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AUTOMATED SPECTROMETER INTERFACE FOR MEASUREMENT OF SHORT HALF-LIFE SAMPLES FOR NEUTRON ACTIVATION ANALYSIS

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ABSTRACT

In this paper a source positioning system was developed, based on a HPGe detector coupled to a Canberra DAS 1000 data acquisition system and Canberra's GENIE2K software and libraries. The system is composed of a step motor coupled to an Arduino Uno microcontroller, which is programmed using C language to allow for a source-detector distance between 0.3 and 20 cm - both components are coupled to a PC computer using the USB interface.

In order to allow automated data acquisition, two additional pieces of software were developed. The first one, a Human-Machine Interface (HMI) programmed in Visual Basic 6, allows the programming and monitoring of the data acquisition process, and the other, in REXX language, controls the data acquisition process in the background. The HMI is user-friendly and versatile, so that the even rather complex data acquisition processes may be easily programmed. When the experiment scheme is saved, two files are created and used by the REXX code to control the acquisition process so that the data acquisition is automatically stopped and saved after a user-defined time, then the source is repositioned and data acquisition is cleared and restarted. While in the present stage the system only offers three distinct source positions, finer source-position adjusting is under development. In its present configuration the system has been tested for stability and repeatability in all three positions, with an excellent performance.

1. INTRODUCTION

The Research Reactor Center of IPEN-CNEN/SP has been developing research on Neutron Activation Analysis (NAA) for over 40 years. Approximately 10 years ago, stimulated by technological developments as high resolution detectors and digital electronic systems, the neutron activation laboratory started aiming at measuring elements that were hard to precisely detect due to limitations imposed by older equipment.

One way to achieve this goal is to automate data acquisition, reducing operator interference and avoiding errors from routine analysis procedure. In this sense, to solve the problem for the automatic measurement of several radioactive samples, a sample changer and suitable software were developed [1].

In this work, the problem is related to the precision of measurement with short half-lives (30s $< T_{1/2} <$ 10h), where the initial activity is high and decreases rapidly with time. The imprecision for measurements of samples in these conditions is related to the high initial counting rate which leads to loss of count due to dead time of the whole system, and to the pile up of pulses in the detector [2].

Dead-time losses are most noticeable in the Analog-to-Digital Converter (ADC) component of the acquisition system, typically ranging from 60 to 600μs, and in less severe cases it may be effectively corrected by increasing the total detection time. The pulse pile-up, where two or more distinct photons interact with the detector almost simultaneously, however, is much harder to address. Possible solutions to this issue include the use of a pulse generator or the inhibition of the pulse conversion in the ADC, but none of these is sufficiently effective for high counting rates in germanium detectors.

A possible and useful solution for the optimization of measurements of short half-life nuclides is the variation of the source-detector distance. When performed manually, though, this procedure requires a lot of user intervention and is rather error-prone.

Thus, a system was developed that automatically controls source-detector distance, consisting of a physical structure to hold the sample, a step motor and associated electronics, coupled to a microcontroller. Resident software, developed in the C programming language, connects to a PC via an USB interface and allows the control of the sample positioning, which may be performed manually or by means of an automatic setup. The test system is composed by a germanium detector coupled to a Canberra DSA1000 Digital Signal Processing system [4] and to the same PC, where it is controlled by the Genie2k acquisition software [5,6].

2. GENERAL SYSTEM DESCRIPTION

In this section both the initial structure and the final project will be presented.

2.1. Initial Structure

The initial structure of the system was composed by a sample positioning system (nicknamed “elevator”), assembled in a previous work, coupled to a driver for the step motor, to an Arduino Uno microcontroller, and a USB interface for the PC connection. The sample positioning system accepts four different predefined sample-detector distances.

Data acquisition is performed by Canberra’s Genie2k software coupled to Canberra’s DSA1000 DSP module, which couples to a PC by means of a USB connection.

In these conditions, both the data acquisition and the sample position change are manually controlled by an operator, working in two distinct and separate software packages. The operator, however, won’t need to physically interact with the source, and the source will be precisely positioned as instructed in the control software. On the other hand, this process is quite error-prone, especially due to the need to operate two separate programs, and there is a loss of potential counting time while the operator stops data acquisition, saves the spectrum, instructs the system to change the source position, clears the spectrum and starts a new acquisition in the new position.

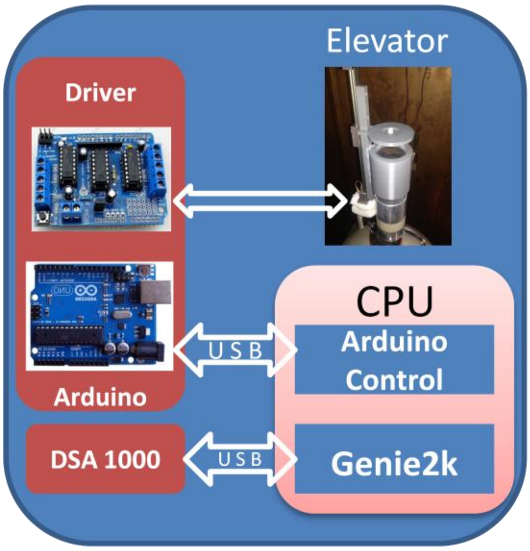

Figure 1: Initial structure of the sample positioning system

2.2. Automatic System Design

For the system to fulfill the requisites for optimal short-life measurements, it must be programmed to avoid human interference during the process, reducing the margin for operational errors and delays.

On the other hand, as there was a previous infrastructure to be used, the new software had to be able to interact with the existing software, at the same time interfacing with the source positioning software (running in the Arduino controller) and with the Genie2k data acquisition software, to manage the data acquisition process. This requires the generation of a set of two distinct data files, one for the *programming* and the other for *control data*.

This final system design can be observed in figure 2.

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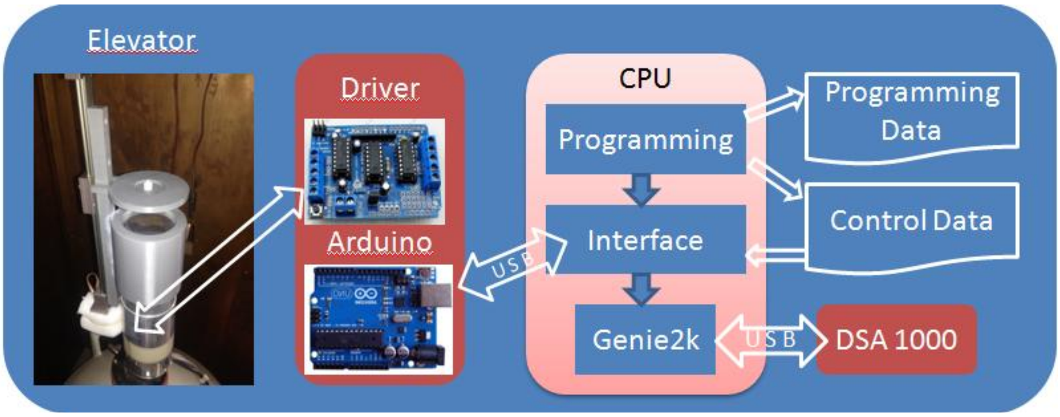


Figure 2: System design after the implementation of the automation process.

2.2.1. Software Programming Tasks

Developed in Visual Basic 6, the software allows programming a set of measurements. The interface is intuitive, with five windows that open sequentially, as seen in figure 3:

- **The main window** (fig 3a) and the **general guide window** (fig. 3e) open in the software initialization, giving the required instructions and allowing for the general definitions, as the working folder;
- **The work window** (fig. 3b) opens after the folder is selected and defined, and allows access to the programming and listing windows;
- **The programming window** (fig. 3c): When opened, it already shows the working folder. In it the operator must select whether to operate in real time of live time mode; afterwards, the number of measurements and the conditions for each measurement are defined – for each measurement, the source position, the acquisition time and the number of repeated acquisitions in this position must be defined. After the end of these definitions, the operator must click on the “finish” button, generating the *programming* and *control data* files.
- **Program listing window** (fig 3d): During the programming steps, this window is fed to guide the operator, who will be able to change the programming at any time.

After finishing the programming of the experiment, the operator has only to select the menu item “Automatic➔execution”, in the main window, to finish the programming step.

2.2.2. Task Performed by the Interface

The interface software was developed in REXX language, as it works with Genie2k’s libraries and accesses rather easily the serial ports of the PC. It is responsible for automated data acquisition, as defined in the programming software. It can be assessed either manually or directly from the programming software screen. Besides, it is a batch program that runs in the background, allowing the PC to be used for other tasks during its execution.

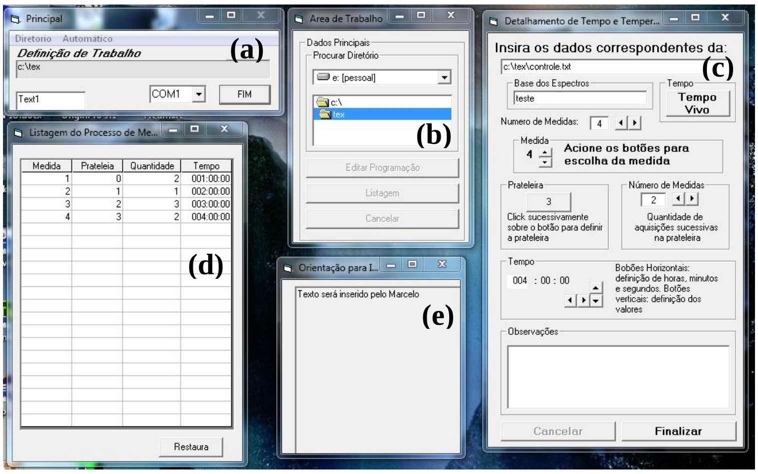


Figure 3: General view of the Human Machine Interface:a) Main window; b) Folder listing; c) Programming; d) Program listing; e) User Info

In these conditions, this software may be divided in four operational stages:

- **Preparation**
  Is the stage where the the Arduino communication interface and the control data file are configured.
- **Header reading**
  Where data common to all spectra, as file basename, time (live/real) and number of measurements, are gathered.
- **Spectra acquisition**
  In this stage, which is repeated for each sample position, the software reads the control data for source position, number of repetitions in this position, and counting time. If the user requested more than one measurement in that position, the process will be repeated for as many times as requested; otherwise, the system will move on for the next source position. After each acquisition a spectrum file is generated in the selected folder.
- **Acquisition ending**
  After the acquisition program is completed, the control data file is closed and both the MCA and the HMI are closed, rendering the system ready for a new programming and acquisition. Details of the algorithm are shown in Fig. 4.

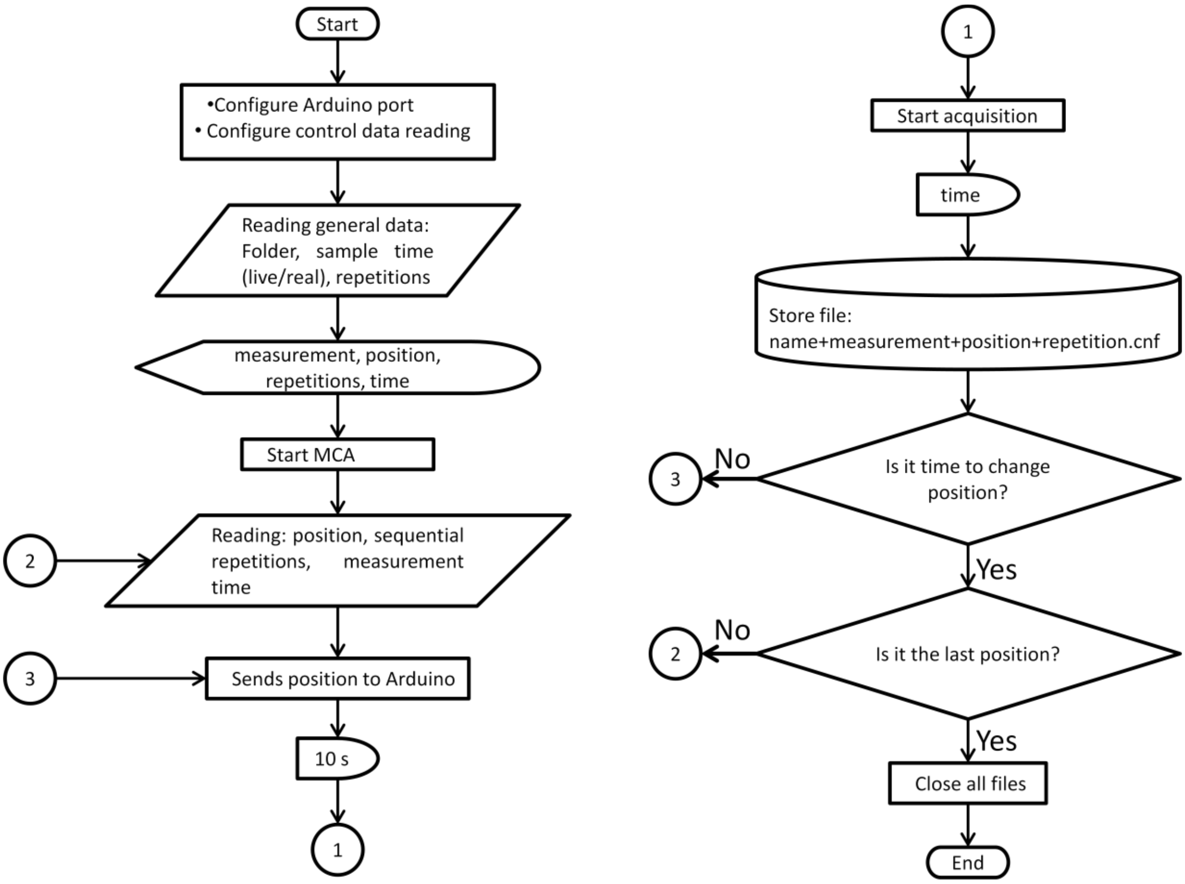
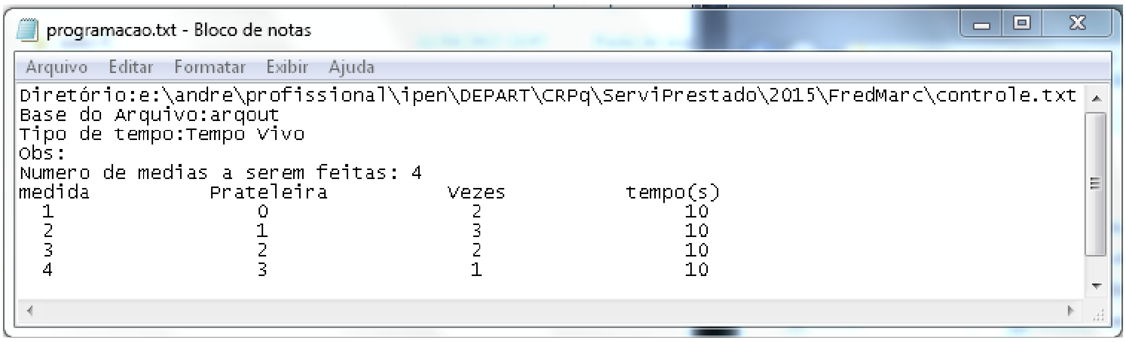


Figure 4: Fluxogram of the HMI program execution.

During data acquisition, the operator may see the real-time spectrum in the MCA, besides observing, in a window opened by the HMI, the stage of program execution. It is also possible to see the whole program selected by clicking on the “programming data” file generated by the HMI (see Fig. 5).


programacao.txt - Bloco de notas

Arquivo Editar Formatar Exibir Ajuda

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Diretório:e:\andre\profissional\ipen\DEPART\CRPq\ServiPrestado\2015\FredMarc\controle.txt
Base do Arquivo:arqout
Tipo de tempo:Tempo Vivo
Obs:
Numero de medias a serem feitas: 4
medida          Prateleira          Vezes          tempo(s)
  1                 0                 2               10
  2                 1                 3               10
  3                 2                 2               10
  4                 3                 1               10
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Figure 5: Data recorded in the programming data file

3. CONCLUSIONS

As shown in the present paper, an existing acquisition system, composed of a HPGe spectrometer and a sample positioning device based on an Arduino microcontroller, have been restructured.

In the initial system, the sample positioning device and the spectrometer were two standalone systems, so two software instances, a HMI in Visual Basic 6 for the programming of the acquisition stages, and a second one in REXX that, using Genie2k’s libraries, performs the interfacing with the acquisition system.

The system was tested by repeated measurements with a ^{60}Co source in four different positions, with satisfactory results.

In the future, it is intended that the source may be positioned in any position, and not only in four predefined positions.

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