USING LABVIEW TO IMPROVE THE OPERATION OF A PARTICLE ACCELERATOR*

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Abstract

This paper describes an automatic system, build around a personal computer and LabVIEW, designed to improve the operation of a Van de Graaff type particle accelerator used by Technological Nuclear Institute in Lisbon, Portugal, to do material characterization.

INTRODUCTION

The Ion Beam Laboratory of the Technological Nuclear Institute (ITN) in Lisbon has a particle accelerator based on the Van de Graaff machine which is used for research in the area of material characterization. The Van de Graaff particle accelerator [1] in the ITN is an horizontal electrostatic accelerator, Model AN-2500 Type-A, manufactured by High Voltage Engineering Europe, and capable of producing Helium (He+) and Hydrogen (H+) ion beams with energies up to 3 MeV and current intensities of a few microamperes. It is like many others around the world dedicated to scientific research [2].

A system was build around it to automate its operation, in particular the procedures required to turn on and off the particle accelerator which include setting the terminal voltage, lighting up the ion source, focusing the beam and controlling the beam current and energy during operation. In addition, the computer monitors the vacuum and is able to make a detail register of the most important events during a normal run.

SYSTEM DESCRIPTION

The system is build around a personal computer (PC) and has two multifunction I/O boards from National Instruments, model PCI 6229, and five electronic modules build specifically for this application.

The computer runs an application build using LabVIEW (Figure 1).

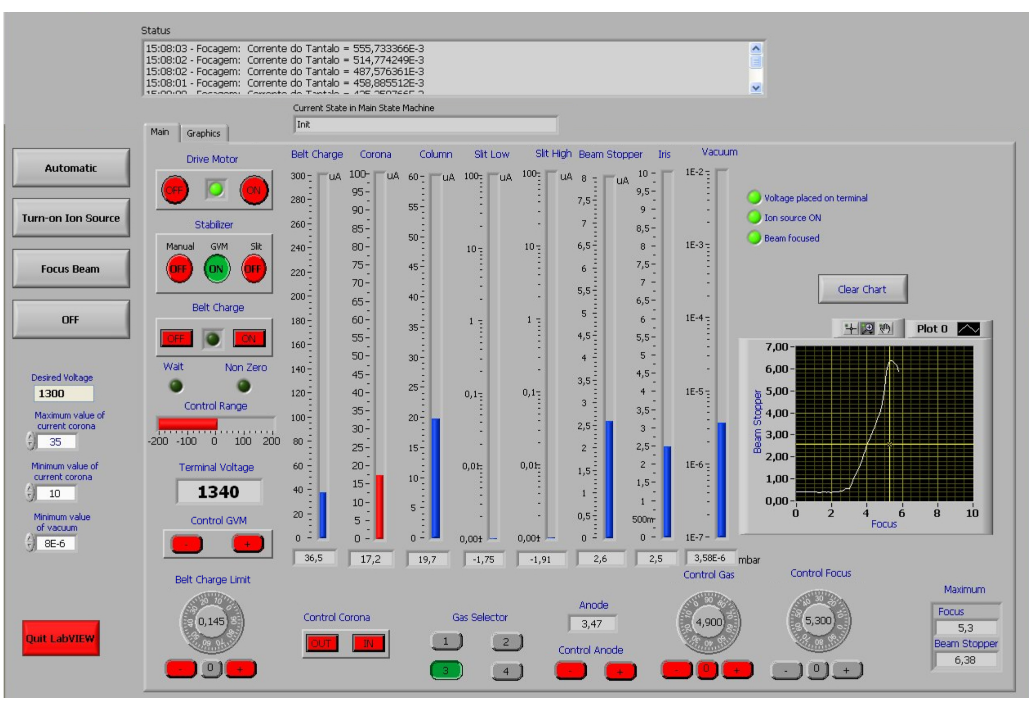

Figure 1: User interface of the control and monitoring application.

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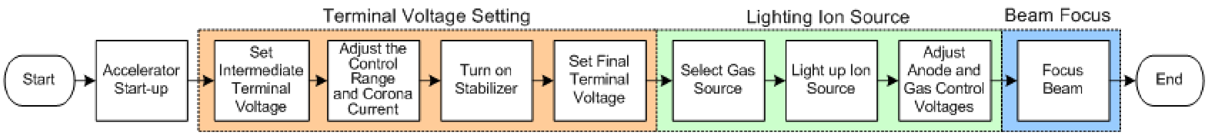

Figure 2: Flowchart of the particle accelerator power up.

The electronic modules that were developed corresponds to: mode selection (i.e. automatic or manual mode); corona and belt drive motor adjustment; ion source control; readings (i.e. beam currents and vacuum values); power source (i.e. electronic power supply). The DAQ controls the electronic modules and the acquisition of digital and analogical signals.

The final system has a switch that allows the user to choose between *Console Operation* and *Computer Controlled Operation*. If the user chooses the first than the control of the machine is made through the existing control console. In case of *Computer Controlled Operation*, the user is able to choose between *Manual Operation*, where the user can interact with the particle accelerator, through the computer, the same way as he does with the existing console, or *Automatic*, where the computer executed by itself the requires operation procedures without user intervention.

When the machine is working in *Automatic Mode*, the control system is able to set the terminal voltage to the desired value, light up the ion source and focus the beam. The user interface presents to the user all accelerator variables for total control of the particle accelerator.

During *Computer Controller Operation*, the accelerator measured signals (i.e. terminal voltage, beam current, corona current, vacuum, etc.) are presented at the same time in the machine's console and in the computer screen where more.

The main advantage of the developed system is that the procedures which are necessary to follow before and after using the particle accelerator are automated which increases the efficiency and frees the user to perform other task during the significant time it takes for the machine to be ready for use.

The 4 main procedures that have been automated are:

- Setting of the Terminal Voltage.
- Lighting up the Ion Source.
- Focusing the Ion Beam.
- Shutting down the particle accelerator.

The first 3 are required to power-up the accelerator, that is, to take it from a shut down state to a having a focused ion beam with a given energy (Fig. 2). In the following sections we describe some of these procedures.

Terminal Voltage

The flow diagram shown in Fig. 3 is used to set the desirable terminal voltage. First the pressure is verified inside the accelerator tube and beam lines. If the values are not in the range (maximum value is $2x10^{-3}$ Pa) an error message is sent and the accelerator is shut-down. Else, corona current is adjusted between 15 and 35 μA, and the Control Range is adjusted between -100 and 100 μA by the belt charge limit. The Control Range indicates the difference between the available and the used charge. If is been used more current than the available, we obtain a negative value. Other wise, the Control Range is positive. These extreme values should be avoided because the first represent the decrease of terminal voltage and the second possible sparks in the accelerator tube.

In order to avoid these situations, the ideal value to obtain is zero but that is difficult by the belt that is continuously putting charges in the terminal. If this is not possible, GVM voltage reference is adjusted and all the previous steps are repeated. After terminal voltage is achieved, ± 50 kV, all the cycle is repeated four times, until the Control Range is between 1 and 25 μA, in order to turn-on the ion source.

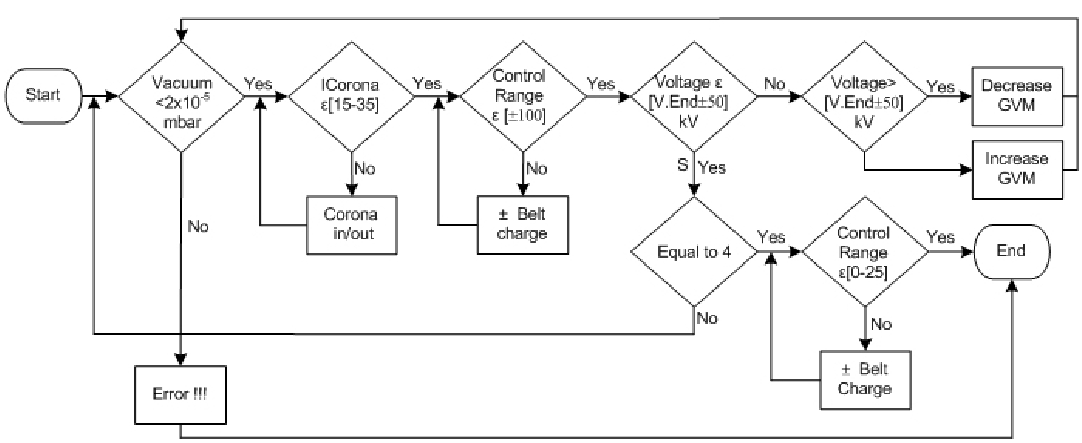

Figure 3: Terminal voltage flowchart.

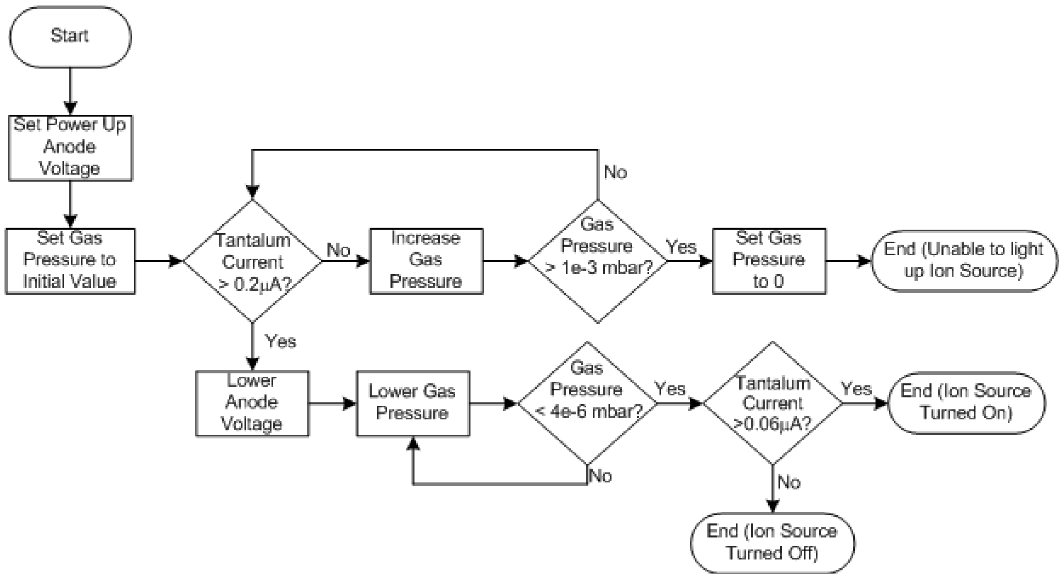

Figure 4: Ion source light up flowchart.

Lightning Up Ion Source

To light up the ion source it is necessary to apply 2 kV to the ion source anode, and slowly increase the gas pressure inside the ion source until it lights up. This is checked through the value of the tantalum current which is the current that flows through a tantalum target which is placed in the way of the ion beam. When it is higher than 0,2 µA it means that the ion source is producing ions and that they are being accelerated toward the tantalum target (Fig. 4).

After the ion source is on, it is necessary to decrease the anode voltage and the gas pressure. Initially this is done rapidly to save gas and then slowly to prevent the ion source from going off until it reaches 4e-6 mbar. If the tantalum current is above 0.06 µA then the ion source is still on.

CONCLUSION

In this paper we presented the automatic control system developed to automate the operation procedures of a Van de Graaff particle accelerator used by Lisbon's Technological and Nuclear Institute for scientific research. The system used a personal computer, two multifunction input/output boards, some custom made electronic interface modules and a LabVIEW application. The user interface presents to the user all accelerator variables for total control of the particle accelerator.

This system is able to the set the terminal voltage, ion source, beam focusing and control of ion beam current and energy during operation, as well as turning on and off the machine. In addition, the computer monitors the pressure and is able to make a detail record of the most important events during a normal run.

For everyday operating conditions the control implemented is able to turn-on and off the machine in about the same time as a specialized technician and attend the normal incidents during operation. This operation allows the use of the machine by less qualified technicians in safe conditions.

In the event of a computer crash, the application developed is prepared to resume operation from a previous state.

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