2013 International Nuclear Atlantic Conference - INAC 2013
Recife, PE, Brazil, November 24-29, 2013
ASSOCIAÇÃO BRASILEIRA DE ENERGIA NUCLEAR - ABEN
***ISBN:* 978-85-99141-05-2**

DEVELOPMENT AND INSTALLATION OF AN AUTOMATIC SAMPLE CHANGER FOR NEUTRON ACTIVATION ANALYSIS

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ABSTRACT

A Programmable and Automatic Sample Changer was built and installed at the Neutron Activation Analysis Laboratory of the Nuclear and Energy Research Institute – IPEN-CNEN/SP. This Automatic Sample Changer allows the fully automated measurement of up to 25 samples in one run. Basically it consists of an electronic circuit and C++ program that controls the positioning of a sample holder in two axes of motion ("X" and "Y"). Each sample is transported and positioned, one by one, inside the shielding coupled to a high-purity germanium (HPGe) radiation detector. A Canberra DSA-1000 Multichannel Analyzer coupled to the Genie 2000 software performs the data acquisition for analysis of the samples. When the counting is finished the results are saved in a hard disk of a PC computer. The sample is brought back by the sample holder to its initial position, and the next sample is carried to the shielding. The Sample Changer was designed and constructed at IPEN-CNEN/SP by employing national components and expertise.

1. INTRODUCTION

Neutron Activation Analysis (NAA) is a quantitative analytical technique with application in several disciplines such as archaeology, geochemistry, biology, environmental monitoring, etc. Due to its sensitivity, accuracy and precision, the technique is suitable for analyzing many different types of samples.

Is this technique, a sample is bombarded with neutrons causing the elements to form radioactive isotopes. The radioactive emissions and radioactive decay paths for each element are well known. Using this information, it is possible to study spectra of the emissions of the radioactive sample, and determine the concentrations of the elements within it.

NAA studies are performed at the Neutron Activation Analysis Laboratory (LAN) of the Nuclear and Energy Research Institute – IPEN-CNEN/SP [1]. This laboratory is equipped with eleven measurement systems that are used twenty-four hours a day by a large number of researchers and students. To increase the number of analyzed samples it is necessary to maximize the use of the nuclear instrumentation. One way to increase the counting capacity of multichannel analyzers is to use multiple detectors and a mixer-router; another possibility

is to develop an automatic sample changer [2] that can be used during the night and week-ends with little or no attention from the operator.

The automatic sample changer described here is suitable for use with the majority of the existing gamma spectrometry systems which utilize germanium lithium (GeLi), high-purity germanium (HPGe) or sodium iodide (NaI) detectors in vertical mode. At LAN, the measurement system consists of a HPGe detector linked to a Canberra DSA-1000 Multichannel Analyzer coupled to the Genie 2000 software. This system can hold 25 samples in line at a time, and offer manual or automatic, single or repeated, modes of operation. It is designed for large volume, low activity environmental samples of various sizes up to maximum dimensions of 40 mm diameter and 60 mm high.

2. GENERAL DESCRIPTION OF THE AUTOMATIC SAMPLE CHANGER

The automatic sample changer consists of two distinct sections, the sample container and the counting station, separated by 50 centimeters. Transport between these positions is made through a mechanical arm, driven by two stepper motors (X and Y) and controlled by an electronic circuit. The opening and closing of the shielding are controlled by pneumatic control. The detector is coupled to the shielding and connected to the acquisition system. The data are sent and saved to a microcomputer which also controls the electronic system of the sample changer. A block diagram of the automatic sample changer is illustrated in figure 1. A view of the complete system can be observed in the figure 2. The following sections give details of the main features of the system.

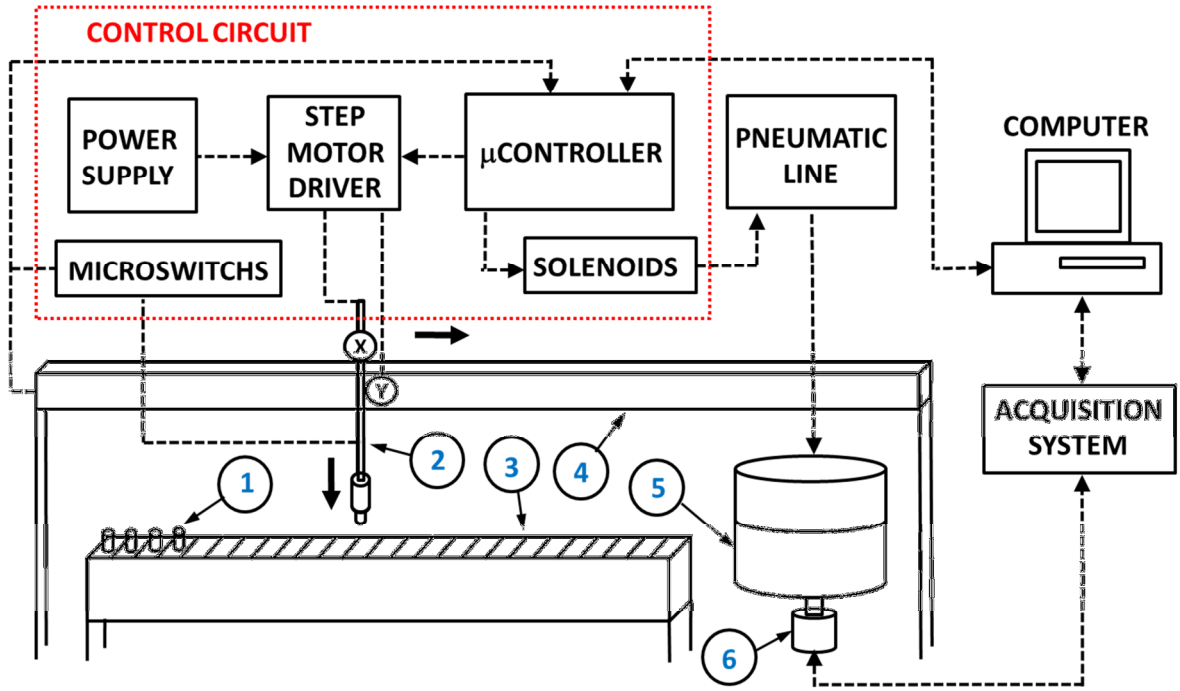

Figure 1: Block diagram of the automatic sample changer (1 - sample tubes; 2 - mechanical arm attached to the X and Y step motors; 3 - sample container; 4 - sample carrier; 5 - shielding; 6 - HPGe detector).

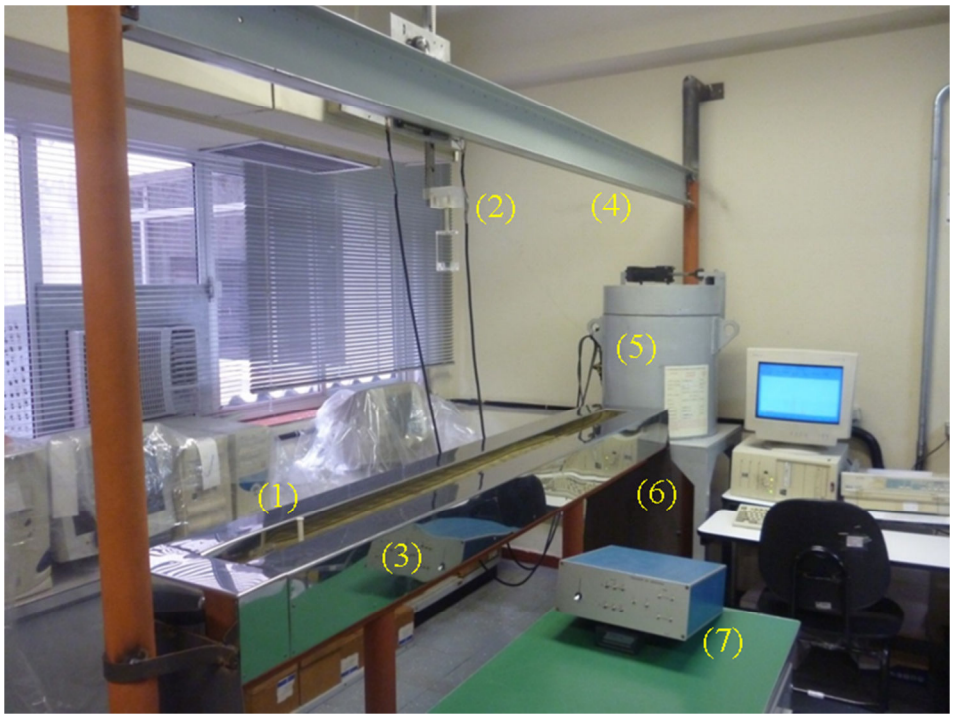

Figure 2: Automatic sample changer installed at LAN. (1 - sample tubes; 2 - mechanical arm attached to the X and Y step motors; 3 - sample container; 4 - sample carrier; 5 - shielding; 6 - HPGe detector; 7 – control circuit).

2.1. Sample Container

The container (3) of samples is 2.20 m long and 0.33 m wide. It is made of stainless steel and internally filled with lead bricks. Inside the container is installed a PVC base able to store the 25 samples (1). Each sample is installed in an acrylic sample holder.

2.2. Mechanical Arm

The mechanical arm (2) is constituted of two stepper motors to allow the drive mechanism in the x and y axes. At the lower end of the mechanical arm is adapted a device called the "catcher". This device allows to pick and to drop the sample holder during the beginning and end of the analysis, respectively. The stepper motors are controlled by the control circuit. The approximate time to take a sample from the sample container to the shielding is of 60 seconds.

2.3. Sample Carrier

The sample carrier (4) consists of a set of rack-gear assembly driven by the X motor. This mechanism allows precise positioning of the mechanical arm in the horizontal direction along the sample container and the shielding.

2.4. Shielding

The shielding is a cylindrical container constituted by a lid and a base of lead (5), whose opening and closing is controlled by an electrical-pneumatic circuit. During a measurement, the electronic circuit activates a solenoid valve which in turn makes the compressed air lift and rotate the cover of lead, opening the lid of the shielding. At the bottom of the shield is coupled the HPGe detector. In this case, the sample holder is positioned just above the detector. At the end of the counting time selected by the operator, the mechanical arm removes the sample holder of the shielding and moves it to the initial position.

2.5. Electronic Circuit

The electronic circuit controls the X and the Y stepper motors, commands the solenoids that open of the shielding cover, make the communication between the microcontroller and the computer and include the power supply circuits of the sample changer. The microcontroller PIC16F877 [3] communicates with the computer via serial communication RS-232. The microcontroller receives initial position information from the microswitchs and drives the stepper motors and solenoids to transfer the sample holder into the shield. The power supply provides voltage to the entire system of the sample changer.

2.6. Acquisition System

A block diagram of the acquisition system is illustrated in figure 3. The data acquisition system consists of a full featured 16K channel integrated Multichannel Analyzer Canberra DSA-1000 operating through the Genie 2000 spectroscopy software [4]. This system processes the signal from the HPGe detector and stores the resultant digital information into the memory of PC via a USB hub. This acquisition system permits the spectral display and manipulation, basic spectrum analysis and reporting. A C++ program using the libraries of the Genie 2000 lets choose how many samples will be analyzed and their counting times. Communication is done via the RS-232 serial interface of the computer with the control circuit sample changer.

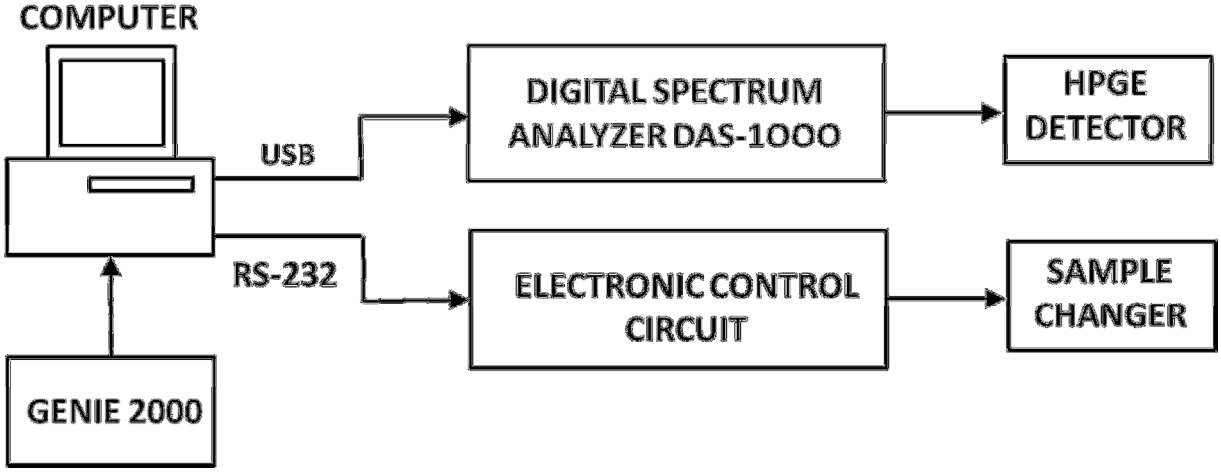

Figure 3: Block diagram of the acquisition system of the automatic sample changer.

3. CONCLUSIONS

A new Programmable and Automatic Sample Changer was built and installed at the Neutron Activation Analysis Laboratory of IPEN-CNEN/SP. This Automatic Sample Changer allows the fully automated measurement of up to 25 samples in one run. This system is not available commercially and has been constructed in our electronic and mechanical workshop. Currently, the sample changer is in initial tests and the results are satisfactory.

ACKNOWLEDGMENTS

Partial financial support for this work was provided by FAPESP.

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