UPGRADE OF BTS CONTROL SYSTEM FOR THE TAIWAN LIGHT SOURCE

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Abstract

The Taiwan Light Source (TLS) is a third generation of synchrotron light source, and it has been operated since 1993. The TLS control system is a proprietary design. It was performed minor upgrade several times to avoid obsolete of some system components and keep up-to-date during last two decades. The control system of BTS (Booster-to-Storage ring) transport line includes control interfaces of power supplies, screen monitors, vacuum and temperature. The cPCI (CompactPCI) based EPICS IOC (Input Output Controller) has been adopted for renewing TLS BTS control system to replace the existed VME based ILC (Intelligent Local Controller) to be as an easy-to-maintain control environment. Moreover, each TLS control console supports not only the existing control software interfaces, but also the newly developed EPICS graphical user interfaces. Upgraded TLS BTS control system had been successfully commissioning in February 2017. Compare new system with old system, new system provides more functionality, fast response, and highly reliability. The efforts are summarized at this paper.

INTRODUCTION

The TLS is a third generation of synchrotron light source built at the National Synchrotron Radiation Research Center (NSRRC) site in Taiwan, and it has been operated since 1993. The TLS consists of a 50 MeV electron Linac, a 1.5 GeV booster synchrotron, and a storage ring with 360 mA top-up injection. The TLS Control system is a proprietary design [1]. It consists of console level workstations and VME based intelligent local controller (ILC) to interface with subsystems. Hardware and software on console level workstation change several times due to evolution of fast evolution of computer technology. Due to the well design of the original control software structure, port to new Linux platform without difficult.

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 and large scientific experiments [2].

The EPICS were chosen as control system framework for the Taiwan Photon Source (TPS) of 3 GeV synchrotron light source [3]. The TPS control system with EPICS mechanism had been integrated and commissioned. On the other hand, in order to adopt update technology and re-use expertise of manpower, the upgrade and maintenance for TLS control system adopts the EPICS as its framework was decided. Moreover, some new installed subsystems runs EPICS control environment also. Mixed existed TLS control system and EPICS environment were proofed without problem.

Original control system of BTS transport line had been adopted VME based architecture as shown in Fig. 1. The IEEE-488 interface cards and GPIB expenders had been used for communicating with the dipole and quadrupole magnets power supplies. The DI/DO/AI/AO cards had been used to control the KIKUSHI power supplies for corrector magnets, to control actuator for screen monitor, and to monitor the vacuum components status. This system had been operated more than twenty years, it is hard to maintain due to some parts are not available now. Response of the existed system is slow and reliability of the system is no good. Thus the control system of BTS transport line was decided to be renewed in 2016; the new platform and technology have been adopted as an easy-to-maintain environment. System simplification and reliability also have been raised.

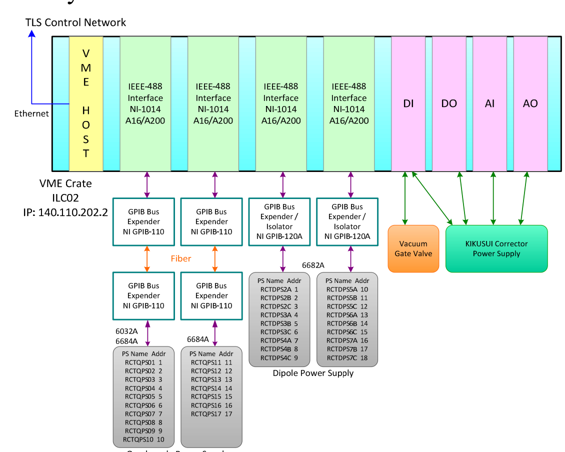

Figure 1: Architecture of original BTS control system.

In recent years, TLS control consoles have continuously operated on the existing control environment at Linux operation system, and additionally supported in the EPICS framework for the subsystem upgrade in the meanwhile [4]. Renewed BTS control system also needs to been operated at the existing control environment and the EPICS PVs (Process Variables) channel access mechanism. The implementation of new BTS control system for TLS is summarized as followings.

IMPLEMENTATION OF NEW BTS CONTROL SYSTEM

Due to the problems of maintenance without spare units and reliability for long time usage, original BTS control system is necessary to be refurbished. A new architecture of BTS control system for TLS was presented and

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implemented. Certainly the EPICS has been chosen as control system framework and integrated into existing TLS control system.

Integrated EPICS Environment into TLS Control System

To implement the EPICS support for some subsystems, the control environment of the IOC is set up with the specific EPICS base, modules and extensions at the Linux operation system. To control and monitor subsystems based on EPICS environment via Ethernet, the clients should be installed the specific EPICS base and the graphical operation toolkits, such as EDM (Extensible Display Manager) and MATLAB (channel access via the "labCA" module) for EPICS channel access.

Most of EPICS related files at IOCs and control consoles are mounted from the dedicated file server by using the NFS service (Network File System) 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.

EPICS IOC Integrated with TLS ILC

An EPICS IOC is activated on an ILC to support homogenous access from TLS console computers. TLS ILCs broadcast their dynamic data, DDB, at 10 Hz to simplify data transaction between consoles and ILCs; with SDB and database-access-library installed TLS console APs manipulate the signals efficiently. The TLS control system is an isolated system.

To have the rich support of EPICS, the plans of upgraded control systems have adopted the EPICS framework. To support access from existing TLS applications, integrated EPICS IOC into ILC is required. The ILC will be running Linux on cPCI but not LynxOS on VME platform instead. A setting thread and a reading thread of the ILC talk to a PV server (call "libca" functions) of EPICS to perform setting request on demand and fill the predefined DDB locations (in an input file) for read-back signals at 10 Hz. The system architecture is illustrated as Fig. 2.

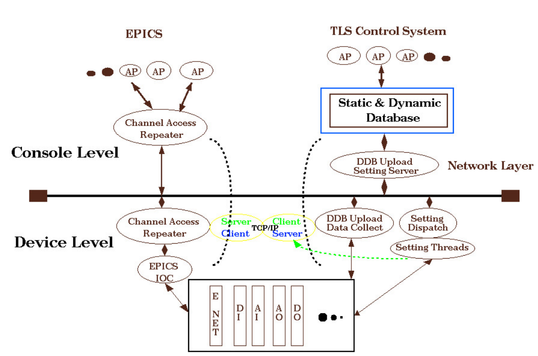

Figure 2: System architecture of EPICS IOC integrated with ILC for the TLS control system.

Several major PVs of renewed subsystems are integrated into TLS control system, but the details of the subsystem status are accessible only via EPICS operation interface to simplify the implementation and lighten CPU load on the ILC. An operator may open EPICS GUI pages and start TLS main GUI to access the subsystems at the same time.

Architecture of Renewed BTS Control System

The cPCI which CPU board runs Linux operation system has been utilized as main control platform. The cPCI CPU board has owned two Ethernet ports, one is access with the TLS control network, and the other is privately for communicating with hardware devices. The architecture of Renewed BTS control system is shown in Fig. 3. Four GPIB/LAN gateway [5] devices have been used to interface with all of dipole and quadrupole magnets power supplies, and related EPICS supports for GPIB devices were built into cPCI IOC. The EPICS records processing needs to be refined to improve the response time which IOC contacts with GPIB attached power supplies, and operating procedures have been more simplified. Indeed response time of improved control system is ten times faster than original system.

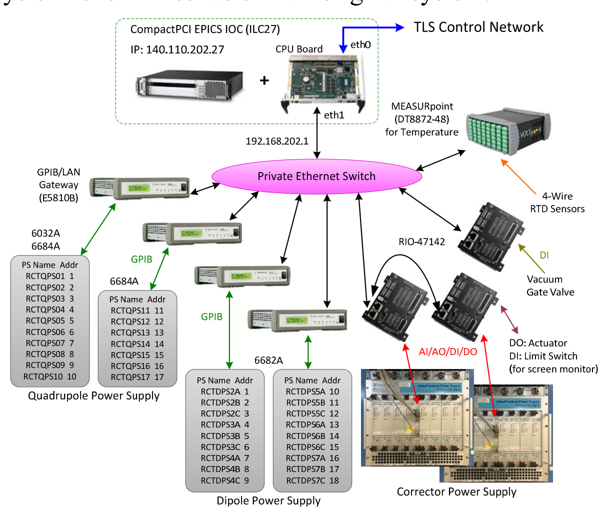

Figure 3: Architecture of new BTS control system.

The RIO-47142 device is a compact PLC with Ethernet that is easy-to-use, cost-effective, and contains a fast RISC processor for handling I/O interface [6]. Each RIO-47142 device is embedded with sixteen channels of DI/DO interfaces and eight channels of AI/AO interfaces. The small power supplies for corrector magnets in the range of ±10 Amp categories are interfaced to analogue interface directly. The corrector magnets power supplies which are NSRRC home made and manufactured by ITRI of Taiwan [7] have been applied to replace original KIKUSUI power supplies. Three RIO-47142 devices with corresponding circuit boards were implemented for corrector magnets power supplies control, actuators control, and monitoring vacuum gate valves.

The MEASURpoint [8] device owns LXI-based Ethernet interface and 48 AI channels to been employed

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for measuring BTS temperature with four-wire RTD sensors. The EPICS support of MEASURpoint was also established into cPCI IOC.

BTS Screen Monitor

In the BTS system has equipped ten screen monitors to directly diagnose the beam profiles from fluorescent screens. An embedded platform has been chosen as an EPICS IOC to access CCD (Charge-Coupled Device) camera to acquire the beam-profile image, and system architecture is illustrated as Fig. 4 [9]. The "areaDetector" software module has been applied into the EPICS IOC for CCD image capture and parameters control. The GigE vision cameras via Ethernet interface with IOC which use dedicated private Ethernet port. A TLS control console can launch the specific graphical user interfaces (by use of EDM and MATLAB) to operate the screen monitor which includes control of exposure time, CCD gain, and trigger delay as shown in Fig. 5.

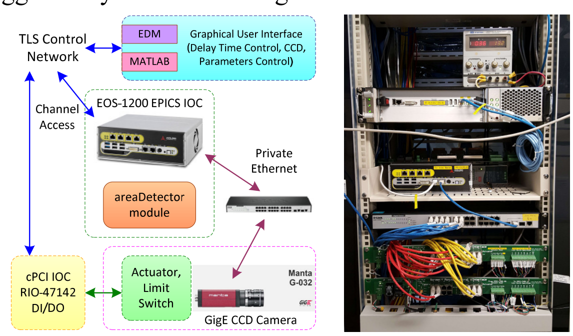

Figure 4: Block diagram and photo of upgraded BTS screen monitor system.

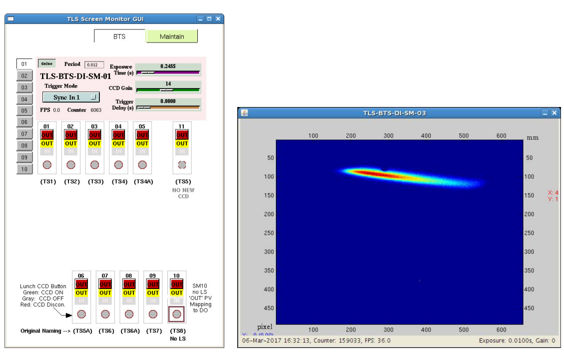

Figure 5: GUI of upgraded BTS screen monitor system.

GUI of Upgraded BTS Control System

Upgraded BTS control system is based on the EPICS framework to establish, and certainly all signals can be controlled and monitored by use of PVs channel access mechanism. To support both of the existing TLS control system and the developing EPICS environment, the TLS control consoles have been setup with EPICS environment to operate. The EPICS based graphical user interfaces have been developed for renewed TLS BTS control system due to specific operation purposes, and shown as Fig. 6.

To keep the existing operation at renewed TLS BTS control system, major PVs of each subsystem of BTS system have been translated to fit the format of TLS signal access. These major signals include setting, reading, status and alarm, and are necessary to support for executing existing routine operation procedures and be recorded into the TLS archive system. These major signals of renewed BTS system are also accessed through existing TLS GUI.

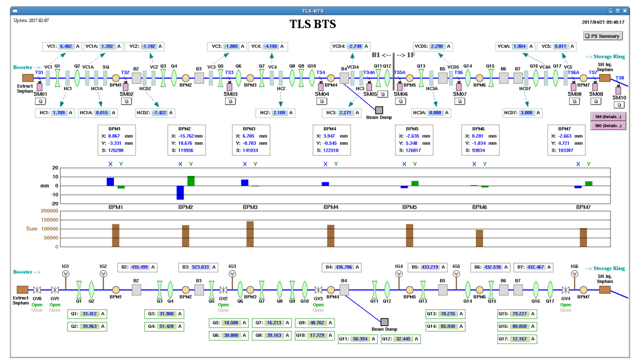

Figure 6: EDM based GUI for new BTS control system.

SUMMARY

Original BTS control system had operated more than twenty years, and some of parts are difficult to obtain to maintain now. Indeed the plan for renewing BTS control system was implemented and completed in February 2017 successfully. New BTS control system has been easy to maintain, and has provided more functionality, fast response, and highly reliability than original system.

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