PAUL SCHERRER INSTITUT

DIAGNOSTICS TEST STAND AND ITS CONTROLS IN LIGHT OF THE FUTURE SwissFEL

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Introduction

The future SwissFEL facility at the Paul Scherrer Institute (PSI) will produce superb photon beams for a variety of cutting-edge user experiments. The project aims to use the lowest electron beam energy compatible with 1 Å facility operation. In these conditions, to ensure successful facility lasing, the machine must be equipped with advanced diagnostics and controls tools continuously monitoring electron beam generation, transport, and compression. The SwissFEL Injector Test Facility (SITF), which has been a major platform for designing and testing such tools since for the last few years, is going to be put out of operations by the end of 2014. After that, there will be no similar platform available on site for the SwissFEL machine component prototyping and testing. In order to supply a satisfactory workbench for electron beam diagnostics and control developments, a dedicated automated Diagnostics and Controls Test Stand (DCTS) was set up in the SwissFEL diagnostics laboratory located in the SITF building. There are several advantages of this location. For instance, being in the area of a well-established SITF control system infrastructure, any required DCTS computer network is easily configurable and supportable. Another important advantage is the direct access to modern laboratory tools for efficient equipment checking and tuning.

To ensure the reproducibility of test results in the real machine environment, diagnostics and controls projects on the stand are required to organize as close to their SwissFEL operational conditions as possible. For example, wire scanner moving components must be kept in vacuum, motor steering cables have to be about ~30 meters long, etc.

All DCTS control system software developments must be compatible with EPICS, which is the principal controls tool at PSI.

DCTS Developments

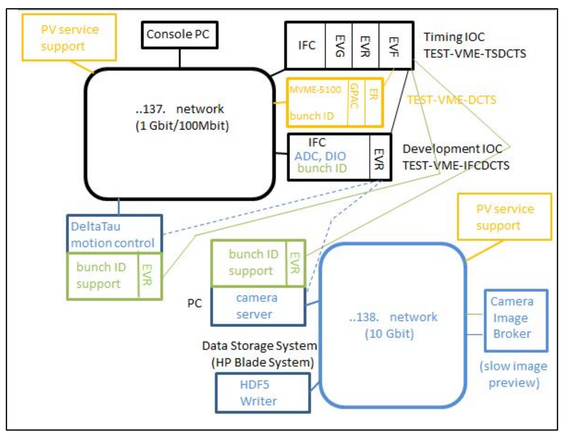
From its very beginning, the DCTS project was divided into several stages based on the SwissFEL type control system hardware and software availability for beam diagnostics applications. On stage one, which was the initial step, the basic test stand control infrastructure was set up and the development of the test procedures for all tasks implemented on the test stand began.

DCTS Control Infrastructure

The main DCTS control network is a general purpose 1 Gbit class C subnet. The operator console is a Linux PC furnished with a high resolution monitor. A standard SwissFEL electronics rack houses the DCTS control equipment, which includes one motion control unit and several VME64x crates.

One VME crate is a primary DCTS software development crate.

It is equipped with a new PSI control computer (IOC), IFC_1210, designed in collaboration with IOxOS Technologies SA, Switzerland. The IFC_1210 is a highly configurable FPGA platform associated with XMC, PMC, and FMC mezzanine slots for custom expansions, a powerful dual core PowerPC, and a real time OS. It is built around a high-performance switched PCI Express GEN2 architecture. The VME support firmware provides a complete VME master/slave interface.



A variety of VME control cards is already supported. The development work is concentrated on fast, not less than 250 Mega-Samples-Per-Second (MSPS), 16 bit ADC, high speed DAC, and digital IO FMC modules available from IOxOS.

The test stand timing system is realized in the second VME crate. It will provide control device triggering mechanisms and synchronous transmissions of DCTS critical data tagged with a SwissFEL bunch ID number. The timing system is based on the latest generation of global event distribution products from Micro-Research Finland Oy.

The content of the VME crate number three is planned to be flexible, depending on current DCTS needs.

The DCTS motion control unit is a Power Brick LV-IMS controller from the Delta Tau Data Systems Inc. In its standard configuration, the Power Brick LV-IMS runs EPICS on top of a Linux OS with a real time kernel, which makes it especially attractive for SwissFEL applications.

The application development environment follows PSI standard. It is based on a powerful hardware inventory database, very efficient application building and installation frameworks, in-house created application installation tools, and the concurrent version system (CVS) dependent software revision control.

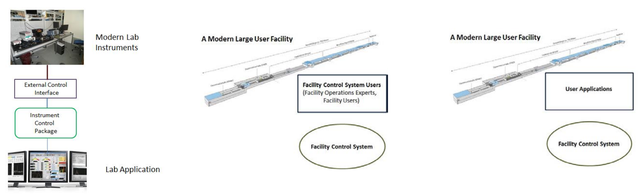
The work on the DCTS project is organized around a dedicated TWiki page, a popular project management tool JIRA, and a PSI Electronic Logbook (ELOG). This allows one to efficiently concentrate all available resources on the most important tasks for any particular time frame.

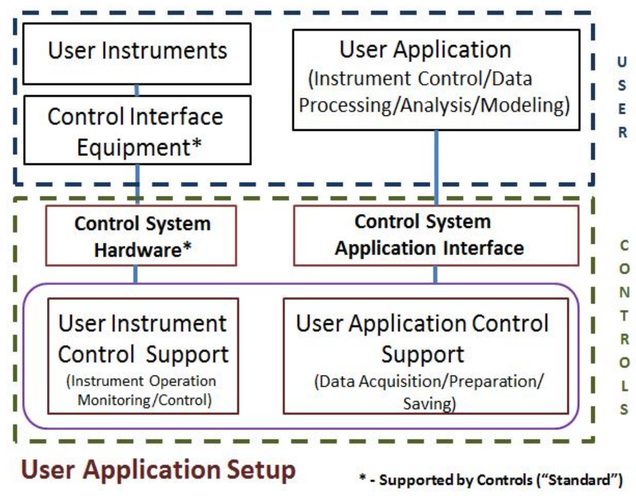
User Application Setups and Test Procedures

Any facility control system serves its users. In the frames of the DCTS control system, each user project (e.g. a wire scanner) is represented as its adequate user application setup.

Users employ a set of instruments to provide required operational conditions and to monitor the state of the project. Instruments are supplied with their control interface equipment, allowing one to operate these instruments efficiently (e.g. remotely).

For example, a combination of a stepper motor and its encoder allows one to rotate a mirror and to measure the rotation angle. The facility control system accesses the control interface equipment via the control system hardware. The PSI control team supports a wide variety of control hardware types, which cover all major control interface and data communication standards utilized in research institutions worldwide. These hardware types form the PSI standard control system hardware. The lists of standard control system hardware types and control interface equipment compliant with these types are published in official PSI control documents.





The DCTS control system software, which manages instrument operational functions based on the control hardware, forms a user instrument control support package.

In control system environment, users operate their instruments remotely, from applications running on computers connected to the control network. The applications (e.g. MATLAB programs, Perl scripts, etc.) talk to the control system on the basis of the control system application interface, such as the EPICS Channel Access (CA).

Some data preparation work for DCTS user applications is done directly on the IOC by a dedicated software module. For example, bunch ID tagged data are collected in allocated EPICS waveform records. Such a software module and the IOC software taking care of the control system application interface form a user application control support package.

Based on the above definition, DCTS user application setup test procedures are divided into three categories.

User Application Setup test procedures

- Instrument Controls Support test procedures
- Application Controls Support test procedures
- Application test procedures

The user instrument control support test procedures must be developed by the control system specialists. In particular, such procedures have to include the detailed instructions of how to set up and test the user control interface equipment and its control hardware, connect the user equipment to the control system run the equipment control software and make sure that it communicates with the equipment properly troubleshoot any possible control hardware and equipment problems.

As a rule, this is done by providing detailed instrument control setup/test/troubleshoot documentation and related project operational tools (e.g. graphical user interface panels).

The user application control support test procedures have to be defined by both control system specialists and users. The goal is to make sure that any required data preparation for user applications is done correctly.

The user application test procedures must be developed by control system users. The procedures have to demonstrate that applications properly control user instrument operations and their data processing software works correctly, which requires the design and use of instrument signal sources with well-known properties, such as a round laser beam as the camera image source.

One of the main goals of the DCTS is to develop all user project specific test procedures based on the experience gained on the test stand.

Nearest DCTS Plans

A series of electron beam diagnostics and control projects is in the list to work on at the test stand in the next few months. The wire scanner control with bunch ID data tagging has to be implemented. The SwissFEL camera server and camera image saving system must be configured to operate at 100 Hz. A productive IOxOS fast ADC control software development environment has to be created. Besides, all this must be accompanied by the work on the proper project test procedures.

CONCLUSIONS AND ACKNOWLEDGEMENTS

The DCTS project gives SwissFEL control system users and specialists a unique opportunity to efficiently work on their projects during the SwissFEL construction. A high flexibility of the DCTS framework allows one not only to create and test project components but also to simplify the development of powerful tools, which can be used to make sure that these components are fully operational: instrument and control hardware test signal sources, project test procedures, project setup and operation plans, etc.

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