NEW LOW LEVEL CONTROLS FOR THE ELETTRA LINAC

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Abstract

A new control system has been installed in one of the seven accelerating sections of the ELETTRA Linac. Starting from the ELETTRA Control System technologies based on Unix workstations and OS-9/VME systems, new solutions have been adopted to interface the control system to the Linac equipment in order to reject the electromagnetic noise of the klystron room. An object oriented analysis of the basic functionality of the Linac sub-systems supported the development of the real-time software and the definition of the control room level applications.

1 INTRODUCTION

In the last year, the project of a new control system for the ELETTRA Linac has entered the implementation phase. The system architecture and the software framework developed for this project are described in [1]. The noisy environment of the klystron room conditioned the choice of the architecture of the control system. The Linac has been divided into several "plants", i.e. the gun, the pre-injector and the seven accelerating sections. Each plant is controlled by one Equipment Controller (EC), which is located close to the equipment in order to avoid electromagnetic noise in the signal transmission. For the interface to the existing equipment the development of a dedicated I/O board using voltage-to-frequency (V/F) conversion techniques has been undertaken.

The requirements of the new control system have been specified using an object-oriented approach, which has lead to the definition of the control system functionality and eventually to the specification of the I/O signals.

The new software framework developed for the Linac control system simplifies the programming of the low-level applications and the development of state machines for the automation of complex operations.

2 MULTI I/O BOARD

The V/F technique has been used to interface the analog signals to the control system. The voltage inputs are converted to frequency and transmitted to the EC where they are read as digital samples. In a symmetric way the EC generates the output frequency signals which are transmitted to the equipment and converted to voltage.

The transmission of frequency signals is less affected by electromagnetic noise: the V/F and F/V conversions are made as close to the equipment as possible in order to minimize analog signal paths. Moreover, the source and the receiver points are electrically insulated to avoid ground loops.

A dedicated VME board called Multi I/O (figure 1) has been developed in-house to interface the Linac signals. Since it acquires and generates square-wave signals it can be also used as a digital I/O board.

The main features of the board are:

- Sixteen optoisolated I/O channels
- Each channel is individually configurable as input/output and digital/frequency
- Programmability through VME mapped registers
- I/O Frequency range from 1 kHz to 8 kHz
- Equivalent resolution better than 12 bits
- Acquisition triggered by an external signal (e.g. 10 Hz) which can optionally generate VME interrupts.

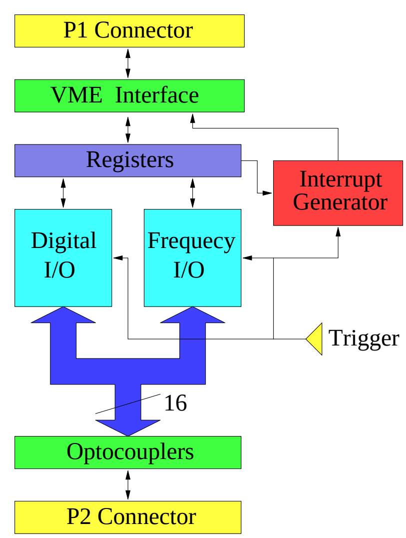

Figure 1: Multi I/O board block diagram

Some input points must be monitored at the Linac repetition frequency, i.e. 10 Hz. A dedicated device driver has been developed to manage the 10 Hz interrupts generated by the Multi I/O board and store the input values in circular buffers. The acquisition can be started and stopped by SW external events in order to allow the analysis of the recorded signals in the period preceding that event.

3 LINAC SUBSYSTEMS

Different types of interfaces are used to connect the Linac equipment to the ECs. Figure 2 shows the layout of the VME chassis.

The Multi I/O board is used for the following subsystems: Solenoid Power Supply (PS), H_2O cooler, Klystron filaments PS, Thyratron filaments PS, Pre-magnetization PS, RF amplifier and Klystron focusing PS.

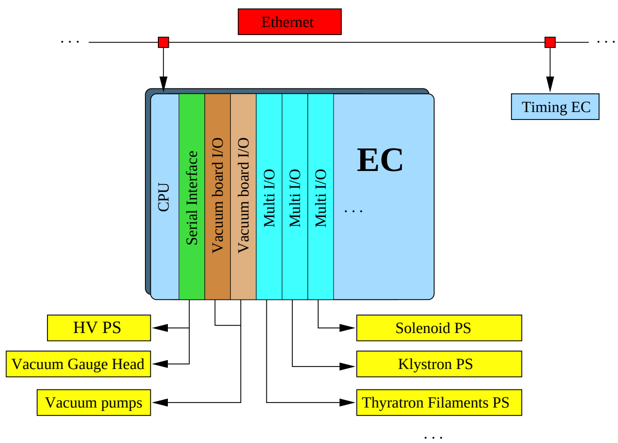

Figure 2: Equipment Controller layout

3.1 Vacuum equipment

The vacuum equipment for each of the Linac plants is made of six ion pumps and one valve controlled by a dedicated hardware already used for the Storage Ring. A vacuum gauge head is controlled through a serial RS-232 interface.

3.2 Timing System

The Linac operation requires a number of trigger signals. A timing board developed at ELETTRA generates these signals [2]. One dedicated EC (VXI) hosts a set of timing boards, each in charge of one Linac section. The communication between the plant dedicated ECs and the timing EC is performed by RPCs (Remote Procedure Call) through the Ethernet network.

3.3 Interlock System

The Linac Group is in charge of developing the interlock system, which is made of a hardwired network of relays. The control system acquires about 60 digital signals from the interlock system for monitoring purposes. A few digital commands are used to acknowledge particular interlock conditions.

For these signals the Multi I/O board is employed.

3.4 Plant HV Power Supply

The High Voltage power supply is connected to the control system by means of a serial RS-232 interface. The voltage setting is made through a software ramp (figure 3). This ramp is composed by a number of linear segments. Each segment is realized by holding some digital samples. Before each step a number of conditions are checked: if this test is not passed the ramp is brought three steps back or to the beginning of the segment if less than three steps have been performed. Then the ramp is suspended until a restart command is received. The voltage is instantly brought to zero if a dangerous fault is detected.

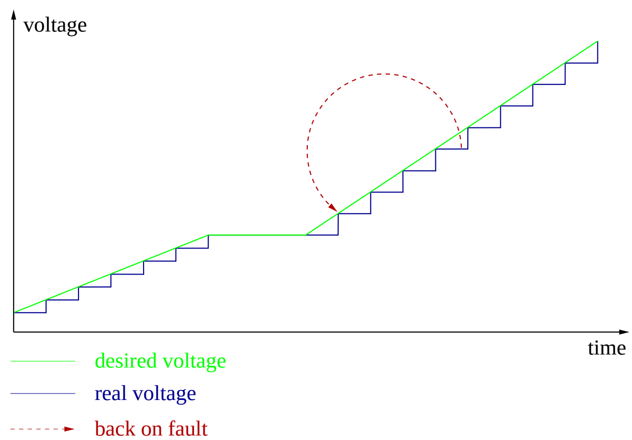

Figure 3: High Voltage ramp

4 SYSTEM ANALYSIS

The adoption of object-oriented tools for the analysis of the new control system has aided the understanding of the requirements and the definition of the details of the interfaces for the controlled equipment.

UML (Unified Modeling Language) is a widely used method for the analysis and design of software applications. We adopted use-cases, actors, activity diagrams and state diagrams [3].

In the analysis work carried out for the ELETTRA Linac control system, use-cases have been employed as the first approach with the technical groups involved in the project. Each use-case follows a precise template: involved actors, preconditions, description, exceptions and post-conditions.

The definition of the actors was the second step. Some actors are related to physical subsystems of the accelerating section, e.g. Vacuum system, Interlock, HV power supply, RF amplifier, Timing, etc. Other actors are service applications like Database, Logger, Alarm Server, etc. The Plant Supervisor is a special actor dedicated to the automation of complex operations performed on the entire plant, like switching-on, switching-off, standby, etc.

The UML description has been appreciated as a convenient method of intercommunication between controls people and the groups involved in this project: it helped us to focus on basic concepts and to get deeper and deeper with the analysis up to the point of project specifications. All of the UML descriptions have been published in local web pages where the control system documentation is shared.

5 PLANT SUPERVISOR

Each subsystem of a Linac plant is controlled by one device controller [1], which is a process in charge of all the operations related to that device. A sort of multi-tasking scheduler allows to run several state machines in parallel inside one device controller. This is used for example to execute asynchronous or multiple commands.

The main operations of a Linac plant like switching-on, switching-off, standby, etc, are complex operations that involve several subsystems. In order to perform these operations, a dedicated device controller called Plant Supervisor has been developed. It is a generic scheduler that launches and coordinates the execution of actions performed by the subsystem device controllers. It is actually implemented as a device controller too, where "device" means the whole plant. It communicates with the other device controllers through logical drivers. Device controllers running on other ECs, like the Timing EC, can be controlled via RPC calls. The supervisor execution can be controlled and monitored by means of a panel running on a control room workstation.

The actions to perform can be described by an activity diagram (figure 4) where each activity (graphically rounded rectangle) represents an operation performed by a device controller, while the synchronization bars indicate that some activities must be completed before going on.

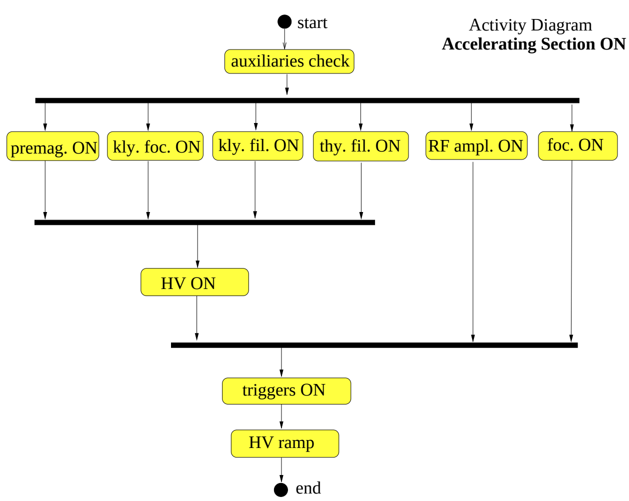

Figure 4: Activity diagram of the plant switching-on performed by the supervisor

Each activity is started with a command sent to the corresponding device controller: then the supervisor waits for the termination of that activity. An error message is returned if the operation cannot be performed. In case of fault, the device controller in charge of that operation sends a message to the supervisor. Depending on the gravity of the fault, three possibilities are considered:

- Fatal fault: the whole supervisor operation is aborted
- Serious fault: the state of the plant is brought back to the starting point
- Local fault: the supervisor is suspended. The operator can either decide to retry the operation, perform the operation manually and "force it done", or abort the whole supervisor operation.

Since for this project several supervisors will be implemented, a generic supervisor has been developed which can be configured for the different applications by means of a file of resources [1], where all of the details of the supervisor operation are described in ASCII format.

6 CONCLUSIONS

The new control system hardware has been installed in one of the accelerating sections. In order to avoid long periods of shut down, that section has been disconnected from the rest of the Linac.

The device controllers for all of the subsystems and the supervisors have been completed. The test phase will start after this conference. As soon as the first plant is ready for operations it will be reintegrated in the Linac.

7 AKNOWLEDGEMENTS

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REFERENCES

[1] M. Lonza et al., “Design and Development of a New Control System for the ELETTRA Linac”, EPAC’96, Barcelona Spain, June 1996.

[2] M. Ferianis et al., “The New Timing System for the ELETTRA Linac”, EPAC’96, Barcelona Spain, June 1996.

[3] M. Fowler et al., “UML Distilled: Applying the Standard Object Modeling Language”, Addison-Wesley, Melrose MA, October 1997.