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AUTOMATION AND INSTRUMENT CONTROL APPLIED TO AN EXPERIMENTAL STUDY OF ELECTRON TRANSPORT DYNAMICS IN AN AVALANCHE MODE RESISTIVE PLATE CHAMBER

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ABSTRACT

In this work it is presented a computer based instrumentation system which was developed to perform data acquisition and integrate the control of different devices in an experimental study of electron transport dynamics in an avalanche mode resistive plate chamber detector in the Radiation Technology Center (CTR) at IPEN-CNEN/SP. System control and data acquisition was performed by a computer program called *RPCLabOperator* written in *MatLab* environment running on a *LeCroy WavePro 7000* digital oscilloscope.

1. INTRODUCTION

The knowledge of electron swarm parameters is of fundamental interest in scientific and technological applications. In particular, within the scope of nuclear and particle physics, they must be taken into account in the design and characterization of gaseous detectors.

For this reason, many experimental studies of swarm parameters in different pure gases and mixtures have been carried out over the years, but there are few data published at high fields strengths and complex molecules. For instance, there are few data available in the case of pure isobutane in multiplication regime, which is of special interest in Resistive Plate Chambers.

This work is part of an effort to develop an experimental setup that aims to obtain accurate measurements of swarm parameters in pure isobutene and other gases. It will focus mainly on automation and instrument control, which are important features in such cases where repetitive measurements are taken, speacially when relatively large amounts of data must be adequately stored. It should also be noticed that automation by means of software also shortens measurement duration and helps the operator in the measurement process.

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Firstly, this paper will proceed with a general description of the experimental apparatus. Secondly, a more detailed description of the computerized system will be presented. Finally, the conclusion section will summarize the main system accomplishments.

2. EXPERIMENTAL SETUP

The experimental setup, shown schematically in Fig. 1, consists of a variable discharge gap between a 3 mm thick glass plate (anode) and a circular shaped aluminium electrode of 3 cm diameter (cathode). High voltage, supplied by a Spellman (Bertan 225-30 IEEE-488) programmable power supply, is applied to the aluminium plate via a low-pass filter.

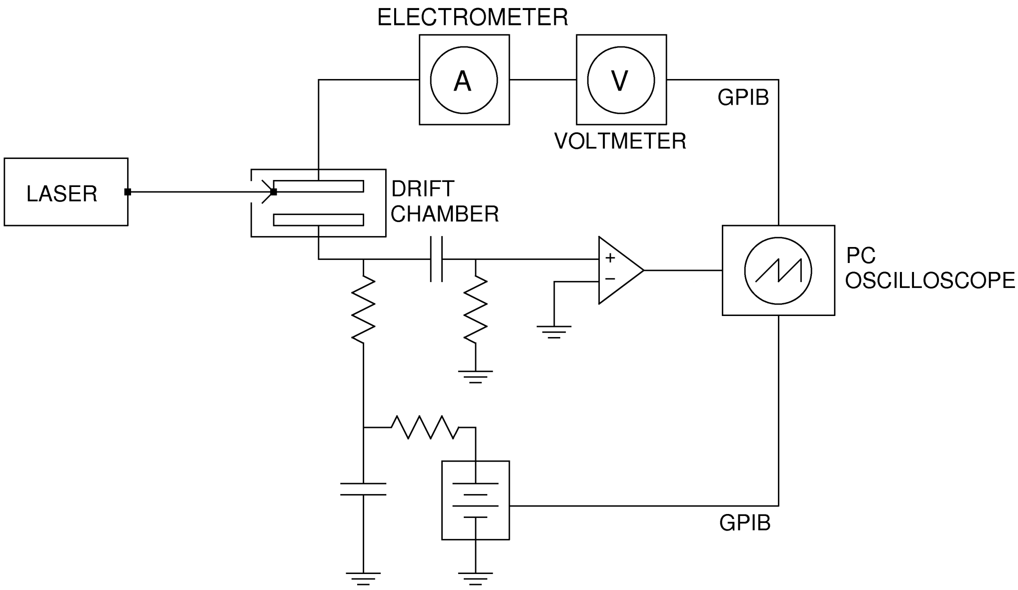

Figure 1: Schematic diagram of the chamber and associated electronics.

These electrodes were housed inside a gas-tight stainless-steel chamber (7600 cm^3) provided with quartz windows for the entrance of a fast nitrogen pulsed laser beam (700ps pulse duration), which released photoelectrons from the metallic cathode.

The anode signal is fed, through a high-pass filter with a high-voltage decoupling capacitor, to a fast amplifier with 10 GHz bandwidth. The amplifier output is digitized by a 1 GHz bandwidth, 10 GS/s sampling rate, *LeCroy* WavePro 7000 oscilloscope. Independent measurements of the average current induced on the cathode were performed with an electrometer custom-made from a commercially available integrated circuit, whose output is read by Keithley 2000 IEEE-488 programmable multimeter.

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3. AUTOMATION AND ACQUISITION SYSTEM

3.1 System Requirements

In order to get a better understanding about the solution proposed, it is necessary to clarify which are the system requirements. It is possible to distinguish two different kinds of tasks which could be computer controlled: *experiment settings* and *data acquisition and analysis*. Besides being user friendly and versatile, the system should also address other requirements such as easy maintenance and upgrading.

3.1.1 Experiment settings

In the scope of this work, experiment settings may be understood as the parameters kept constant during one particular measurement and then possibly changed in another one, such as the laser beam frequency, voltage and gap thickness.

The laser beam must be turned on and off and have its frequency adjusted during the experiment. This task was made possible by means of manufacturer provided software. Although one may consider interesting to have this functionality integrated into the main program, in order to have all the processes centralized by the same controller, it was not considered a major issue, as it will be shown later.

The high voltage output must be changed every measurement and it can be done manually or via remote control by means of a GPIB bus. Although the high voltage supply was not far from the chamber, it was considered interesting to implement the remote control in order to shorten experiment time.

On the other hand, as the gap thickness does not need to be changed very often, the possibility of making this task computer controlled was totally discarded.

3.1.2 Data acquisition and data analysis

In this experiment, the oscilloscope and the multimeter are two instruments that acquire considerable amount of data. The oscilloscope already deals with data acquisition, but it does not store data conveniently. It can save one pulse at a time or the average of several pulses, but it can not store a fixed sequence of subsequent pulses. Since the information of individual pulses are important to statistical analysis, the system should overcome this limitation.

The electrometer output (in volts) is displayed in a programmable multimeter, Keithley 2000, which can make up to 1024 readings. If the system could also be connected to this instrument to receive data, it would be possible to improve experiment statistics that otherwise would not be possible if data were accessed directly from instrument front panel.

A first statistical treatment could also be done during measurement, but it is not a crucial requirement, since statistical results are not fed back to maintain the process of measurement.

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The fit analysis, on the other hand, is too complex to be performed during data acquisition. It must be treated separately**,** with special attention.

3.1.3 Other requirements

One major issue that one should always have in mind is the possible modifications and upgrades that the experiment may have over the time. Therefore, the program was expected to be versatile if, for example, instruments have to be changed or added.

Another feature one should take into account is making the system easy to use, even to whom with no programming skills. Also, the ability of displaying measurements online was added.

3.2 Solution and Results

3.2.1 Programming language

The programming language chosen was MATLAB® for several reasons: it offers support to instrument control via GPIB and it is fully compatible with the oscilloscope used. It also offers a Graphical User Interface (GUI) easy to program. Another advantage is its support for a wide range of instruments.

The software developed for this work, called *RPCLab*, should run on the digital oscilloscope, which have the same capabilities of a personal computer. When acting as the system controller, the oscilloscope will be referred to as the *controller*. The system user will be referred as the operator.

3.2.2 Voltage and laser control

The controller was connected to the high-voltage power supply through a *National Instruments* high-speed USB-GPIB bus (IEEE-488.2). The option of remote or manual mode operation can be easily selected by the operator. When operating in remote mode, the operator should specify an initial voltage, a final voltage and a voltage increment. Software prevents wrong or undesirable input values, such as too high final voltages and voltage increments. The controller permits checking both the stability of the applied voltage before starting a new set of measurements and whether the high voltage was properly decreased or not in case of restarting or closing the acquisition program.

Finally, as a compatible driver for remotely controlling the laser was not found, it was not yet integrated to the main program.

3.2.3 Data acquisition

As mentioned earlier, pulse data acquisition is performed and displayed by the oscilloscope, but it does not store data conveniently. Since internal data access to the digitalized pulses by other applications running on the oscilloscope was also supported, it was possible to give the controller the power to store data properly. The oscilloscope manufacturer software

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implements *ActiveX* objects to store data, settings and acquisition properties, allowing another application that can manage *ActiveX* objects, such as MATLAB®, to get oscilloscope full control.

In order to allow the controller to have access to the multimeter readings, this device was put on the same USB-GPIB net connected to the high-voltage power supply. Not only the controller receives and stores readings, but also displays it graphically. Since there was no need of simultaneous acquisition of pulse and current, the controller accomplishes both of these tasks sequentially.

3.2.4 Graphical User Interface (GUI)

This section aims to explain the Graphical User Interface and it will aid to understand how RPCLab works from the user's point of view. The main window is shown in Fig. 2.

The two figure controls on the top display the acquisition plots. The left one plots pulse data from oscilloscope and the other plots the current over time. The command “Figures” also displays axes labels with physical units. Other capabilities, such as zoom in/out or printing, were also inherited from GUI. In the example shown in Fig. 2, the left figure displays five noise pulses and the right one is empty, since current measurement option is not selected.

There are two modes of operation relative to high-voltage control: *remote control* and *manual control*. When manual control is selected, RPCLab is not connected to the high-voltage supply, so it must be controlled manually. In the example shown, this mode of operation is set. If the controller is operating in manual mode, the operator can switch to remote mode, but the controller will only attempt to connect on the next measurement. If it is operating in remote mode, it can be instantaneously changed to manual mode by simply selecting the radio GUI control.

Before starting the measurement, the operator must specify all relevant parameters such as: environment temperature, pressure, gap thickness, maximum voltage, initial voltage, final voltage and increment voltage (when in remote control). Once all these parameters are defined, the program displays the electric field (V/cm) and reduced electric field (Td) to be applied. Hereafter, the status panel is upgraded. When selected, a radio GUI control enables to keep electric field constant when gap thickness or initial voltage is changed.

The controller also allows the operator to choose whether voltage and current pulses will be acquired simultaneously or not. The operator should always specify the number of acquisitions. In the case of pulse measurements, the maximum voltage readings are limited to 100, in order to avoid memory overflow. As mentioned before, current readings are limited to 1024.

After all the parameters are defined, measurement may be started by clicking the “Measure” button. The controller will ask the operator to shut off the laser in order to measure background noise and then to shut it on to start measurement. After a measurement has finished, data is stored in the user specified directory and the status panel is upgraded to show the actual high-voltage.

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When "Restart" button is clicked, all the parameters return to their default values. In case of being in remote mode, the controller decreases the high-voltage to its lowest level.

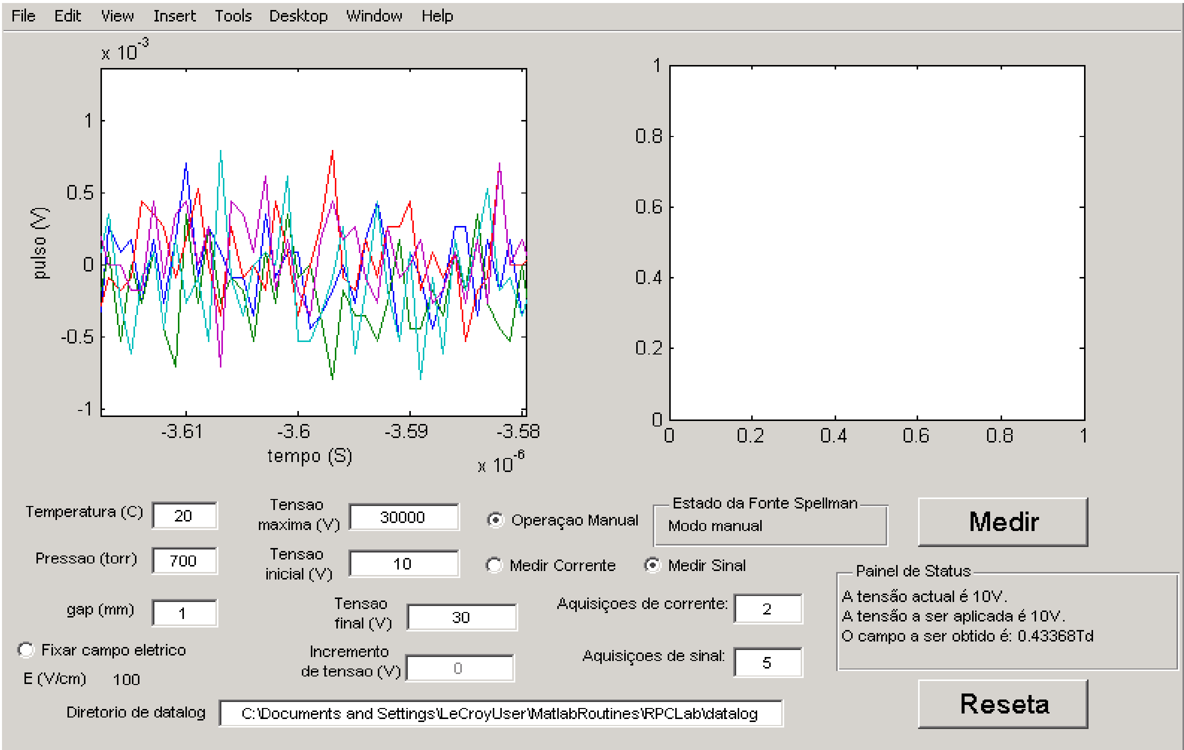

Figure 2: ***RPCLab main window.***

4. CONCLUSIONS

The main goal of the present work, related to the instrument control and data acquisition software used in an experimental setup to study electron transport parameters in gases, was successfully achieved. Also, the expertise acquired within this specific project will contribute to other experiments in which computerized instrumentation may be needed.

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