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 toolkit. Selection of hardware platform and software components are in proceed. Test-bed has been set up to evaluate various selected hardware and software. 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 which in construction 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. Civil construction has started from February 2010. The construction works will continue until mid-2102. Accelerator system installation and system integration will then be proceeding for one-year period. Control system for the TPS is based on the EPICS framework [2]. The control system consists of more than a hundred of EPICS IOCs. 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. Adopting cPCI platform for EPICS ILCs provides us a chance to take advantages of local IT industry products with better supports and low cost. Another proprietary IOCs are also possible to design provided by vendors. 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. High reliability and availability of TPS control system with reasonable cost and 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 and etc. If users have found these tools inadequate, development of in-house alternatives is feasible and compatible. 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 to control accelerator system.

Equipment Interface Layer

Most of the devices and equipments will connect to cPCI IOCs crates running EPICS directly. The cPCI EPICS IOC equipped with the latest generation CPU board will be standardized as ADLINK cPCI-6510 CPU module [3]. The 128 bits DI/DO module will be used for BI, BO solution. ADC module embedded EPICS IOC will provide slow data acquisition and waveform data at same time [4]. High precision DAC module (equipped with 20 or 18 bits DAC) will be dedicated for power supply control [4]. Industry pack (IP) carrier board in 6U cPCI form factor can equip up to 4 IP modules. Various IP modules are adopted for necessary applications. Event system modules are in 6U cPCI form factor. Private Ethernet will be heavily used as field-bus to connect many devices. Power supplies of all magnets except for corrector equip with Ethernet to the EPICS IOC communication. Multi-axis motion controller with Ethernet interface will be the standard support for the control system. Temperature monitor with LXI interface will be a standard solution for RTD or thermocouple solution. Oscilloscopes with Ethernet interface (LXI comply or not) are chosen. Commercial EPICS scope might be employed also. Gigabit Vision cameras will be used for diagnostic standard and the other applications. The μTCA/aTCA platform will be used as EPICS IOC for some special applications.

Networking

Mixed of 1/10 Gbps switched Ethernet will be deployed for the TPS control system [3]. Most of devices will provide GbE connection. The control network backbone will be 10 G links. Private Ethernet is used for Ethernet based devices access and GigE Vision camera applications. Adequate isolation and routing topology will balance of network security and needed flexibility. The file and database servers are connected to the private and intranet network, allowing the exchange of data among them. Availability, reliability and security, and network management are focus in the design phase.

Operator Interface

The operator interface level consists of Linux PCs for consoles and servers for various purposes. Various EPICS OPI tools and Matlab will be adopted for OPI development. It is planned currently that most of the GUIs will be implemented by EDM and Matlab. Consoles in the control room have multiple LCD screens. The OPI computer will be installed at the equipment area of control room with optical PCIe extension to remote 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 and etc.

Applications and Physics Programming Interface

Generic applications provided by the EPICS toolkit will be used for all kinds of applications. Standard tools such as the archiver, alarm handler and save-restore tools are supported. Channel Access (CA) is used as an interface for machine process variables (PVs) access. 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 include extensively adopted Matlab Middle Layer (MML) and Accelerator Toolbox (AT) software packages. It enables various developed applications of different machines to 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 to give simulation of the accelerators through the EPICS PV interface. It was developed by provided EPICS device support to interface the model using the AT and MML.

CURRENT STATUS

Define TPS control system standard is the efforts during last couple of years. Efforts of the control system development status are summarized in following paragraphs.

Standardization of the cPCI EPICS IOC Modules

The 6U cPCI platform was shosen for the EPICS IOC platform. Local company manufactured crate and CPU module provide an economic solution is the major reason. To simplify various developments at construction phase, only 6U modules will be supported for the machine control system. The 1st lots of CPU board will be ADLINK cPCI-6510 CPU module equipped with Intel Core i7 CPU running Linux. The latest releases version of Fedora core Linux distribution will be adopted at IOC level.

The ADLINK NuDAQ cPCI-7452 128 bits DI and DO module were selected for BI, BO solution, this high density 128 bits version in 6U form factor will save crate slots and satisfy most of applications.

High resolution ADC module embedded with EPICS IOC from D-tAcq will be used for the analogue signal reading, it provides 10 Hz rate reading and has transient capture buffer. ADC module in IP module will be for smaller number of channel application, such as insertion devices control.

Specifications of the high solution DAC module (current prototype is 18 bits, 20 bits is planned) have been defined. Corrector power supplies will be driven by the output of this module. The EPICS CA is via cPCI crate backplane. Four SFP ports supported by the on board FPGA (Spatan 6), these SFP ports will receive correction setting (Rocket I/O or Gigabit Ethernet) from orbit feedback computation engine, feed-forward correction computer and IOC. Setting command received by these SFP ports will be added with the slow setting for EPICS CA setting.

Ethernet attached devices will connect to the EPICS IOC via private Ethernet.

Power Supply System

TPS power supplies control interface are divided into three categories rather than a unify solution. All of the power supplies will be provided by three different vendors. The reason of this choice is to meet the practical situation from manpower, budget and available vendors.

The small power supply for corrector magnets in the range of ±10 Amp categories will interface to the cPCI analogue interface directly. The cPCI ADC modules support buffer to capture events for post-mortem analysis following a beam loss or other events.

The intermediate power supply with current rating 250 Amp will be equipped with Ethernet interface. Power-supplies are expected to have internal data buffer with post-mortem capability. Output current of the power supply will output at rear plane BNC connector, which can connect to the cPCI ADC module also.

The storage ring dipole DC power supply and power supplies for the dipole and quadrupole power supply of the booster synchrotron will equip Ethernet interface. Control resolution of these power supplies will be 18 bits effective number, noise and drift will be better than 10 ppm of these power supplies. The dipole and quadrupole power supply of the booster synchrotron have built in waveform support with external trigger capability. This functionality is essential for energy ramping purpose. All of these power supplies will interface with the EPICS IOCs directly.

Timing System

The event system [5] consists of event generator (EVG), event receivers (EVRs) and a timing distribution fiber network. EVG and EVRs can be installed with various universal I/O mezzanine modules to meet different input/output requirements. The mechanical form factor is 6U cPCI module. The 125 MHz event rate will deliver 8 nsec coarse timing resolution. Its high resolution and low timing jitter allow accurate synchronization of hardware 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. Large scale prototype will setup in 2011 for software development.

Diagnostic 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 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. 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.

Feedbacks and Feed-forward Plans

Integrated global orbit feedback system by using slow and fast correctors in the same feedback loop is the baseline design. A counter rotate multi-gigabit links will circulate 10 kHz rate orbit data among all BPM/XBPM platforms. The FPGA module embedded in the BPM platforms will be configured as distributed feedback engines. All of these platforms will be installed EPICS interface for various feedback supports such as PID parameters, matrix download. The correction command will sent to the corrector control DACs which located at the power supply control cPCI EPICS IOCs via dedicated links (RocketIO or GigE links) interfaces. Sniffer nodes 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. The capture can be triggered either software or hardware with post-mortem capability.

The DAC module installed the EPICS IOCs equipped with a dedicated fast interface could receive fast setting package. It provides a global setting for feed-forward applications; like setting for correctors and skew quadrupoles. Noise excitation of the beam for various experiments can be done in a similar way. These setting can be issued from EPICS IOCs or any client computer running control rules. The DAC modules can be accept to 10 kHz rate data setting. The setting will synchronize by the timing system.

The bunch-by-bunch feedback system will adopt signal processor based on the latest generation FPGA processor with embedded EPICS and build-in diagnostics.

Turnkey System Solution

Turnkey systems such as linear accelerator and RF transmitters will be delivered by industry as turnkey contracts. These systems will be delivered with EPICS control system. It will be easy to integrate with the TPS control system.

PLC and Interlock Solution

Current TPS control system will support Siemens S7-300 or compatible model from VIPA PLC which are delivered from the turn-key vendors. Yokogawa FM3R PLC will be used for most of control system related interlock system. FM3R with embedded EPICS IOC will be used for some applications also. Control system will support the safety PLC which will be determined by the radiation safety group for access control. 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 and etc. to send the beam disable commands to trip beam or inhibit injection.

Relational Database

Adopting the IRMIS to build a common Relational Data Base schema and a set of tools to populate and search an RDB that contains information about the operational EPICS IOCs of TPS control system is explored. 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.

SUMMARY

Design and implementation of the TPS control system is in proceed. Define control system standard is current focus. Major procurement will perform in 2010~2012. The TPS control system will take advantages of the latest hardware and software technology to deliver better performance and functionality, avoid quickly obsolesce and more economic.

REFERENCES

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