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WAVEFORM REMOTE SUPPORTS FOR THE TAIWAN PHOTON SOURCE PROJECT

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Abstract

The 3 GeV Taiwan Photon Source (TPS) synchrotron light source is ready for commissioning. Various waveforms includes booster power supply current, pulse magnets current, beam signal, and etc. need monitoring to support commission and routine operation. Remote access of waveforms and spectrums from various digitizer, oscilloscope and spectrum analyzer were implemented to eliminate requirements of long distance cabling and to improve signal quality. Various EPICS supports of Ethernet-based oscilloscope and spectrum analyzer for the TPS are developed for filling pattern measurement, beam spectrum, pulse magnet power supply, and etc. Different operation interfaces to integrate waveform and spectrum acquisition are implemented by various GUI tools to satisfy all kinds of applications. 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 the third quarter 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 had 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.

One of EPICS database records is the waveform record to store data array acquired from the device. There are many waveforms such as signals which should be observed in synchrotron light sources including waveform variation of booster current, beam current measured by the fast current transformer, and filling pattern, RF pulse, pulse magnet current and etc. Acquiring waveform data should be based upon EPICS waveform supports. Through PV (Process Variable) channel access the client console can observe the waveform by using various toolkits (EDM, CS-Studio, MATLAB and etc). In addition, Ethernet based interface LXI instruments will be adopted extensively to build EPICS supports which can be communicated with these instruments would be necessary.

One of the benefits on EPICS waveform supports is that various LXI-based oscilloscopes can be controlled remotely and users can easily observe the acquired waveform data by using display toolkit on the control consoles. The efforts of implementing EPICS waveform support for the TPS project are summarized in the following paragraphs.

EPICS WAVEFORM SUPPORTS

Using the EPICS toolkit can build various database records to access I/O data and setting parameters. One of the EPICS database record types is the waveform record to store data array acquired from the instrumentations. To implement the environment of remote waveform data access for the TPS, various EPICS supports were built to communicate with the dedicated equipments, such as Ethernet-based oscilloscopes, LXI-compliant instruments (spectrum analyzer, function generator, meter and etc.).

One key advantage of LXI (LAN eXtensions for Instrumentation) is its ability to leverage ongoing innovations in LANs that satisfy the requirement for speed, and LXI enhances performance by enabling faster system throughput [3]. The LXI-compliant instruments support the VXI-11 or TCP protocol, which is based on the RPC (Remote Procedure Call) protocol for communicating.

System Architecture

The standalone PC-based platform which runs the Linux operation system had been set up to built as the dedicated soft-IOC to connect with instruments via Ethernet interface. The IOC uses the VXI-11 or TCP protocol to communicate with the LXI/Ethernet-based instruments. The console user can observe the waveform data by using specific OPI toolkits (EDM, MATLAB and CS-Studio) through EPICS PVs channel access. The system architecture is illustrated as Fig. 1.

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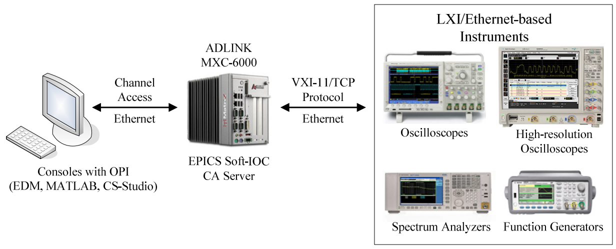

Figure 1: System architecture of building EPICS waveform support environment with LXI/Ethernet-based instruments.

To build the EPICS waveform support, the IOC should be set up with the specific EPICS base and modules at the Linux operation system. The related software environment is summarized as shown in Table 1. In addition, clients should be installed the EPICS base and specific OPI toolkits (EDM or CS-Studio) to channel access the PVs of waveform and data parameters from the dedicated IOC.

Table 1: Software Environment of the EPICS Support

	Version
OS	RHEL 5.x
EPICS	base-3.14.11
Modules	asyn-4.18 StreamDevice-2.5
Extension	labCA-3.4.1
OPI	edm-1.12.8x CS-Studio-3.2.1x

To implement the EPICS support of LXI/Ethernet-based instruments, the device support was built to communicate with the device driver through the ASYN module. The related record support was created with link to the device support. The CA client with OPI applications can access PVs from CA server which acquires data from database in the dedicated IOC. The schema is shown as Fig. 2.

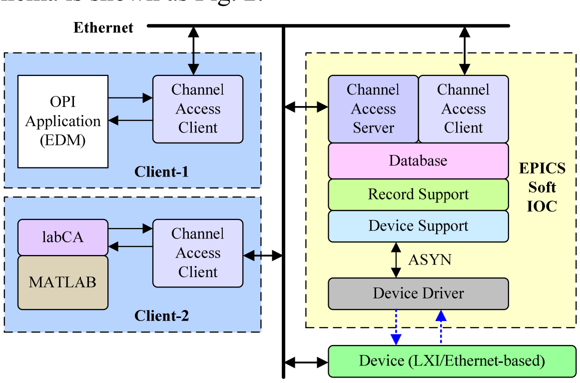

Figure 2: Software block diagram of building EPICS support for communicating with LXI/Ethernet-based devices.

EPICS SUPPORT OF ETHERNET-BASED OSCILLOSCOPE

Several types of oscilloscopes had been used for different purposes at the TPS control system as shown in Table 2. The DPO4000 [4] are usually used for observing waveform of pulse magnets current transformer. Specially the DSO9000H [5] is higher resolution oscilloscope and used for observing and analyzing waveform of storage ring injection kicker current transformer in detail at every injection. The DSO9000H are also used for BR&SR fill pattern measurement with 400K waveform length, and its waveform acquired rate is satisfied with 1 updated/second. Moreover, few Windows-based oscilloscopes or spectrum analyzers are installed the VNC-server toolkit [6] for only test used. The control console can use the VNC-viewer toolkit to connect the assigned VNC-server oscilloscopes to show the live oscilloscope screen for observing the waveform temporality.

Table 2: Oscilloscopes at the TPS Control System

Device	Waveform Length	Purpose
Tektronix DPO4000	10K	BR Septum CT, BR Kicker CT SR Septum CT, SR Pinger CT
Agilent DSO9000H	20K	Linac RF signal, FC & WCM LTB&BTS FCT SR Injection kicker CT
Agilent DSO9000H	400K	BR fill pattern measurement SR fill pattern measurement
Tektronix DPO7000		VNC for observing beam signals

Kicker Waveform Analysis Interface

The SR injection kicker CT waveform data is acquired from oscilloscope and save into the dedicated EPICS IOC. To analyze the difference of kicker waveforms in every injection, the kicker waveform analysis interface has been developed by the MATLAB with labCA. This interface was verified in the TLS as shown in Fig. 3.

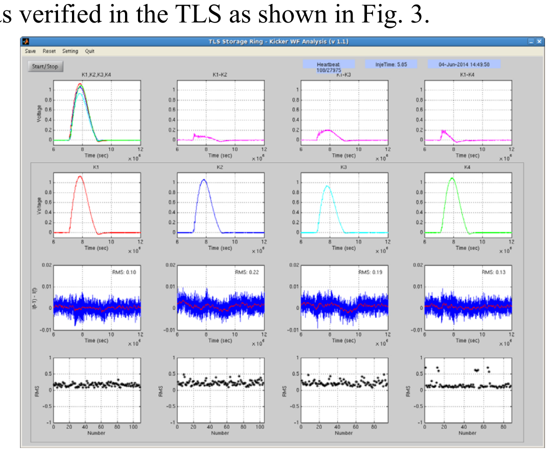

Figure 3: Kicker waveform analysis interface which was verified in the TLS.

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Fill Pattern Measurement

The DSO9000H oscilloscope is used to observe the beam signal from one of BPM (Beam Position Monitor), and the waveform data of beam signal can be acquired to the dedicated EPICS IOC. The fill pattern measurement interface has been developed by use of the MATLAB to calculate every bunch current. All calculated bunch currents are formed to one waveform array and save into the dedicated PV, and the specific EDM page was created to show the calculated fill pattern as Fig. 4.

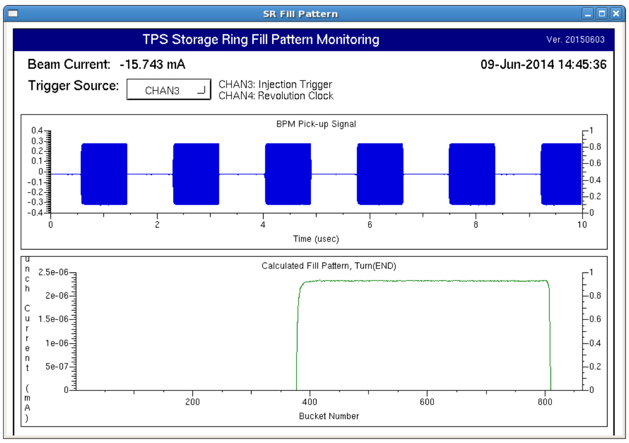

Figure 4: EDM page for the TPS storage ring fill pattern monitoring with the simulated signal.

WAVEFORMS OF TCSPC APPLICATION

The TCSPC (Time-Correlated Single Photon Counting) can record the time difference between the single photon event and storage ring revolution trigger to measure the fill pattern. The layout of the EDM display GUI for fill pattern measurement is shown in Fig. 5. The GUI can run in multiple clients simultaneously and control the TCSPC parameters, read/display the results from EPICS IOC. The GUI contains two parts: control panel (in left side), results (in right side). The control panel provides display of the system status, resolution, program heartbeat and setting the system key parameters such as DFC, divider, range, acquisition time, and etc. The raw data of the fill pattern with marked-peak position is integrated into the right side. In the below figure, some important parameters of the two-channel input signal are also shown in here.

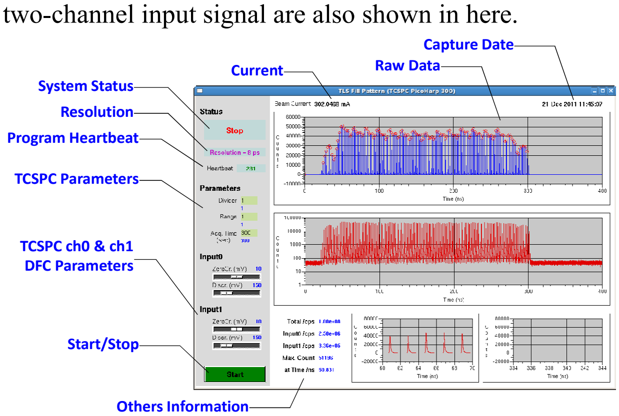

Figure 5: Layout of the TCSPC EDM page.

WAVEFORMS OF BUNCH-BY-BUNCH FEEDBACK APPLICATIONS

One of commercial bunch-by-bunch feedback solutions is iGp (Integrated Giga-sample Processor) [7]. The iGp system is embedded into the EPICS framework. The commissioning of the iGp is ongoing to upgrade the bunch-by-bunch feedback system to enhance functionalities and get better performance. A simple GUI was deployed for the control room operator usage and tested in TLS as shown in Fig. 6. Several waveforms accompany this interface let the operator tell whether the bunch-by-bunch system is working properly or not.

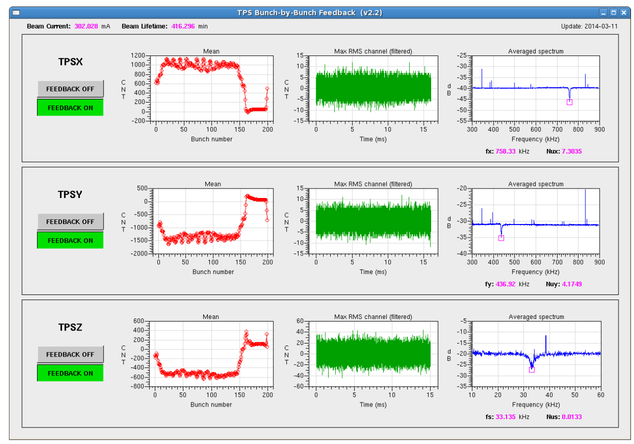

Figure 6: Operator interface to operate the bunch-by-bunch feedback system include transverse as well as longitudinal feedback system. Various waveforms include beam oscillation amplitude in RMS and bunch phase oscillation in RMS, are shown on the integrated with front-end and iGp control page.

SUMMARY

Remote operations of all waveform acquisition instruments for the TPS are used to eliminate long distance cabling and improve signal quality. Development of various possible EPICS waveform supports has been performed recently. The EPICS waveform support consists of several different kinds of LXI/Ethernet based instruments. The dedicated EPICS soft-IOCs to communicate with these supported instruments had been built, and the different operation interfaces had been also created. Solutions of waveform remote supports are applied in the TPS project and enhanced continually.

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