SAFETY CONTROL SYSTEM AND ITS INTERFACE TO EPICS FOR THE OFF-LINE FRONT END OF THE SPES PROJECT

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Abstract

The SPES off-line front-end apparatus involves a number of subsystems and procedures that are potentially dangerous both for human operators and for the equipments. The high voltage power supply, the ion source complex power supplies, the target chamber handling systems and the laser source are some example of these subsystems. For that reason, a safety control system has been developed. It is based on Schneider Electrics Preventa family safety modules that control the power supply of critical subsystems in combination with safety detectors that monitor critical variables. A Programmable Logic Controller (PLC), model BMXP342020 from the Schneider Electrics Modicon M340 family, is used for monitoring the status of the system as well as controlling the sequence of some operations in automatic way. A touch screen, model XBTGT5330 from the Schneider Electrics Magelis family, is used as Human Machine Interface (HMI) and communicates with the PLC using MODBUS-TCP. Additionally, an interface to the EPICS control network was developed using a home-made MODBUS-TCP EPICS driver in order to integrate it to the control system of the Front End as well as present the status of the system to the users on the main control panel.

INTRODUCTION

Selective Production of Exotic Species (SPES) is an Istituto Nazionale di Fisica Nucleare (INFN) Project for the development of the Nuclear Physics as an intermediate step toward EURISOL and to cover interdisciplinary applied physics in the fields of material science and medical applications. The project is based on a facility (Fig. 1) for the production of neutron-reach Radioactive Ion Beams (RIB) using the Isotope Separation On-Line (ISOL) technique [1, 2].

The radioactive ion beams are produced by proton induced fission on a Uranium Carbide (UCx) direct target at a rate of $10^{13} fission/s$. The radioactive ions are reaccelerated at energies higher than 10 $AMeV$ for mass region $A = 130$. Re-acceleration will be performed by the superconducting linear accelerator complex (PIAVE-ALPI) of the LNL. The expected beam-on-target is on the order of 10^8 pps for ^{132}Sn, ^{90}Kr, and about $10^5 - 10^6$ pps for ^{134}Sn, ^{95}Kr considering a total efficiency of 2% from the +1 source to the experimental target [2, 3, 4, 5].

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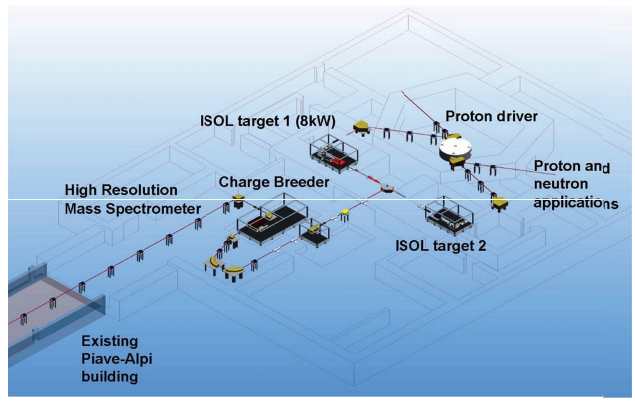

Figure 1: The SPES facility.

At the present, a test bench, called the Front End (Fig. 2), has been constructed at the LNL. It is an apparatus for the acceleration of stable +1 ions up to energies of 30 keV. It permits testing and improving the key systems used on the RIB production like the target complex, the ionization devices and the beam focalization and transport subsystems.

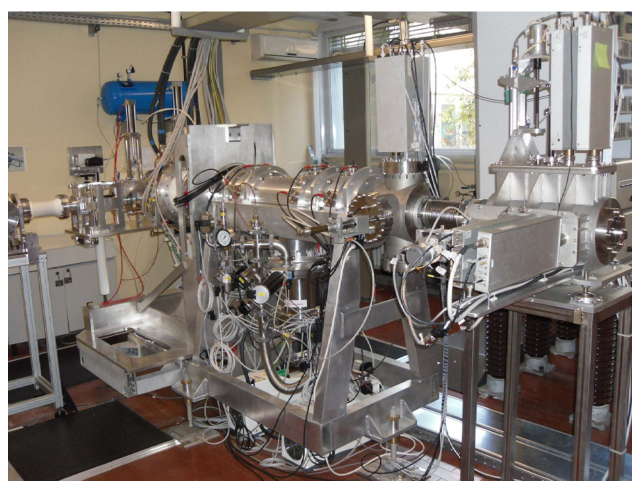

Figure 2: The off-line Front End of the SPES project.

The control system of the Front End has been developed using heterogeneous hardware and software solutions but they are integrated under an unique communication model based on the "Channel Access" of the set of open source tools EPICS (Experimental Physics and Industrial Control System) [6]. Moreover, thanks to this unification, the entire apparatus can be controlled from a main control panel developed using Control System Studio (CSS) collection of user interface tools.

The SPES off-line Front End apparatus involves a number of subsystems and procedures that are potentially dangerous for both human operators and equipments. Among the most potentially dangerous systems are: the high voltage power supply, the ion source complex power supplies, the target chamber handling mechanisms and the laser source.

In order to prevent possible injuries to the operators and damages to the equipments, a safety interlock system has been developed. Furthermore, this system has been interconnected to the EPICS Channel Access in order to have and unify control system.

THE SAFETY CONTROL SYSTEM

The Safety control system have been designed using self-controlled devices and applying redundancy for achieving a PL e/Cat. 4 (EN/ISO 13849-1) and a SIL3 (EN/IEC 62061) safety level. It was developed as a decentralized, distributed structure using Schneider Preventa safety devices. This safety modules are in charge of enabling or disabling the systems that are potentially dangerous, according to the conditions of the system.

The enabling or disabling of a system is done by the safety device controlling two contactors, serially connected, that transmit the power supply to the system. Controlling two contactors increase the reliability of the protection.

The conditions are determined by the status of critical variables (from the safety point of view) that are continuously being monitoring by the same safety devices. To maintain a required level of reliability, the monitoring of the variables is carried out using safety devices.

The critical variables monitored by the safety devices are: the status of the isolation cage gates (using safety magnetic limit switch), the presence of a person around the target chamber (using safety mats), the activation of the command to move the target chamber (using a safety two-hand controller), the activation of an emergency stop (using safety emergency push buttons), the temperature of the target chamber surface (using thermocouples and PT100 devices), the air system pressure (using a pressure switch), the water system flux (using flux meters) and the vacuum level inside the Front End (using vacuum heads and a pressure switch).

A system can be controlled by as much safety devices as critical variables are associated to its operation. Each pair of contactors (for each safety device) is serially connected to the others. In this way, only when every one of the safety devices enables the system, the power supply is transmitted and the system is power on.

For each system, an additional contactor has been added. It is controlled directly by a PLC in order to be able to power on the system when the user requires it, once the right conditions are satisfied. As an additional function, the PLC monitors the status of all the safety modules. A touch screen is used to allow the user to power on and off each system (when possible) and to show him the status of the system.

The PLC used is a BMXP342020 from the Schneider Electrics Modicon M340 family, while the touch screen is a XBTGT5330 from the Schneider Electrics Magelis family. They communication is carry out through the MODBUS-TCP protocol.

The system controlled by the safety controls are: the high voltage power supply, the ion source complex power supplies, the target chamber handling systems and the laser source. Figure 3 shows the safety system for the laser source as an example.

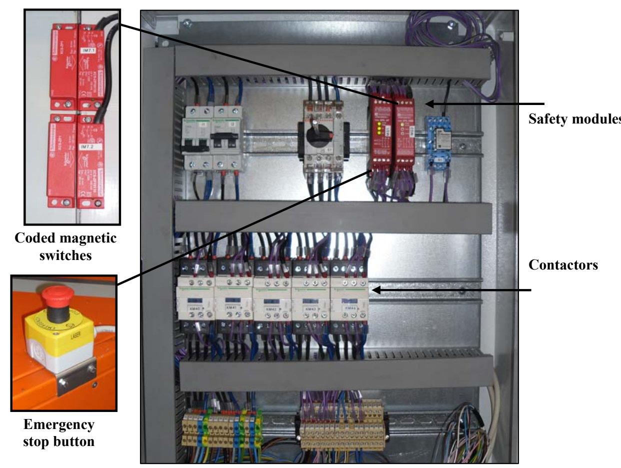

Figure 3: The LASER safety control system.

THE INTERFACE TO EPICS

An EPICS IOC (Input Output Controller) implementing a home-made MODBUS-TCP driver was developed in order to interconnect the EPICS and the safety control systems. This driver requests the PLC the status of the variable associated to the safety control systems and write them on EPICS records, available thus to the entire system through the EPICS Channel Access (CA).

The IOC is implemented on a Linux PC using two Ethernet interfaces: one is use for the PLC communication (MODBUS-TCP) and the other one is use for the EPICS communication (Channel Access). (Fig. 4). On the other hand, the MODBUS-TCP driver was developed using the "StreamDevice" device support for EPICS.

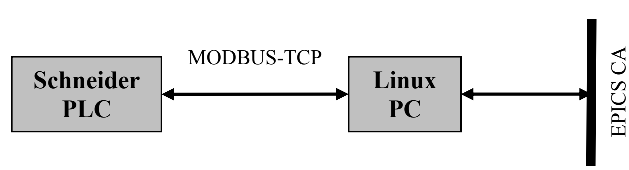

Figure 4: EPICS and safety control systems interconnection.

The MODBUS request is assembled on the IOC record data base and then it is encapsulated on the TCP/IP datagram by the StreamDevice device. The resulting packet is send to the PLC through the corresponding Ethernet interface.

The PLC receives the request, processes it, and them sends the respond through the same Ethernet interface to the IOC. This packet is first received by the StreamDevice who extracts the MODBUS response from the TCP/IP datagram. Next, this MODBUS response is delivered to the IOC record data base where the requested information (the variable status) is read, process and placed on suitable records that are accessible on the Channel Access.

Once the variable statuses are accessible on the Channel Access, they can be monitored by any Channel Access client inside the EPICS network. In our particular case, the statuses of the variables are presented to the user on the Front End main control panel (Fig. 5).

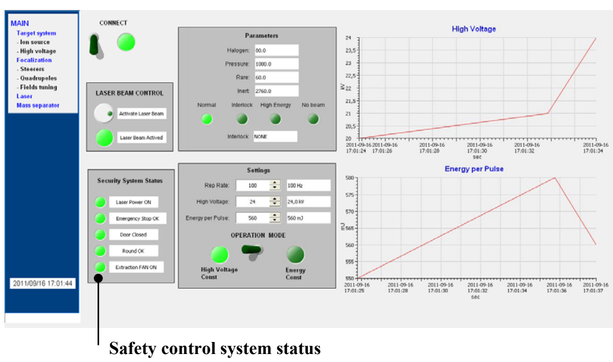

Figure 5: Safety control systems status presented on the LASER control GUI.

CONCLUSIONS

The SPES off-line Front End apparatus involves the use of potentially dangerous equipments. Additionally, the project is getting close to its operative time. Consequently, it was necessary to develop and implement a safety control system to protect both, the equipments and, more importantly, human operators that will be involve soon with the system.

The fact that the project involves dangerous conditions to human being, it demands that the safety control system must be as reliable as possible. Because of that, a distributed hardware-oriented safety control structure was implemented, using special safety devices and techniques achieving PL e/Cat. 4 (EN/ISO 13849-1) and a SIL3 (EN/IEC 62061) safety levels.

Furthermore, although the safety control system is decentralized and not controlled by any other system, a surveillance PLC collects the status information and presents it to the user locally on a touch screen and remotely on the Front End main control panel through an interface to the EPICS Channel Access.

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