

SOFTWARE FOR NAA SAMPLE CHANGER CONTROL

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ABSTRACT

In CDTN/CNEN laboratories, the neutron activation analysis (NAA) is an analytical technique routinely employed. The irradiation is performed in the TRIGA MARK I IPR-R1 reactor. After irradiated, the samples depend of an operator to be changed, creating a bottle neck in the process. To optimize the whole process, an automatization of the changing samples is necessary. In order to achieve this goal, it was developed a software to control a sample changer under construction at CDTN laboratories. Two programs, running in two different environments, manages the entire acquisition process and performs all activities necessary to move the motors to positioning the samples and control the vacuum to grip the vials. The high level routine communicates with Genie 2000 software to control a Canberra Multiport II, while a low level program controls the physical assemble.

1. INTRODUCTION

The neutron activation analysis (NAA) is a well-known analytical technique. At CDTN/CNEN the irradiation is performed in the TRIGA MARK I IPR-R1 reactor. NAA's depends on radionuclide decay time, which may be long, and the time necessary to perform the gamma spectrometry. Some samples are submitted to gamma counting for 1 hour each, others for 3-5 hours, and overnight. Moreover, the irradiation day is scheduled according to operator availability for changing samples all day long. It means that on weekends, for instance, it is not easy to find someone available for this task. With this limitation, the counting system's capacity is not fully used.

The automatic changing of samples comes as a solution that improves the quality of the results, process speed as a whole and allows an unattended operation during the sample counting routine. Automation also makes the NAA more competitive with other analytical techniques. Each laboratory has its own singularities that depends on the vial sample size, geometry, mass, plastic type and detector shield characteristics as well. Some laboratories have developed its own solutions as well [1],[2].

In order to achieve this goal, it was developed a software to control a sample changer that is under construction at CDTN laboratories. The software is composed by two parts, running in two different environments. In the PC, a high level program in Visual Basic version 6 (VB6) manages the entire acquisition process, sends the commands through USB to an external

microcontroller to change the samples, controls the external multichannel analyzer and saves the counting results. Besides the operator's window, there is also a maintenance window, through which the operator can interact with the sample changer, moving it to specific positions and changing parameters like maximum speed or acceleration, for instance. The microcontroller, programmed in C, performs all activities necessary to move the motors to positioning the samples and manages the vacuum to grip the vials.

2. THE SAMPLE CHANGER SYSTEM

The vials used have 3 different lengths (Fig.1), but the same diameter. They are small and light, but very slippery, due to the plastic material employed in its fabrication. To maintain the reproducibility of the vial's position in the detector, an acrylic template used over it. This increases the difficult to pick up the lowest vial. To overcome this issue, a vacuum cup system was chosen to grip the vial (Fig.2).

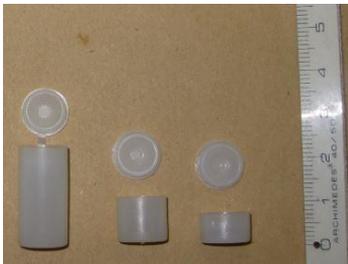


Figure 1: The 3 vials sizes.

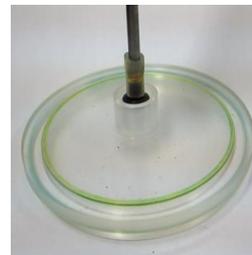


Figure 2: The suction cup gripping the lowest vial.

The mechanical part of the sample changer system under construction at CDTN is a Cartesian system with 3 axes driven by 3 step-motors. The vials are picked up by a small cup in which vacuum is applied when a vial is detected in the Z axis way. The vials are distributed in a matrix tray that moves only in the Y direction (Fig.3)..

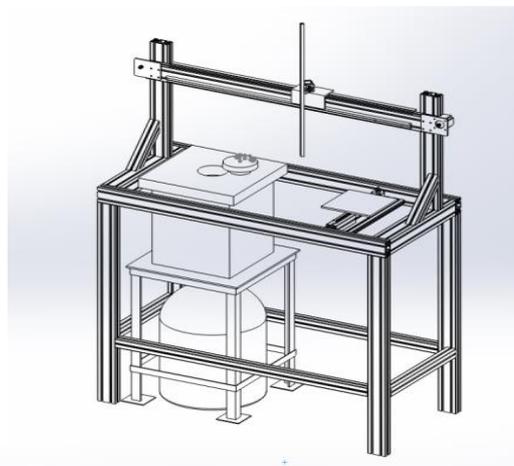


Figure 3: Perspective view of the whole mechanical system arrangement.

The mechanical system is controlled by a Microchip's PIC168F4550 [3], programmed in C (CCS version) and has all the necessary routines to receive commands and move each axis, with specific acceleration and speed for each one (Fig.4).

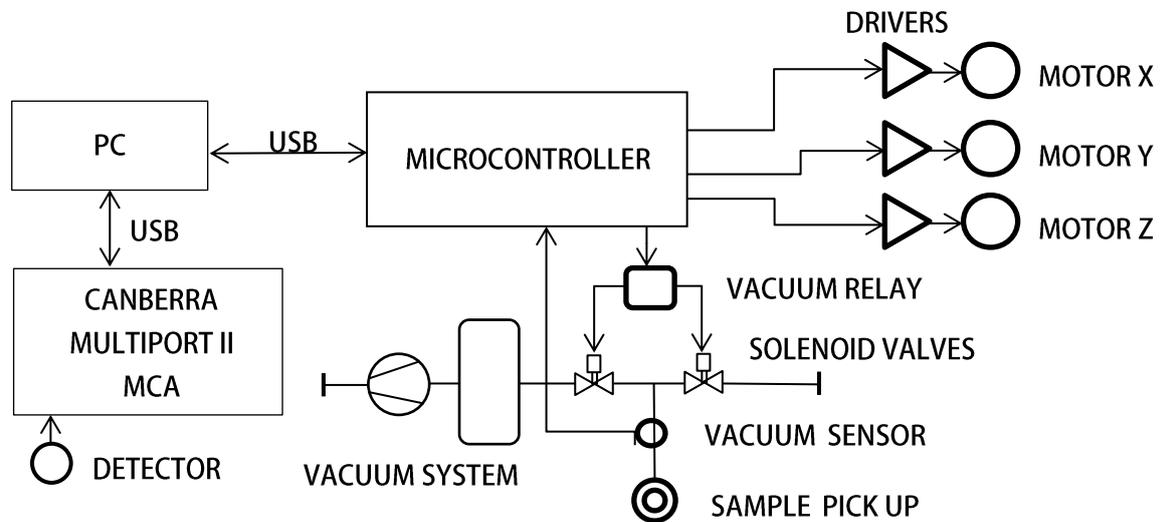


Figure 4: System block diagram.

3. THE SOFTWARE

The microcontroller was programmed in 'C' language compiler of CCS Company [4]. It performs the acceleration calculation and has a set of commands that helps in the development stage and in the maintenance situation. Through USB cdc mode, each motor axis can be moved independently to a desired distance, the maximum speed can be set, the vacuum can be turned on/off and even composed commands like "take sample XX and put it in the position to count" or "remove the sample" can be executed. It takes care also of the sample height detection. The acceleration routines are based on the Austin's algorithm [5].

The vacuum of the pickup is also previewed to be monitored in order to detect an abnormal situation like vial lost or leakage.

To integrate the Genie 2000 with a custom program there are some approaches: one can use the S561 REXX package [6], use the S560 Programming package [7] or the simplest, use the available dlls in the "exefiles" of the Genie installation folder. This last one was choose, due to its simplicity and easy integration with VB6 language.

The PC runs a VB6 program which sends commands to the microcontroller specifying which sample should be moved. All the process is done with handshaking, minimizing error synchronization. After it receives the "ok" from the microcontroller it starts the Canberra Multiport II MCA counting and waits until it finishes. The counting time and the number of samples to be counted can be preset by the operator in the main program screen. After the count stage, the spectrum is saved and the sample is removed from the detector, initiating a new cycle for the next sample, until the last one is processed. This process can be interrupted whenever it is necessary.

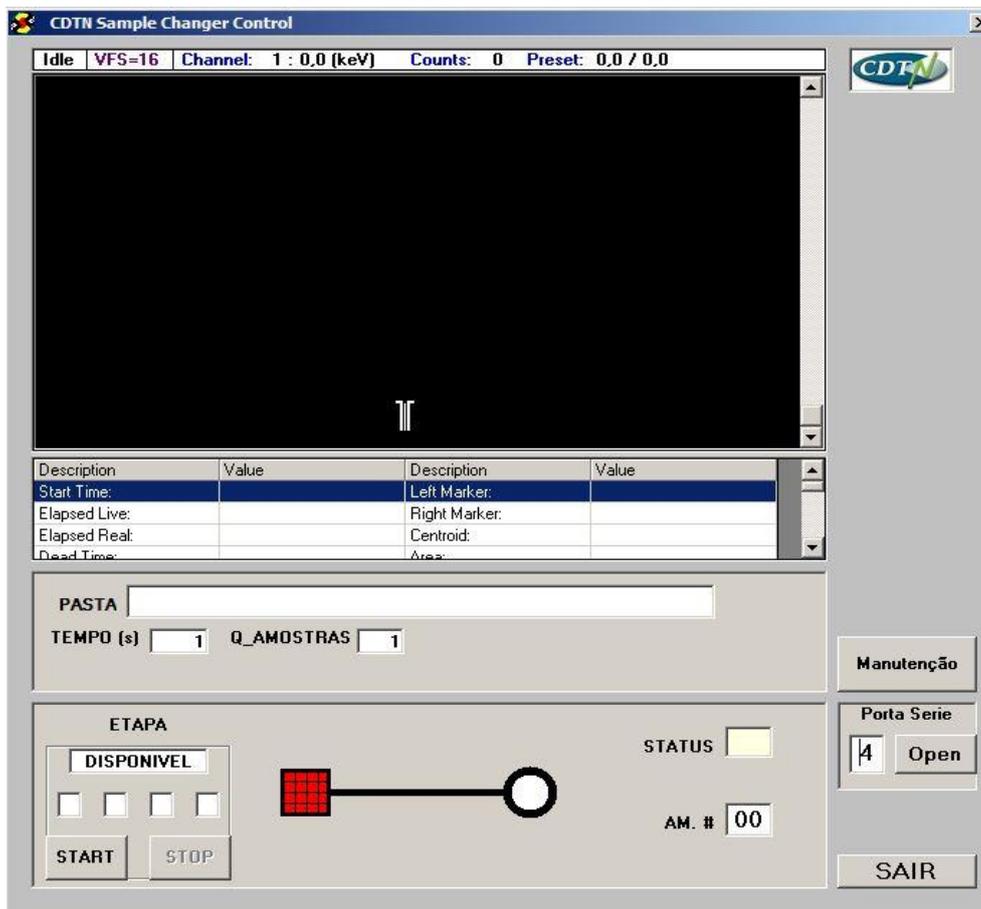


Figure 5: The program's main window.

In the program's main screen (Fig.5) there is a graphical animation showing which cycle phase is running. It is useful to help the operator to know where the process is, giving him more confidence. The spectrum is also showed in real time, allowing an observation of the counting evolution, helpful to detect unexpected results or abnormal situations. It was designed to be a clean and operator's user friendly interface.

The commands to the Multiport II MCA [8] are done using Genie2k dlls, instead of REXX language routines as many sample changers do [1],[2],[9]. So, the start, stop, save and display functions regarding the MCA are performed using the dlls of the Genie's "exefiles" folder, following the S560 Programming Library Manual [7], much like in the Excel2Genie [10] new version program in which this author has collaborate [11].

Since we use a k-zero procedures, the spectrum is saved as it is collected, in raw form, with no calculation or any manipulation.

The VB6 program has a secondary window, called from the main window, dedicated to maintenance (Fig.6). In this window one can give direct commands to the microcontroller to execute complete or single axis movements and monitor its status. This will be helpful for maintenance purposes too, after the development stage.



Figure 6: Secondary window, for maintenance.

To avoid deadlock loop in the VB6 program, a timer was used to create a state machine system. Each 300ms a case structure is called and the current state is checked. If it is finished, control is passed to the following phase. In a very simplified form, Figure 7 depicts the flow diagram of such implementation. This loop is executed for each sample to be counted.

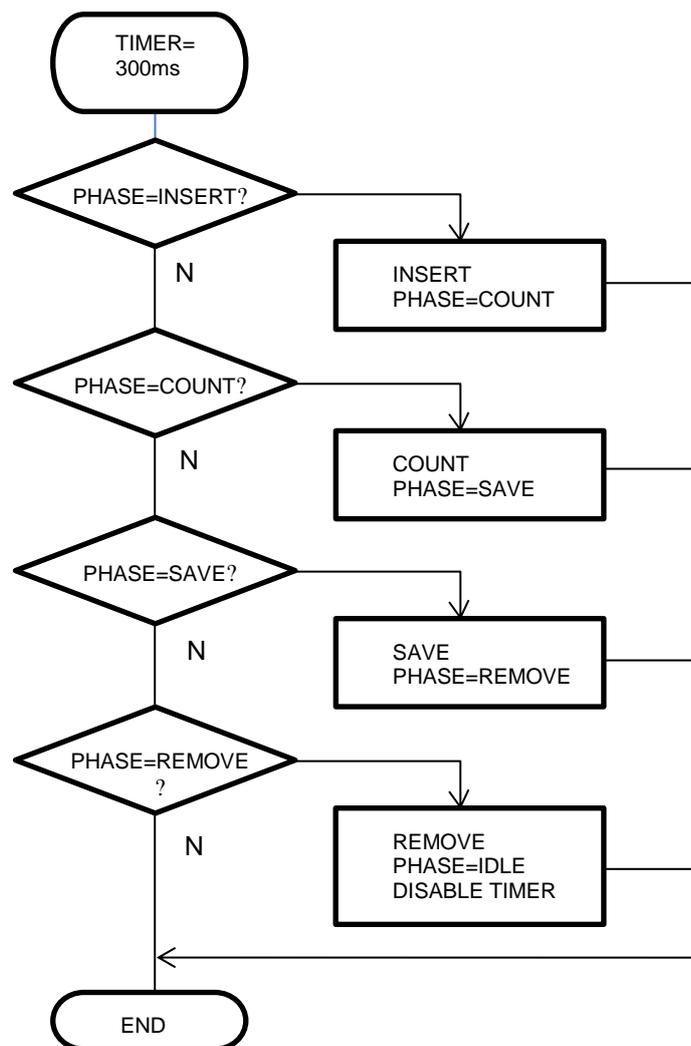


Figure 7: Switch case structure.

The whole software system was tested in the bench. Since the mechanical assembly is not yet fully mounted, the motors for X and Y axis were tested floating, with no load. However, the Z axis has completely tested, including the vacuum gripper. The control of the Multiport II and the commands for the microprocessor were fully tested also.

4. CONCLUSIONS

The software developed shows to be efficient, even being simple enough to do the essential tasks. The VB6 program has a clean interface with the operator, showing the most important parameters and presenting the minimum of the necessary information to avoid overcharging the operator's attention. This is a very important aspect during the implementation phase, when the operator familiarizes itself with the new system.

The microcontroller was capable to control the motors' acceleration and position, with minimum overhead and with enough accuracy.

The system is fully known, since it was developed in-house, allowing any modification to be feasible and enabling an independent maintenance.

The final tests of the whole system should occur as soon as the mechanical structure is ready, foreseen for the next three months. Then some software settings and refinements would be necessary.

Once completed, it is expected that the sample changer will improve the NAA process, increasing the number of samples analyzed, with better analysis control and consequently better results, and minimizing operator's exposition to radiation.

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6. REFERENCES

1. André L. Lapolli, Casimiro S. Munita, "Development of a System Using the Library of the Genie Spectroscopy Software and exchange of Samples", 2011 International Nuclear Atlantic Conference - INAC 2011, ISBN: 978-85-99141-04-5
2. Cláudio Domienikan, André L. Lapolli, Roberto M. Schoueri, Edson G. Moreira and Marina B. A. Vasconcellos, "Development and Installation of an Automatic Sample Changer for Neutron Activation Analysis", 2013 International Nuclear Atlantic Conference - INAC 2013, ISBN: 978-85-99141-05-2
3. "PIC18F2455/2550/4455/4550 Data Sheet", Microchip Technology Inc., (2006), <http://ww1.microchip.com/downloads/en/devicedoc/39632c.pdf>
4. "CCS C Compiler Manual", Custom Computer Services, Inc. (2015), <https://www.ccsinfo.com/>
5. David Austin "Generate stepper-motor speed profiles in real time", EE Times-India, eetindia.com, (January 2005)
6. "S561 Batch Tools Support Reference Manual", Canberra Industries, Inc.
7. "Model S560 Genie™ 2000 Programming Library V3.2 User's Manual", Canberra Industries Inc.,
8. "Multiport II Multichannel Analyzer – User's Manual", Canberra Industries Inc., (2003)
9. S. Landsberger, K. Jackman, L. Welch, "Neutron activation analysis using Excel files and Canberra Genie-2000", Journal of Radioanalytical and Nuclear Chemistry, Vol. 264, No. 1 pp.235–237, (2005)
10. Attila Forgács, László Balkay, Lajos Trón, Péter Raics, "Excel2Genie: A Microsoft Excel application to improve the flexibility of the Genie-2000", *Spectroscopic software Applied Radiation and Isotopes*, **Volume 94**, Pp. 77-81, (December 2014)
11. https://www.researchgate.net/publication/277713634_Excel2Genie_v11May2015