DESIGN OF AN INTEGRATED PLATFORM BASED ON CSS AND MATLAB FOR SSC-LINAC SYSTEM CONTROLLING AND DATA ANALYSIS

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Abstract

CSS is the abbreviation of Control System Studio and is widely used in particle accelerator experiments area. Based on Eclipse, it is a collection of tools which can display details of the PV, show alarm state, as well as the function of data browsers, archive engine and so on. CSS offers an integrated approach to build a control system. We have recently developed a control and monitor system for the SSC-LINAC system to control and monitor power supply, vacuum, high frequency, and other accelerator equipments. In the area of accelerator controlling, we often need to do some mathematical operations like Fourier transform of the monitored data to get some accuracy performances of interested equipments. Unfortunately, CSS cannot satisfy this requirement. It is well known that MATLAB plays very well in data process and provides many mathematical tools. If we can combine these two tools together, we can get better control strategy. In the presentation, we will discuss the design of this integrated platform to implement the display, control and data process.

INTRODUCTION

EPICS is a set of Open Source software tools and applications which allow us to build soft real-time control systems for scientific instruments such as particle accelerators, telescopes and other large scientific experiments[1]. EPICS is the basic structure of SSC-LINAC control system. The basic components of EPICS are IOC, LAN and OPI. IOCs (Input/Output Controllers) provide interfaces to real hardware and publish the data information to EPICS client over a Channel Access (CA) network protocol. OPIs (Operator Interface) provide interfaces to users and access IOC database via CA. The EPICS framework supports all major operating systems and hardware platforms such as GNU/Linux, Solaris, MS Windows, MacOS and RTEMS[2]. Because of these characteristics, EPICS is become more and more widely applied in the experimental physics area for developing control system.

CSS (Control System Studio) is an effort to implement control-system related OPI applications which deal with process variables and connections to control system[3]. It is based on Java and Eclipse RCP. CSS provides facility for database development, alarm management system, display development and conversion, data trending, diagnostic tools etc. In the past few years, developers use MEDM or EDM for development OPI application. These years, with the development of CSS and constantly updated, friendly interface and faster development efficiency make it increasingly welcomed by OPI software designers.

It is necessary to add SSC-LINAC in order to upgrade the Lanzhou Heavy Ion Research Facility platform. Considering the advantage of EPICS structure, we use EPICS to build SSC-LINAC control system and use CSS to build OPI application. CSS shows good performance in data monitoring and display, but its mathematical function is relatively weak. In SSC-LINAC control system, we often need to do some mathematical operations like Fourier transform of the monitored data to get some information of interested equipments. So, we bring MATLAB to this system to deal with the data processing.

METHOD AND MATERIAL

CSS Operation Interface

CSS application interface consists of the top level overall control interface and subsystem interfaces. The overall control and monitor interface displays running state of all subsystem and if any subsystem has any fault there will be alarm generated which is provided by Alarm Server. Subsystem interfaces provide actual control to adjust beam tuning related parameters like including adjust power supply, vacuum, high frequency and so on. Besides, we have build Achieve Engine which can meet our requirement to access historic data. The overall structure of SSC-LINAC control system is shown in Figure1. CSS plays the role of Operator Interface to control device and display device data. Meanwhile, it calls MATLAB application to process data and show processed data.

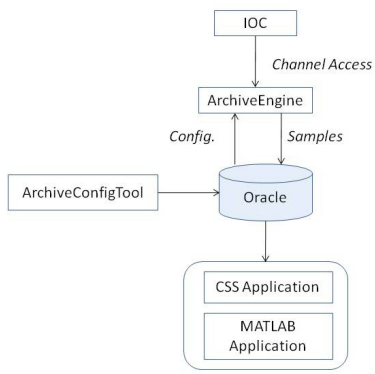

Figure1: Overall structure.

Use MATLAB to Access Oracle and Process Data

In most cases, developers will choose Linux system to develop IOC and run IOC. In SSC-LINAC control system, IOC runs on Linux platform and CSS application runs on Windows platform. The reason is that all the computers were installed Windows and the operators are more accustomed to using Windows operating system. MATLAB is a very popular tool, which is used for processing and visualization of physics data[5]. Though MATLAB can access PV via MCA(MATLAB Channel Access) and we can use MATLAB to store PV values and then process them, we do not tend to choose this method for OS platforms difference.

Thanks to CSS Archive Engine, every PV value is stored in Oracle database for a period of time which can be set according to Archive configuration file. In our design, we use MATLAB to access PV values which are stored in Oracle database via Archive Engine and then do the data processing. We can enter the time period of the PV to query and we also can enter several PV names to query. In table SAMPLE, the SMPL_TIME field has fractional second precision (10^{-9}s) and is used to store time value. So, it completely meets the time accuracy requirement.

We can use the following MATLAB code to access Oracle database and fetch data.

(1) conn = database('linacdb','linacuser','password');
(2) curs = exc(conn,'sql');
(3) curs1 = fetch(curs);
(4) close(curs);
(5) close(conn);

In step 3, after executing the fetch function, the data we need will be in curs1.Data which can be used in later data processing.

Up to now, we use MATLAB code to process data mainly to realize the following functions.

1. Access data in Oracle database and check the stability of these data. By monitoring a particular value of the equipment for a particular time period, we can get the stability of the equipment. Through the analysis of the parameters of the beams we can obtain the status information of the beam.

2. Use FFT transform to do signal analysis. FFT is a fast algorithm of Discrete Fourier Transform. A signal can be transformed into the frequency domain from time domain using FFT function. It is difficult to see any features of some signals in the time domain but in the frequency domain, it is easy to see the characteristic. This is the reason that a lot of signal analysis based on FFT transform.

3. Calculate. It is now in researching and the function will be completed according to actual need.

RESULTS

CSS Based User Interface

Figure2 shows the top level overall control interface of this system. We can see all the equipments in this system and several subsystem buttons such as the ECR, power supply, high frequency, vacuum and beam diagnose subsystems as well as the MATLAB data process function. Figure3 shows the power supply subsystem as an example of these second-level control interface. Using this interface, we can set adjustable parameters of each power supply and monitor the current and voltage information. Meanwhile, the waveform of current is shown for visual display. Data import/save functions, data process functions, alarm functions, remote power on/off functions are also included in the interface.

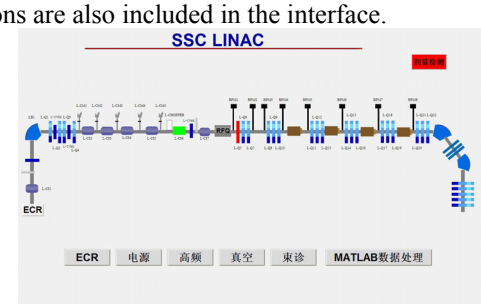

Figure 2: Overall control interface.

Figure 3: Control interface of the power supply subsystem.

MATLAB Based Data Processing

One of the improvements we add in this system is the bring-in of MATLAB for data processing. Figure4 shows one of this data processing functions. The data which need to be processed had already been saved in database by our control interface. In this step, we first use SQL language to fetch data from Oracle database. The selecting conditions are the start time, stop time and PV name. The first axes in Figure4 shows the waveform of interested data. The middle and the last axes separately shows the Fourier transform of the red signal and blue signal in axes 1. Through this basic process, we can easily see the periodicity of the data and do some other analysis.

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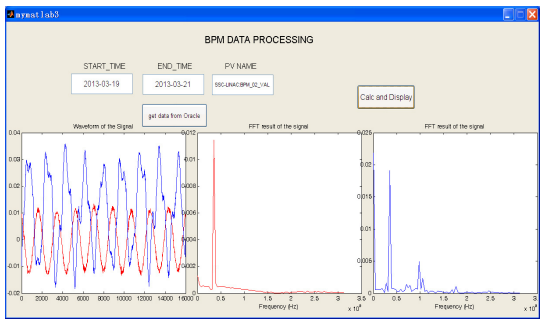

Figure 4: BPM data processing using MATLAB.

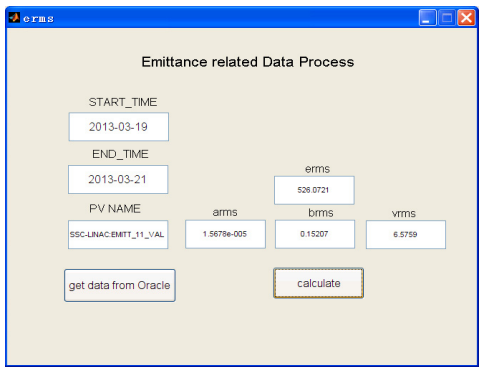

Figure 5: Emittance related data processing.

Beside visual waveform analysis, we can also operate mathematical computing using this system. Figure 5 shows one emittance related data processing function. This function also needs the former saved data in Oracle and the data selection process is similar. Unlike the above FFT function, there are only some parameters being calculated and shown in this function. These parameters can be used in the following steps.

SUMMARY

In this paper, we use CSS to build the EPICS OPI application in which MATLAB is used as the data processing engine. CSS displays real data flexibly and controls device conveniently. MATLAB data processing makes up for the weakness of CSS on data processing. The platform is in continuing research and development and we are continuously developing related applications with the progress of SSC-LINAC project.

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