WAVEFORM AND SPECTRUM ACQUISITION FOR THE TLS

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Abstract

To enhance waveform and spectrum remote access supports in the Taiwan Light Source (TLS), development of the EPICS support of Ethernet-based oscilloscope and spectrum analyzer for the TLS is under way. The EPICS platforms which built to interface these instruments could access the waveform and spectrum through the PV (Process Variable) channel access. By using remote operations of waveform and spectrum acquisition, long distance cabling could be eliminated and signal quality be improved. The EDM (Extensible Display Manager) tool is used to implement the operation interface of control console and provide waveform display. According to specific purpose use, different graphical user interfaces to integrate waveform and spectrum acquisition are built. This project is the preparation for future control room integration with the Taiwan Photon Source control room. The efforts will be described at this report.

INTRODUCTION

The TLS is a third generation of synchrotron light source built at the National Synchrotron Radiation Research Center (NSRRC) in Taiwan, and it is operation 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 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 [1]. In the field of accelerators, many facilities particularly have good experiences for the 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.

The EPICS toolkits were also chosen as control system framework for the new project of 3 GeV synchrotron light source (Taiwan Photon Source, TPS). The control system prototype of TPS with the EPICS mechanism has been gradually built and tested. On the other hand, in order to gain the experiences and more advanced approach and technology, the upgrade and maintenance for the TLS control system are attempted to adopt the EPICS toolkits as its framework. Moreover, since the TLS will share the same control room with the TPS in the future, remote waveform data access would be one of the required features to support controls of instruments located at different sites. The waveform data includes microwave pulses, pulse magnet current waveform, beam signals, beam spectrum and etc. Acquiring waveform data will be based upon EPICS mechanism to access. Through the EPCIS PVs channel access, remote access waveform data via Ethernet interface could be displayed by the graphical OPI (Operation Interface) toolkits, such as EDM and MATLAB (channel access via the labCA module) on the control console. In the TLS, the control console can continuously operate on the existed control system environment and develop additionally the EPICS framework for the subsystem upgrade in the meanwhile. One of the advantages is that it should not sent signals to the control room by dedicated cabling in the future.

To achieve remote waveform acquisition for the TLS, the EPICS waveform support should be gradually developed and improved. The efforts of implementation of the EPICS waveform support 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 TLS, various EPICS supports were built to communicate with the existed Ethernet-based equipments, such as Ethernet-based oscilloscopes, LXI-compliant spectrum analyzers and etc. to save limited resource.

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 [2]. The LXI-compliant instruments support the VXI-11 or TCP protocol, which is based on the RPC (Remote Procedure Call) protocol for communicating.

An EPICS support IOC (Input Output Controller) can interface various instrumentations anytime and anywhere. By the EPICS channel access, the clients can use the specific toolkits to access IOCs which communicate with devices. Using specific graphical toolkits can construct the various monitor and control pages for different purposes. The basic functions of these pages include that show channel status, select display input channel, save and load configuration, save waveform to file, waveform hardcopy and etc. The various implemented interfaces of waveform support would be described as the following sections.

System Architecture

The standalone server which runs the Linux operation system has been set up to built as the dedicated soft-IOC to connect with instrumentations via Ethernet interface. The IOC uses the VXI-11 or TCP protocol to communicate with LXI/Ethernet-based instrumentations.

The client console can acquire the waveform data by using various OPI toolkits (EDM, MATLAB and etc) through PVs channel access. The system architecture is illustrated as Fig. 1.
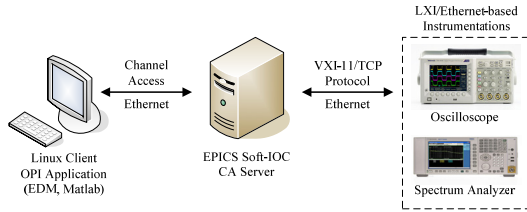

Figure 1: System architecture of building EPICS waveform support environment with LXI/Ethernet-based instrumentations.

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. The client should be installed the EPICS base and extension of EDM to channel access the PVs of parameters and waveform data from IOC server.

Table 1: Software environment of the EPICS support

	Version
OS	RHEL 5
EPICS	base-3.14.10
Modules	asyn-4.11a
	StreamDevice-2.4
	calc-2.6.7
	seq-2.0.12
Extension	edm-1.12.xx

To implement the EPICS support of LXI/Ethernet-based instrument devices, 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 (channel access) client with OPI applications can access PVs from CA server which acquires data from database in the IOC. The schematic is shown as Fig. 2.
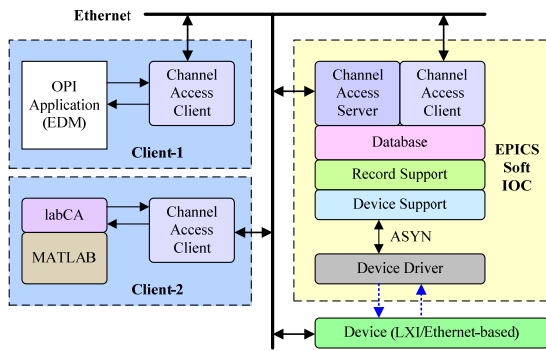

Figure 2: Software block diagram of building EPICS support for communicating with LXI/Ethernet-based devices.
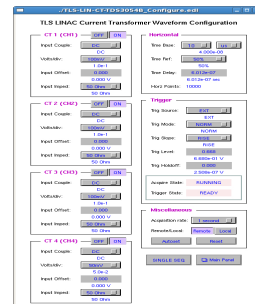
ETHERNET-BASED OSCILLOSCOPE

The existed Ethernet-based oscilloscope, Tektronix TDS3054B (4-channel) and TDS3052B (2-channel), was chosen to be built with the EPICS support for observing waveform in the TLS. The TDS3054B and TDS3053B consist of the 100Mbps Ethernet interface, 500 MHz bandwidth, and 5 Gsa/sec sample rate and etc [3]. The firmware of TDS3054B and TDS3052B is both the version 3.41. One server as the dedicated EPICS soft-IOC was set up to implement the EPICS support, and communicates with the TDS oscilloscope via Ethernet interface. The system architecture for EPICS support is represented as the Fig. 1 and Fig. 2.

In the dedicated soft-IOC, the ASYN module was utilized to connect with the TDS oscilloscope through the VXI-11 protocol. The device support of the tds3000-2.4 module [4] was modified to be suitable for TDS3054B and TDS3052B. The device supports for TDS305xB include request and readout commands to communicate. The database records were created to store the setting parameter and acquired data. The clients adopt the specific graphic toolkits, such as EDM or MATLAB with the labCA module, to channel access PVs from the database of the dedicated soft-IOC via Ethernet interface. In order to learn the effect of EPICS waveform support, the actual signals of the TLS are applied in these implementations to observe remote waveform access. The specific EDM pages were created as shown in Fig. 3.
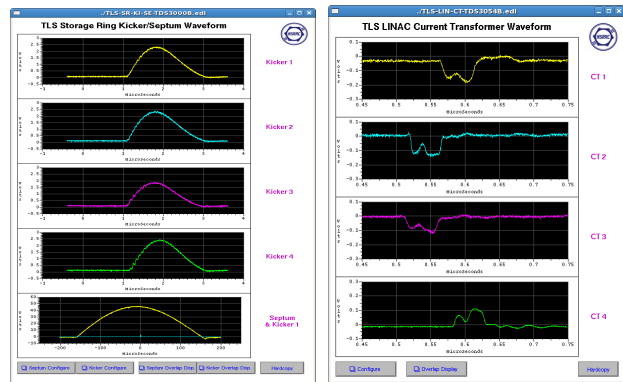
(a)   (b)

(c)

Figure 3: EDM page for Ethernet-based oscilloscope: (a) TLS storage ring injection kickers and septum waveforms. (b) TLS Linac current transformer waveform. (c) Parameter setting page for configuring oscilloscope.

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LXI-COMPLIANT SPECTRUM ANALYSER

The existed LXI-compliant spectrum analyzer, Agilent N9010A EXA [5], was used to build the EPICS support for observing beam spectrum of the TLS storage ring. The system architecture for EPICS support is the same as the Fig. 1 and Fig. 2. The ASYN module was applied to communication with the EXA through the TCP protocol. The StreamDevice module was utilized for the device support as using specific protocol files [6]. The protocol files were established according to the SCPI (Standard Commands for Programmable Instruments) commands of EXA. The database records were created along with the protocol file which was used to request and readout from the EXA. The EXA has two measurement modes. One is the spectrum mode, and the other is the IQ mode. In order to observe the waveform data of these two modes, the waveform record was set to take turns to acquire each mode waveform data during slice second. The specific EDM page was created as shown in Fig. 4, the upper graph is the beam spectrum with 500MHz to 1GHz, and the lower graph is tune measurement (IQ mode).
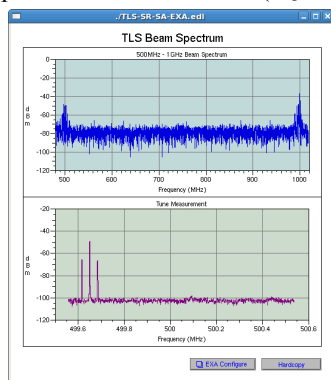

Figure 4: EDM page of EPICS waveform support for beam spectrum and tune measurement.

EPICS SCOPE

One solution of EPICS waveform support adopts the commercial EPICS scope. The ZTEC EPICS scope was tested as remote waveform access [7]. The PVs can support complete oscilloscope control attached the EPICS mechanism. The client can utilize the EDM graphic toolkit to observe and control the oscilloscope without building another IOC to communicate. In addition, according to different purpose the different EDM control and display page would be designed.

TUNE MONITOR

One of commercial bunch-by-bunch feedback solutions is iGp [8]. 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. The tune monitor based on the transverse feedback system is the waveform access from iGp, and specific EDM page is created as shown in Fig. 5. The two notches in averaged

spectrum corresponding to vertical and horizontal reject betatron sideband. It can be a betatron tune monitor with high resolution without exciting beam.
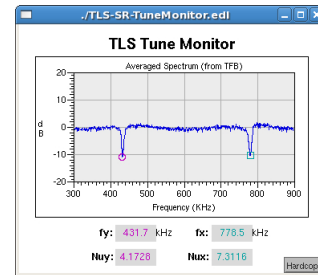

Figure 5: EDM page for tune monitor based on the transverse feedback system from iGp.

FUTURE WORKS

Another solution for the new LXI/Ethernet-based oscilloscopes is planned to develop the EPICS support to apply in the situation that the existed oscilloscopes are not enough for measurement. The developed EPICS support will be used for the BPM, filling pattern and etc. Moreover, the various purposes of scan rates for EPICS support will be researched. Two kinds of acquisition: 10Hz rate and non-10Hz rate acquisition will be studied for specific needs.

SUMMARY

To accommodate the situation that the TLS will share the same control room with the TPS in the future, remote mechanism of waveform and spectrum acquisition is gradually developed for the TLS. The long distance cabling can be eliminated and signal quality be improved. The existed Ethernet-based oscilloscopes and LXI-compliant spectrum analyzer are adopted to build the EPICS support to achieve remote waveform access. The dedicated soft-IOCs were set up to communicate with these equipments. Additionally, to support both of the existed TLS control system and the EPICS environment, the client consoles were setup with basis EPICS environment for remote waveform acquisition through PV channel access from the dedicated IOC. The various EDM pages of different purposes were created for operating at the TLS. These implementations will be improved continually in under way, and will be applied for the TPS project in the future.

REFERENCES

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