two years. Setup of an EPICS test bed to evaluate various functionalities is current focus. Various servers are also planned. Functionalities of the control system will be tested in the coming years.

## STRATEGIES TO SUCCESS

Richness resources of the EPICS collaboration are available at various EPICS sites around the world. Since the evolve of IT technology are very fast during a last decade since EPICS toolkits appeared, more modern hardware and software technology will be advantages of the TPS control system to gain better performance and avoid obsolesce. It is plans to adopt more economy products based upon budget concerns; it requires some efforts for R&D. Help from EPICS community can ensure the success of the TPS project.

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