ISHN ION SOURCE CONTROL SYSTEM OVERVIEW AND FUTURE DEVELOPMENTS

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Abstract

ISHN project consists on a Penning ion source, which will deliver up to 65 mA of H- beam pulsed at 50 Hz, with a diagnostics vessel for beam testing purposes. The present work summarizes the control system of this research facility, and presents its future developments. ISHN consists of several power supplies for plasma generation and beam extraction, including auxiliary equipment and several diagnostics elements. The control system implemented with LabVIEW is based on PXI systems from National Instruments, using two chassis connected through a dedicated fiber optic link between the HV platform and ground. Source operation is managed by a real time processor, while additional tasks are performed by means of an FPGA. In addition, the control system uses a MySQL database for data logging, by means of a LabVIEW application connected to such DB. The integration of EPICS into the control system by deploying a Channel Access Server is the main ongoing work, being several alternatives under test. Finally, a high resolution synchronization system has been designed, for generating timing for triggers of plasma generation and beam extraction as well as data acquisition for beam diagnostics.

INTRODUCTION

The ESS-Bilbao (ESSB) light ion linear accelerator has been conceived as a multi-purpose machine, useful as the core of a new standalone accelerator facility in southern Europe giving support to local beam users and accelerator physicists [1]. The project aims to develop significant in-house capabilities needed to support the country participation in a good number of accelerator projects worldwide. In this context, the designed modular, multipurpose accelerator should serve as a benchmark for components and subsystems relevant for the ESS project as well as to provide the basque and spanish science and technology networks with hands-on experience on power accelerators science and technology.

In this context, the development of a front-end test stand for ion sources will allow ESSB to test, develop and optimize ion sources and their working parameters (see Fig. 1). Currently, a penning ion source on loan from ISIS, modified to use permanent magnet instead of an electromagnet to generate the penning field, is being tested [2]. This project serves several goals. It generates experimental data that can be contrasted with simulations. It serves as test stand for control systems and hardware. It is also a small scale test of the data acquisition, logging and analysis that will be required for the accelerator. And, in general, it provides experience in the operation and maintenance of ion sources and the equipment associated with them.

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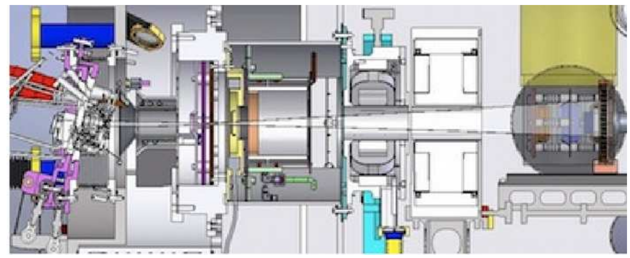

Figure 1: ISHN Ion Source Overview: from left to right: tilted Penning Source, Cs trap section (grey box), post-extraction electrodes (pink), ACCT (orange), DCCT (grey), Quadrupole (light blue), Dipole (white), RPA and Pepperpot (brown).

A penning type ion source is operated applying a pulsed discharge periodically ($800\mu sec.$, $30A$) to source's cathode, generating a mixed plasma of Hydrogen gas and Caesium vapour. Hydrogen is fed applying a pulsed voltage to a piezovalve for $250\mu sec.$, and it is automatically controlled for maintaining a constant pressure in the plasma chamber. Once the plasma is stabilized ($\sim 500\mu sec$ later), a pulsed extraction voltage is applied ($300\mu sec.$, $12kVolt$) generating an H^- beam. This pulse diagram is repeated at $50Hz$, see Fig. 2. In order to accelerate the beam, the platform high voltage power supply gives up to $100kVolt$, but in the current commissioning phase, it usually runs at $35kVolt$. In addition, a continuos power supply ($600V$ and $2A$) is needed for conditioning ion source's electrodes, which is used in the beginning of the operation. The principal devices required for source operation are listed in Table 1.

Table 1: Main Devices for Source Operation

Utilities	**Plasma Creation**
Cs Heaters	DC Power Supply
H_2O Refrigeration	Pulsed Power Supply
Air Refrigeration	H_2 Piezovalve
Vacuum pumps and sensors	
Beam Extraction	
Extraction Power Supply	
High Voltage Power Supply	

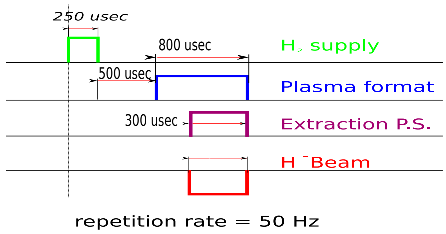

Figure 2: Pulse diagram for beam generation.

Figure 3: Diagnostic devices: from left to right, ACCT and DCCT (not visible), Quadrupole, Dipole, Faraday Cup, RPA (behind) and Pepperpot grid.

Once the beam is extracted, it goes through the so called diagnostics vessel, Fig. 3 shows a picture. The first diagnostics are the current transformers (an ACCT and a DCCT). Then, a quadrupole focuses the beam and a dipole is used for obtaining information about the degree of stripping and beam species components. The last beam diagnostics cannot be activated simultaneously and are also used as beam stoppers: a Faraday Cup for measurement of beam current, a Retarding Energy Analyzer for energy spread analysis, and, finally, a pepperpot device for obtaining emittance values.

The control system is in charge of all of these elements, ensuring its correct operation and granting safety for both personnel and machine. In the following section, the architecture of the system will be explained.

CONTROL SYSTEM OVERVIEW

The control system architecture can be observed in Fig. 4. Due to the high voltage in the platform, the main system is divided into two control subsystem, located at ground and at the platform, respectively. Each area has its own operator panel, allowing the operation of the ion source from both control desks, but not simultaneously. However, continuos monitorization of the status of the system is always active. The source is usually managed from platform panel until high voltage power supply is turned on.

The control system architecture is mainly based on hardware from National Instruments for source operation and data acquisition. Two PXI chassis are used, at ground and platform, whose are linked with a dedicated fiber optic card from same vendor, which facilitates the programming since it integrates the second chassis as a PCI bus extension of the first one. Therefore, the two-chassis system can be treated as a single element.

The chassis located at ground contains a RealTime controller programmed in LabVIEW. It manages Cesium boilers' and pressure control loop, some data acquisition through other PXI cards and a FPGA and communication with the operator's control desk using shared variables. It also communicates with some power supplies by GPIB and pressure sensor by serial protocol link.

On the other hand, the FPGA located on the HV platform controls diverse elements. It manages the trigger signals for plasma power supplies and H_2 supply, generating the pulse diagram of Fig. 2. In addition, it manages some safety signals from and to plasma power supplies and controls several electrovalves for gas supply and refrigeration of the ion source. Being the only card with signal acquisition capabilities in platform, it is in charge of acquiring voltage and current waveforms from plasma generation power supplies. Furthermore, it also measures gas flow rate, temperatures of the ion source and some other minor parameters.

As there are two operator panels, the code should avoid data overwriting between both monitorization applications. Therefore, two mode of operation are defined, local and remote. The last operation mode is prepared to be integrated in an EPICS control network. All of the code has been programmed in LabVIEW: the Real Time application, the FPGA and both monitorization programs.

In addition to the main controllers, a Twido PLC manages the operation of the vacuum system, which consists of two mechanical and two turbomolecular pumps. The advantage of this modular solution is to have the ability of performing stops and upgrades of the main control system without disturbing vacuum operation. This is very important in the commissioning phase, where adjustments of diverse elements and minor changes of the control system are usual. Moreover, a modular control approach leads to the possibility of reuse code and proposed control solution in other projects.

Two safety PLCs from PILZ located in both cabinets ensures safety during operation. The one located at ground handless several safety sensors (doors, grounding arm status, ...) and ensures that power supplies only receive electrical supply if safety environment is granted. The safety PLC located in the platform handles the signals related to the H_2 supply and the electrical power supply of the Cs heaters. If any problem is detected or if the emergency stop is pressed, safety system shutdowns high voltage power supplies.

The fiber optic link is used for ethernet communication, and the real time controller, both monitor panels, plasma power supplies, PLCs and some other noncritical devices are attached to this network.

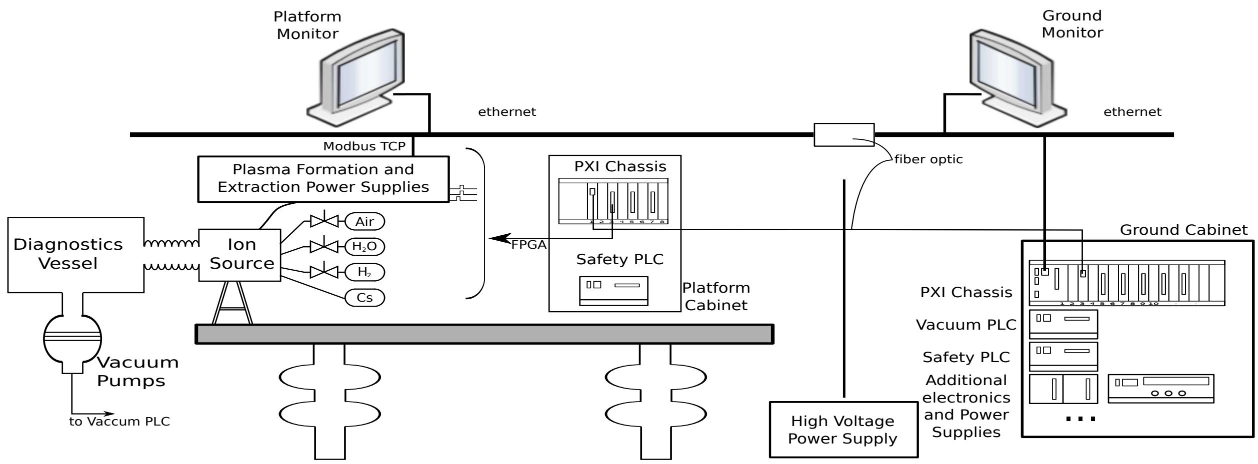

Figure 4: Control system architecture.

Diagnostics and Data Base Storage

As has been mentioned, there are several diagnostics inside the diagnostics vessel. Currently, most of them are under test, except the retarding potential analyzer which is being redesigned, and managed by the real time application, except the pepperpot which is half managed by a laptop connected to the camera.

The experimental data obtained must be analyzed and a storage system has been implemented. MySQL is probably the most popular open source database, and it is extremely easy to download and install on any OS. On the other hand, the LabVIEW Database Connectivity Toolkit contains a set of *VI*s with common database tasks, therefore, the data acquired in LabVIEW was directly recorded in the MySQL database through the Microsoft ODBC driver for MySQL.

Currently, data is stored as array for beam current measurements (ACCT, DCCT and Faraday-Cup) and signals of the power supplies (current and voltage), while the rest of the parameters are scalar variables. Data arrays are saved every $5min.$ and scalar variables every $5sec.$,. The total amount of data is around $10MB/hour$. Regarding data visualization, a custom python program has been developed for retrieving data from the database.

ONGOING WORK

The ISNH facility serves as test platform for different technologies required in particle accelerators, including control. Now, the ISNH control system is under development in various aspects:

- Integration of the control system in a EPICS network: with additional minor modifications in current control system, an EPICS server has been implemented, This is based on the implementation by National Instruments, and runs on the real time target in the PXI controller.

- Data storage system: as far as the database architecture is concerned, it was decided to keep the MySQL schema provided by the ArchiveEngine utility [4], an EPICS ChannelAccess client. Using this client, any channel served by any ChannelAccess server can automatically save to a relational database, like MySQL or Oracle. Hyperachiver is a customized version of the RDB Archiver, using HyperTable as an alternative database to MySQL or Oracle. This has been modified and developed at INFN laboratories at Legnaro (Italy). Since this database choice requires a linux environment, the current implementations is running on Fedora14.

- Timing and synchronization system: an independent high resolution synchronization system has been designed, for generating timing for triggers of plasma generation and extraction as well as data acquisition for beam diagnostics. The current design is based on commercial devices [5].

These changes already have been tested successfully in the laboratory. The control system will be upgraded in a future maintenance stop of the ion source.

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