

VIBRATION AND BEAM MOTION MONITORING IN TLS

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Abstract

Due to asynchronous nature of various vibration and beam motion related data acquisition subsystems, it is hard to analysis the correlation between them. Therefore, the synchronous distributed data acquisition system is designed to make an improvement for better analysis. For different circumstances, the system supports two data flow: one is display the real-time data which could be archived continuously and the other is waveform which could be acquired on demand or triggered by event with high sampling rate. In addition, the viewer will improve some useful features, such as trigger by customize signal or EPICS PV record, automatic screenshot and plot the multiple history events. The preliminary test results and implementation details will be summarized in this report.

INTRODUCTION

TPS (Taiwan Photon Source) is the latest generation synchrotron light source which is settling next to TLS (Taiwan Light Source). Due to the construction of TPS since 2010, the vibration caused by excavating and pile-sinking is deteriorating the stability of TLS beamline intensity. In order to monitor and clarify the relationship between vibration and beam stability, an online integrated system is useful to identify the reasons and sources. Because of the inconsistency sampling rates of each device, system software has to synchronize and confirm the sampling data. In consider of above reason, EPICS (Experimental Physics and Industrial Control System) is adopted for the development framework not only satisfied the requirement but also the flexibility and expansibility. In this report, implementation details and manipulation interface for beam orbit and vibration monitoring system will be presented.

THE SYSTEM ARCHITECTURE OF VIBRATION MONITORING

The system architecture of vibration monitoring is shown in Fig 1. There are several parts, including data acquisition device, accelerometers, BPMs (beam position monitors), EPICS IOC and GUI (Graphical User Interface) console.

Vibration monitoring system needs to compatible with the control system. The standard platform of TLS control system is Linux environment; however, most of commercial system is working under Windows. To measure the large area by distributed sensors without long distance of cabling, DT8837 module is chosen since few channel count and high connectivity. In addition, the voltage signals and ICP accelerometers are both supported.

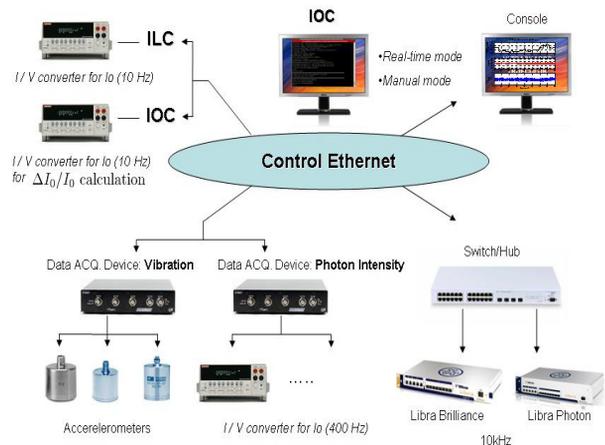


Figure 1: The structure of data acquisition system for vibration monitoring.

Instead of cabling of LXI trigger bus, Ethernet broadcasting is more convenient for the distributed system while the synchronization of data acquisition. To guarantee the delay between DT8837 modules, the delay time has been measured. Based on the experiment [1], phase uncertainty of the ADC (Analog to Digital Convertor) sampling clock for different units are within 2.5 msec maximum for 400 Hz sampling rate. For higher sampling rate, the phase uncertainty can be minimized so far. At highest analysis frequency of the vibration is around 100 Hz, maximum phase error is 90 degree. It is acceptable for spectra analysis. However, coherence analysis is limited at higher frequency side.

A soft EPICS IOC is created to EPICS channel access server and provides the interface to communicate with other clients. For the vibration monitoring IOC, it controls not only the command firing and data receiving, but also the process flow and data unit translating from distributed system. To observe and analyse the vibration trend, the system supports two operation modes: one is real-time mode which updates and archived the waveform continuously and the other is on demand by manual or triggered by events. In the other hand, stream device toolkit is also adopt due to the SCPI (Standard Commands for Programmable Instruments) command is the main communication syntax while process is proceeding.

For the beam motion part, there are two nodes of beam orbit data are available to capture from the 10 kHz data stream of the BPM system (Ethernet grouping of the BPM Libera Brilliance units). To analysis the relationship between beam motion and vibration event, the information data from peripheral device such as electron beam, photon beam and vibration are synchronized by a software trigger in 100 msec. 10 Hz data from ILC could

be acquired in real-time and archived, the fast transient motion could be also observed in adjustable higher time resolution and sampling rate up to 10 kHz.

DEDICATED EPICS IOC FOR DATA ACQUISITION

In order to control DT8837 and convert the data unit of the received waveform, dedicated EPICS IOC (Input/Output Controller) is built and run on a standalone server. To implement the vibration monitor system which is compatible with existed accelerator control system, the specific software environment is shown in Table 1. Notice that, client side should install the EPICS base and extensions for receiving the PV data via channel access.

Table 1: Software environment for EPICS supports.

| Type | Version |
|-----------|--|
| OS | RHEL 5 |
| EPICS | Base-3.14.10 |
| Modules | Asyn-4.11a StreamDevice-2.4 aSub-1.6 |
| Extension | labCA-3.3 edm-1.2 |
| Library | Lib-netinet |

The Schematic of EPICS IOC

By using the EPICS framework, Fig 2 describes the relationship between EPICS IOC and other devices. In this report, the IOC has supported two control methods: LXI-SCPI commands and socket stream. Both of them are introduced in the following paragraphs.

To communicate with the device via Ethernet, there are two paths to link the Ethernet Port Driver. One is ASYN module, and the other is the socket stream. The Stream Device is constructed upon the ASYN module which can send/receive the SCPI commands and control the IOC properly. However, the socket stream is encapsulated in aSub PV record to query the waveform data from BPM and DT8837. At the operation control part, MATLAB GUI and EDM OPI (Operation Interface) are chosen to request the IOC through CA (Channel Access) Client by using PV records. Incidentally, the client side of MATLAB GUI needs the labCA extension toolkit to send or receive the data value by PV record.

At the device part, DT8837 data acquisition module only supports SCPI commands so that Stream Device is used to send SCPI commands from IOC. However, the data format of received waveform is not general that Stream Device cannot interpret the data waveform with proper values. According to the above reason, send SCPI commands via Ethernet directly is another way for instead. The socket stream program is embedded in the aSub PV record for SCPI request data command in UDP packets. For sending commands and receiving data waveform from BPMs, tcp_command is a program developed with TCP socket stream. The program processes as following:

First, the “freeze” option broadcasts to notify all BPMs being ready for recording. Then, “read” option calls for start recording. In the end, the “grab” option fetch the data waveform and store in PV records.

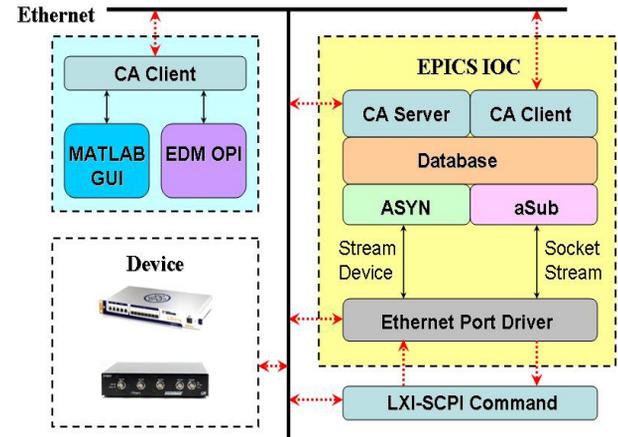


Figure 2: The block diagram of EPICS soft IOC which is communicated with the device via LXI-SCPI commands and Ethernet socket stream.

Design for Distributed Data Acquisition Modules

The soft IOC of vibration and beam motion monitoring is designed for supporting single or multiple data acquisition module(s). Nevertheless, single and multiple modules have individual strategies. Both of operation strategies and distributed waveform control are discussed in this section.

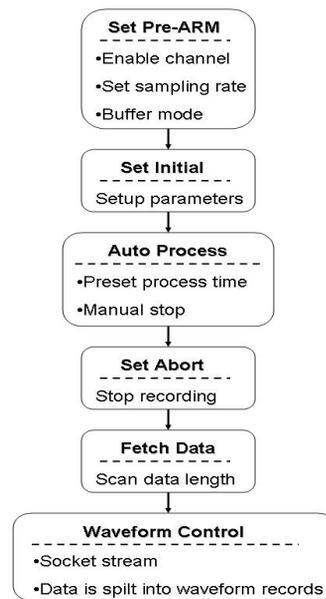


Figure 3: The EPICS record processing flow diagram for single data acquisition module.

The record processing flow of single module is shown in Fig 3. To start recording the data, first of all, *Set Pre-ARM* draw up to enable/disable channels, assigns the sampling rate and wrap/non-wrap mode of the buffer. Then, setup these parameters into the device module by

Set Initial. After that, *Auto Process* executes the period of time and *Set Abort* is activated automatically; relatively, it can manual stop by the user. *Fetch Data* scan the length of waveform data and pass it to *Waveform Control* for notifying the data length. The waveform data is fetched through the UDP socket stream and stored in IOC's memory by the *memset* function. In the end, the data waveform is spilt into individual waveform and filled in the waveform record of each channel.

In Fig 4, it shows the record flow of multiple data acquisition modules. In contrast with the single module, multiple modules should be activated at the same time. To avoid the asynchronous among modules, *Mutex Lock* is used to ensure the whole modules have set up parameters. And, *Trigger Group* is used to trigger modules by an UDP packet. In order to reduce the process time of the IOC, multi-thread is applied for *Waveform Control* process.

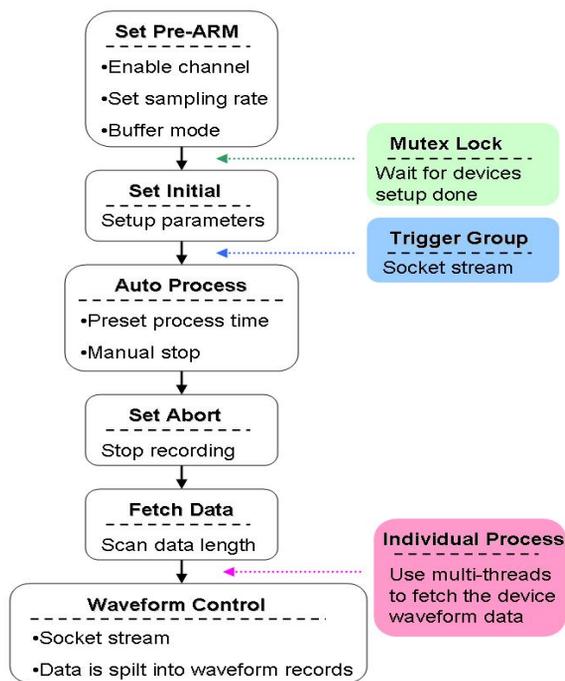
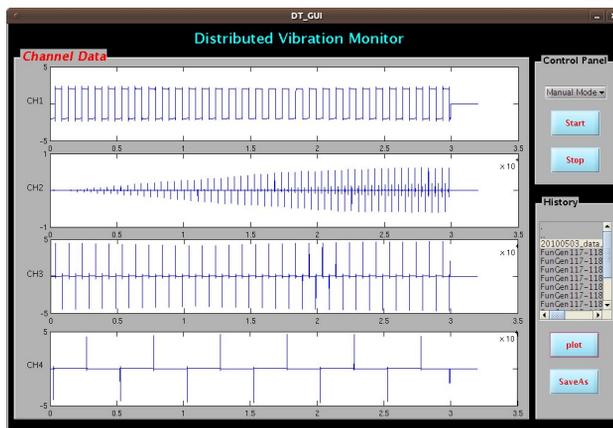


Figure 4: The EPICS record processing flow diagram for multiple data acquisition modules which are distributed nearby the measured area. Mutex Lock is used to avoid the race condition of device setup time. Trigger Group sends an UDP packet to trigger all modules to start recording.

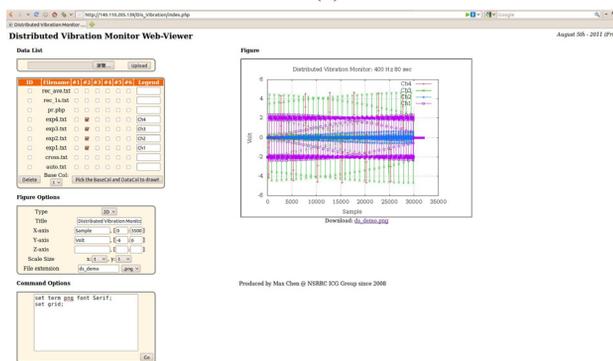
The GUI and Operation Mode

The graphical user interface is shown in Fig 5. There are two GUIs version which are demand on experimental or viewer-only.

The experimental GUI is made by MATLAB. It is used to control the IOC and monitoring the history events data. In consider of the backup feature, the screenshot and data export function are also available. For the period of scanning, it also supports the fixed timer mode and manual mode.



(a)



(b)

Figure 5: (a) MATLAB GUI with IOC control function. (b) Web Interface support online plotting, set the range of x or y axis tic, export file and download features.

Web version is another way to view the history event and export the figure by any computer. For the history event, the different row data are allowed to plot in the same figure as Fig 5 (b). To adjust the ties for x and y axis, the range feature is also available. *Command Options* area is designed to enter complex drawing commands for specific figure plotting. In the end, the zoom in and out of the figure is useful for analysis.

SUMMARY

Nowadays, vibration has become an important factor for light source facility. In this report, we had not only built the distributed vibration monitor system, but also developed two kinds of GUIs. By the vibration monitoring system, it is more easily to clarify some inconsistent events between vibration and beam motion. These implementations experience are very useful for TLS or TPS performance improvement.

REFERENCES

[1] Y. K. Chen, et al., "Vibration and Beam Motion Diagnostics in TLS", Proc. of DIPAC 2011.
[2] <http://www.datatranslation.com/products/dataacquisition/ethernet/dt8837.asp>