DESIGN OF A HYBRID CONTROL MODEL FOR AUTOMATIC SAMPLE CHANGERS AT SGAS/IAEA

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ABSTRACT

The International Atomic Energy Agency's (IAEA) Safeguards Analytical Services (SGAS) and their laboratories analyze nuclear material and environmental samples taken by Safeguards Inspectors in the field. The radiometry team at the SGAS's Environmental Laboratory (ESL) is responsible for detailed non-destructive sample screening prior any other analytical procedure, using a variety of radiometric techniques, such as gamma-spectrometry, X-ray fluorescence spectrometry and Secondary Electron Microscope (SEM). However, sample screening is very time consuming due the required measurement periods. Since working hours at SGAS are not 24/7, automatic sample changer systems can be used to save time and ensures the proper placement of samples on the detector. The ESL has a couple of sample changers (both, turntables and robotic arms) for gamma-screening, but since some of them have come to a certain age, the radiometry teams thinks of an open solution to replace old relay-based control units with new ones. Thus, a modern and flexible control unit was developed in LabView (Laboratory Virtual Instrumentation Engineering Workbench), to fulfill all the requirements needed as well for robotic arms systems as for turntable systems: starting/stopping a measurement, moving the turntable/robotic arm, monitoring intrinsic systems parameters, but also managing the data storage, barcode screening and reporting. To ensure best variability all these tasks can be mounted as subroutines to the controller. Thus, it consists of two main control units, one for sample changing and the other one for data handling. LabView has been proven to be a good choice was for the new sample changer's control unit, and it is able to control both, turntable sampling changers and robotic arms.

Keywords: Automatic Sample Changer, Control Unit, LabView, Machine Monitoring.

Presenting Author's biography

Katharina Breitenecker studied Technical Physics at the Vienna University of Technology, where she did her Master's in neutron activation analysis and her PhD in Nuclear Physics. She worked at the Nuclear Engineering Seibersdorf. After finishing her PhD, she started working at the International Atomic Energy Agency as a radiometry specialist. She really enjoys her rather contradictory working area, where she can combine both, mathematical modelling and practical work in the lab.

1 Introduction

The International Atomic Energy Agency's (IAEA) Safeguards Analytical Services (SGAS) laboratories analyze nuclear material and environmental samples taken by Safeguards Inspectors in the field.

The radiometry team of the Environmental Laboratory (ESL) is responsible for detailed non-destructive sample screening prior any other analytical procedure, using a variety of radiometric techniques, such gamma-spectrometry and X-ray fluorescence spectrometry and Secondary Electron Microscope for particle analyses. The team is able to perform other analytical procedures as well, like alpha spectrometry or liquid scintillation counting (LSC), but these methods require special (destructive) sample preparation.

The ESL owns a couple of different sample changers (both, turntables and robotic arms) for gamma-ray screening. However, since some of them have come to a certain age, the radiometry teams thought of an open solution to replace the old relay-based control units with new ones. Thus, a project was launched to develop a LabView (Laboratory Virtual Instrumentation Engineering Workbench) based control unit in a modular construction system that is able to run both sample changing types.

2 Sample Screening

As already mentioned, sample screening is performed prior any other analyzing method by gamma-spectrometry and followed by XRF-measurement. Performing not only qualitative data reduction but also quantitative, each different sample type needs a respective calibration file in order to compare samples amongst each other. However, the orientation when placing the sample on the detector has to be taken into account as well; it has always to be placed in the same way, otherwise results can not be compared.

Additionally, environmental samples usually hold a small amount of nuclides relevant for Safeguards. Thus, detection limits are very little and sample analyses can only be done after an appropriate measuring period, which is necessary for a good counting statistics. Thus, gamma screening for a single sample takes in the average 21000s. Since the working hours in the Agency's Laboratory are not 24/7, an automatic sample changer with a well designed control unit can be used to save time and ensures the proper placing of the samples on the detector.

Since the ESL is certified to ISO 9001 it is important to observe and record the detection system, too, by keeping trace of parameters like high voltage and power switch, current (detectors), pressure (vacuum systems), temperature (semiconductors), conductivity (preamplifier), power (XRAY-tubes), etc. Recording these parameters provides evidence in the case of an increase of the error propagation. Additionally these data are of importance for the system's operator to plan machine maintenance in time.

3 Sample Changers

Control units that are in charge of sample changers have either a robotic arm or a turntable to move a sample from the rack to the detector and back. If the rack is big enough, a certain amount of samples can be loaded, the measurement started, and the measuring period can be performed overnight. As long as the acquisition software is told how many samples are to be measured.

Thus, a good control unit consists of a visual interface (VI) that serves as a communication platform between the user and the data acquisition software. The operator enters data of importance for the acquisition (i.e. sample number, geometry, weight, measuring period) via the VI. When the measurement begins, the robotic arm or turntable takes one of the samples, opens the lid of the detector's shielding, places the sample in the correct position on the detector, closes the lid and gives a start signal to the data acquisition software to start the measurement.

In principle, each manufacturer for detector provides its own data acquisition and analyses software. Even there're still some home-made acquisition modules in use, it is strongly recommended to stick to the manufacturers program. However most of ESL's sample changers were home-made in the SGAS' mechanical workshop, thus a good solution for operating the controller has to be found by ourselves.

Since the old relay-based solution was to be replaced by a modern and flexible one a suitable programming language has to be taken to our requirements: flexibility by using exchangeable sub-routines, QA-recording of samples when loading, QA-recording of the detection-system itself, combining input-data from the VI with the measurement data and data recording. Since LabView (Laboratory Virtual Instrumentation Engineering Workbench) has already proven successful in former projects and because of its big flexibility in handling sub-routines and the ability to simulate data from external devices (such as temperature sensor, voltmeter, etc.) LabView became our choice.

4 LabView

LabVIEW is a platform and development environment which is commonly used for data acquisition, instrument control, and industrial automation on a variety of platforms. The execution of a main control unit (MCU) is determined by the structure of a

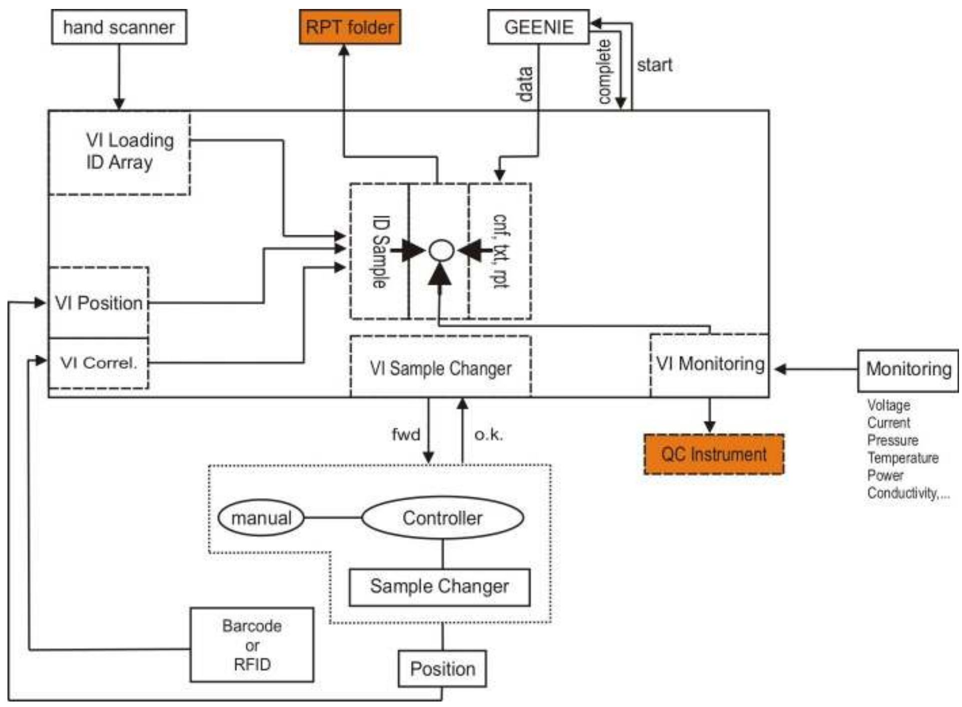

Fig. 1 Block Diagram of the Control Unit

raphical block diagram. Input data can be defined over visual interfaces (subroutines) and the programmer connects different function-nodes by drawing wires. These wires propagate variables and any node can execute as soon as all its input data become available. Since this might be the case for multiple nodes simultaneously, parallel execution is possible.

A LabVIEW subroutine (VI) has three components: a block diagram, a front panel, and a connector panel. The connector panel is used to represent the VI in the block diagrams of the (MCU), whereas controls and indicators on the front panel allow an operator to input data or to extract data from a running virtual instrument. However, the front panel can also serve as an interface. Thus, a virtual instrument can either be run as a program, with the front panel serving as a user interface, or, when dropped as a node onto the block diagram on the MCU, the front panel defines the inputs and outputs for the given node through the connector panel.

5 LabView Controller for Sample Changers

A Low Energy Germanium Detector (LEGe) and a turntable sample changer unit were subjected to develop a new control unit, which should later be used for all kinds of our sample changing. The controller of this turntable was programmed some 15 years ago, the mechanical parts of the sample changer are still in an excellent condition (regardless some high mortality parts).

However the respective control was realized by relay circuits. In the last year it was observed that the relay based controller became quite fault-prone.

The block diagram of the developed multi-usage sample changer control unit is shown in figure 1. The control units is divided into two main control units (MCUs); one for controlling the sample changer and therefore for moving samples, data acquisition and for additional QA measurements (**SampleChangerVI**); the other gathers all necessary files like input data by the operator (sample number, weights, bar code of samples and sample beakers) and the data achieved from the acquisition program and from all the sensors used for QA in order to assemble and report them organised in a special folder (**FileManagingVI**). Each sample is reported in folder named by its sample number.

Whenever a new measurement circle is initiated, the SampleChangerVI controls the turntable to move to the next. The lid of the Gamma-detector is opened and a special elevator system takes the sample beaker down to the detector itself. Then it gives a signal (see SampleChangerVI) to the acquisition software called GEENIE to start the measurement. When a measurement of a sample is completed, GENIE gives a signal back to the SampleChangerVI and the sample is loaded back to the turntable. The turntable moves to the next position and the measurement of the next sample can be started.

The acquisition software GEENIE reports three different files for each sample to the FileManagingVI: a cnf-file that contains the spectrum of the measured sample, a text file with the data information and a report (text)-file that contains the rough data for data reduction in a folder that has the same name as the as the sample itself. Each sample has a barcode and in future each sample beaker will be adjusted with a barcode or an RFID-chip. When a sample is placed into a certain beaker, sample number and beaker number are scanned and stored in a LoadingIDArrayVI. When the beaker is loaded to the turntable the beaker is scanned, and therefore the position number and all these information is stored in the IDSampleVI.

While a measurement is running the MonitoringVI observes relevant additional QA-information like room temperature. As long as the measurement runs, the room temperature in a certain time step is measured and stored in a graph. This graph is also sent to the FileManagingVI.

When all this information is given to the FileManagingVI a folder is created that is named after the sample number and stores is in the report archive.

6 LabView Subroutines

After defining both main MCUs subroutines (subVis) with different tasks were programmed. These include tasks like sample loading, sample positioning, communication to GEENIE, etc., or temperature and voltage for machine monitoring.

Both of the main MCUs remain the same for each detector sample changer combination. It is the subroutines and their mounting and unmounting gives that flexibility to the new controller.

In the next section two different LabView subroutines, one for the SampleChangerVI and the other one for the FileManagingVI are explained a bit more in detail.

This example for a machine monitoring VI runs on RT targets, even it was not specifically written for the LabView RealTime Module. First, a VI called GraphTempVI is presented. This graph collects data, i.e. the measurement of the room temperature in the lab, and draws a graph over the time. A XY graph and a FOR-LOOP is used to display the aquired temoerature values. The sampling period is specified by the user, as well as the number of points the operator wants to have to have displayed. The graph will display the data after all simulated or real data points have been acquired.

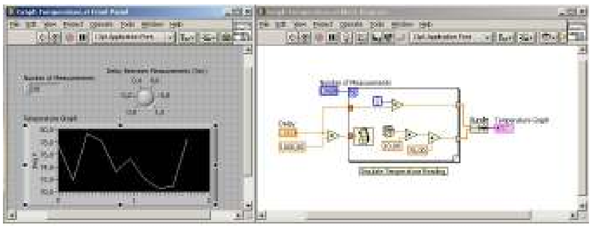

Fig 2. Graph Temperature

7 Conclusions

The multi-usage controller for all kind of sample changers has shown its great flexibility up to know. By the definition of two MCUs and the mounting of the necessary subroutines gives the controller the multi-usage desired. The possibility of simulating real devices like sensors has been proven of being a valuable instrument for code testing. Thus, the new LabView based controller is able to run both, turntable sampling changers and robotic arms.

8 References

[1] LabView Release 9a – Help Function