Nucl. Sci. and Tech, Vol.5, No. 1 (2015), pp. 33-38

Nuclear Science and Technology

Journal homepage: https://jnst.vn/index.php/nst

Research on development of multi - channel analyzer used for monitoring and warning radiation equipment

Nguyen Van Sy*, Dang Quang Thieu, Nguyen Thi Bao My

Hanoi Irradiation Center
Km 12, Route 32, Minh Khai, Bac Tu liem, Ha Noi
**Email: vansybn@gmail.com*

Abstract: The subject assigned to this paper presents research on development of multi-channel analyzer used for monitoring and warning environmental radiation equipment under the project KC.05.16/11-15 "Research on manufacturing equipment monitoring and warning radiation". In this thematic we have two subjects that need to be resolved such as: i) Designing spectroscopy amplifier block (AMP) duty pulse signals obtained about few hundred millivolts output from scintillation detector preamplifier, amplified as a few volts and the standard Gaussian pulses shaped to connect to the analog-to-digital converter. The spectroscopy amplifier block can change the gain by digital control to respond to the problem of automatic spectrum stability for multi-channel analyzer systems. ii) Designing analog-to-digital converter block (ADC) in accordance with the actual conditions, such as high stability, fast convertion time, high throughput, and it consums low energy. Selecting suitable microprocessor for fast connection ability, to operate reliably paired with the analog-to-digital converter into a multi-channel analyzer (MCA) serving analysis.

Keywords: *Multi-channel analyzer, Analog-to-digital converter, Spectroscopy amplifier.*

I. INTRODUCTION

The multi-channel analyzer system for monitoring and warning environmental radiation equipment, with such requirements: The device using scintillation detector must have a high sensitivity to measure low dose range. Dose rates are calculated through spectrum to identify radioactive isotopes. Equipment must be stable in any environmental conditions so that the device was be equipped the energy calibrated circuit to adjust changing of wide temperature range. The manufactored device should be enough memory to store data for several days.

To solve above-mentioned requirements, multi-channel analyzer operates accompany with stable spectroscopy amplifier having digital gain circuit controlled by microcontroller. Using the fast analog-to-digital converter and suitable micro-controller should be considered in designed time. In addition, energy consumption is optimized for the system to ensure long-term operation when the electric network not yet.

II. DESIGN AND CONSTRUCTION

A. Spectroscopy amplifier block

The universal designed spectroscopy amplifier with the following parameters: amplification pulse signal from the several hundred millivolts to pulse width 4μsec Gaussian shape, amplitude from 0 to 10V. The microcontroller can set the digitized gain of amplifier, relying on that the spectra could be automatically calibrated and stabilized.

The spectroscopy amplifier is required to complete the following functions: the differentiation and pole zero cancellation, amplified amplitude, pulse shaping, base-line restore, and increased output strength [1].

https://doi.org/10.53747/jnst.v5i1.183
Received 20 January 2015, accepted 28 May 2015

From the analysis and put forward the request on the spectroscopy amplifier the block diagram is shown in Figure 1.

In this diagram all chips amplifiers are LF356 devices, they are fast amplifier with JFET high impedance input. The digital gain, set up by a digital-to-analog converter using DAC0808 device, can be adjusted the pulse amplitude up to 50% entrance. The resistors used in the circuit with high precision of 1% error removal from components.

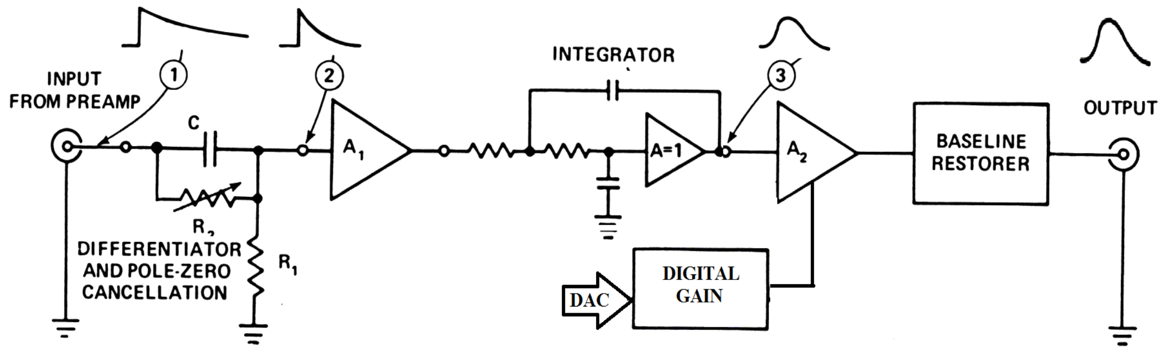

Fig.1. Diagram of the spectroscopy amplifier

B. Analog to Digital converter block

The designed innovative analog to digital converter used for the monitoring and warning environmental radiation system are required steady work and fast convertion time, data access updated continuously ensure accurate alerts and continuously. The requirements of the system are analyzed [2]:

- 4000 channel resolution.
- 5-7μsec conversion time.
- The integral nonlinearity ≤ 0.025%.
- The differential nonlinearity ≤ 1.5%.

To meet the demands posed problem we select and offer solutions designed block-number variation similar to Figure 2.

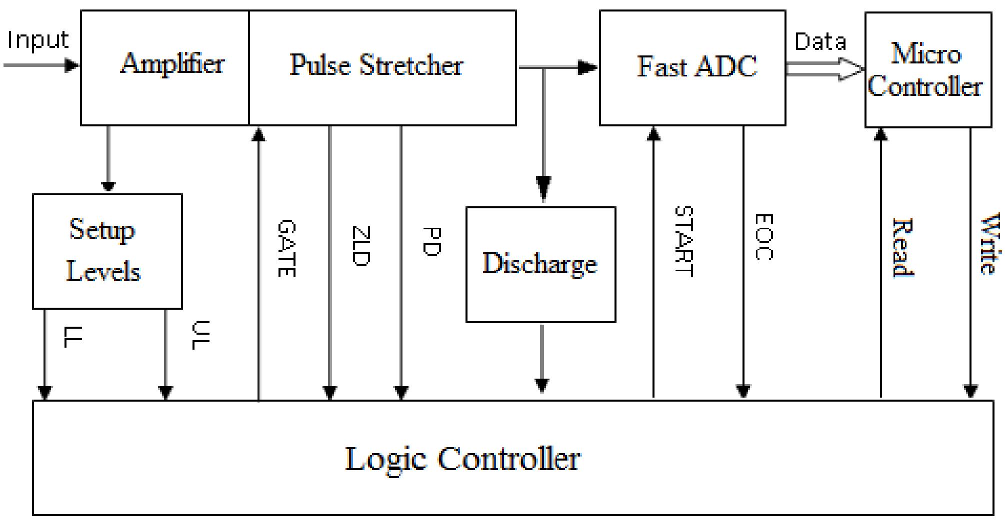

Fig.2. Block diagram of the analog-to-digital converter

Based on these objectives and this block diagram we selected IC analog-to-digital converter AD7472 with the following specifications: 500ns convertion time, the integral nonlinearity is ± 0,5LSB and differential nonlinearity is ± 1LSB, low consumption 8,7mW line with single 5V power supply.

The using Cypress AN2131 micro-controller for acquisition, processing the spectrum data and communication with the computer allows meets the requirements. The supplied logic combination using a programmable IC GAL20V8 entire cycle control, it was programming to generate the discretion of the user [2]. The logic combination creates full lifecycle of multi-channel systems analysis.

After completing the design schematic and PCB circuit diagram in spectroscopy amplifier block and analog to digital converter block, assembly of one complete circuit components and multi-channel analyzer as shown in Figure 3.

Conducting calibration amplifier block we reach to the following parameters [3]:

- Amplifier output amplitude range from 0V to 10V in the shape of Gaussian pulse with 4μs shapping time.
- Amplification factor can be change from potentiometers and from microcontroller can set the digitized gain from 0 to 255, while the coefficient iz changing of 10 units, the channel number will change 20 channels, based on parameters for the ddress the problem of universal stability.

III. RESULTS AND DISCUSSION

Fig.3. Diagram final assembly of multi-channel analyzer

The firmware program for the microcontroller is written in Keil C51 software tools and user program for interfacing, common data processing and accquisition control were written in Labview; rely on this program for us to survey the parameters of multi-channel analyzer system.

Survey of integral nonlinear gathers is shown in Figure 4 and plot of linear function of the pulse amplitude against the channel entrance is presented in the figure 5.

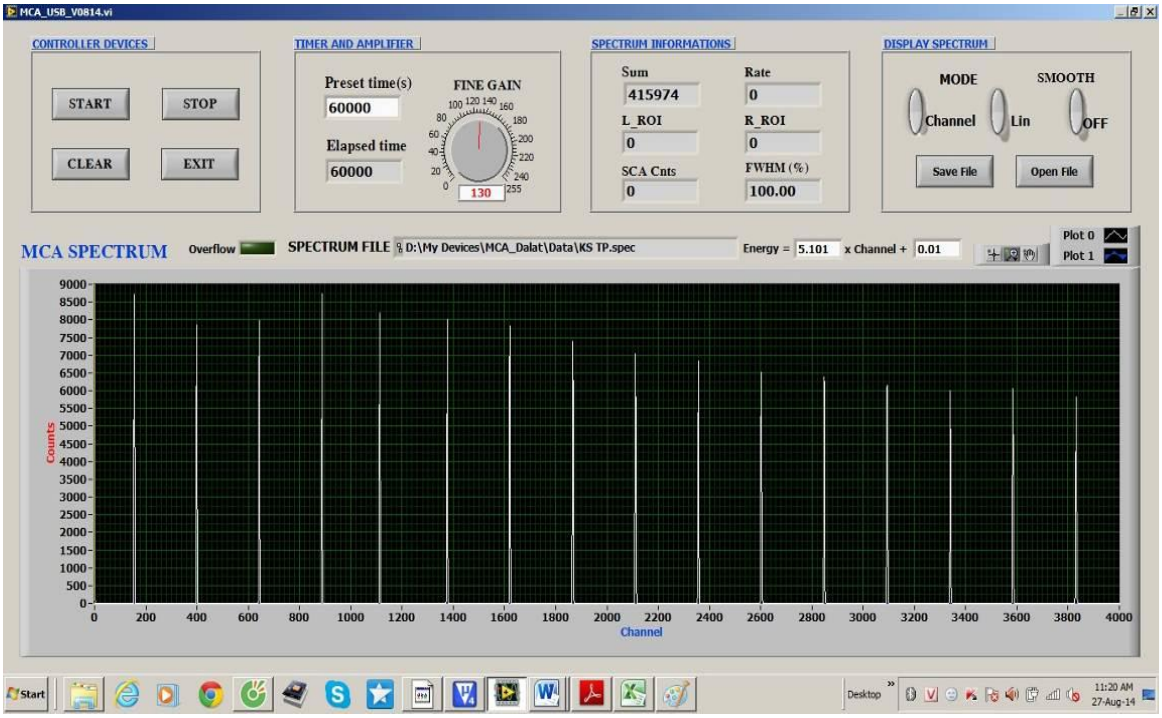

Fig.4. Survey data of integral nonlinearity

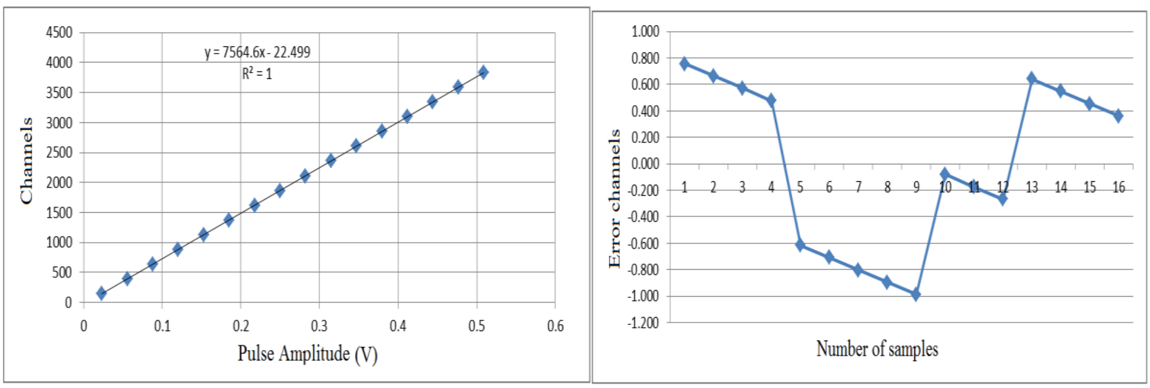

Fig.5. Graph jaw joints survey data of integral nonlinearity

Command's misjudging channel function was fit to the measured experimental values have been the diagram in Figure 5. From the formula [4] we calculate the integral nonlinearity of the system is:

$$INL\% = \frac{\Delta dmax}{Schannel} x100 = \frac{0.895}{4000} x100 = 0.022\%$$

Survey of differential nonlinearity data collection is shown in Figure 6, and we were evaluating the differential nonlinearity based on our data sets shown in in Figure 7.

According to our calculation formula [4] is the differential nonlinearity of the system is:

$$DNL\% = \frac{Nmax - Navg}{Navg} x100 = \frac{24214 - 23859.73}{24214} x100 = 1.48\%$$

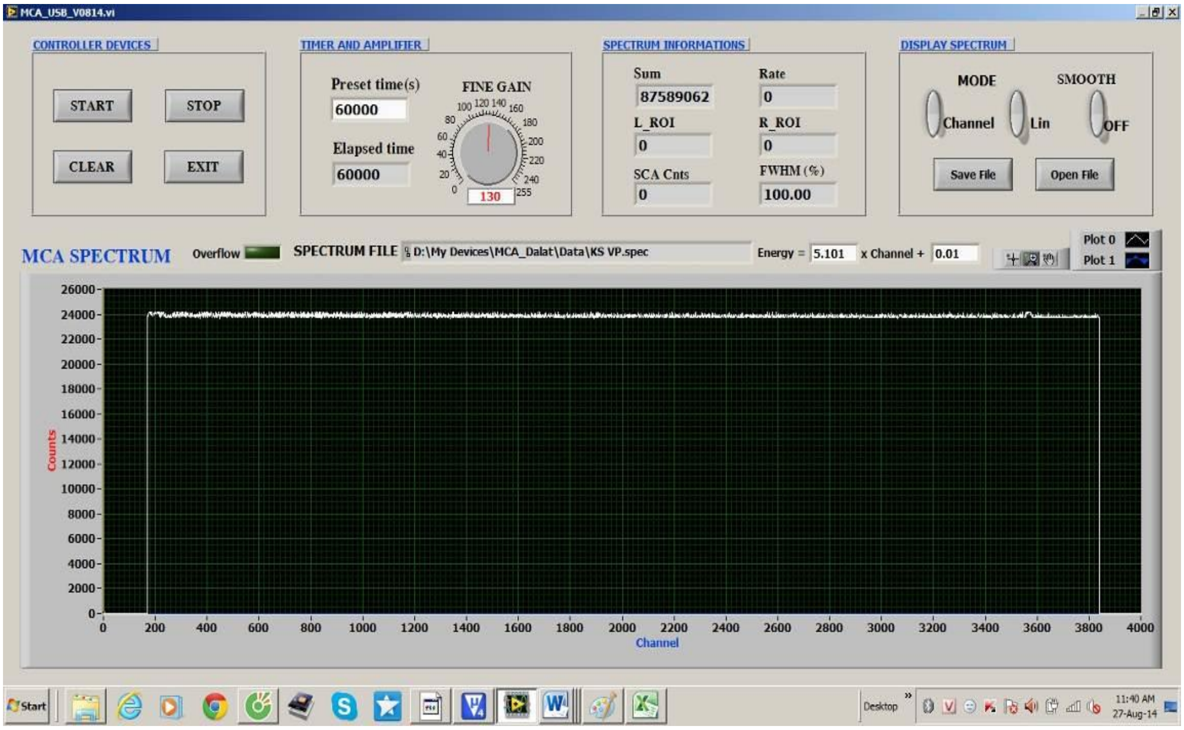

Fig.6. Survey data of differential nonlinearity

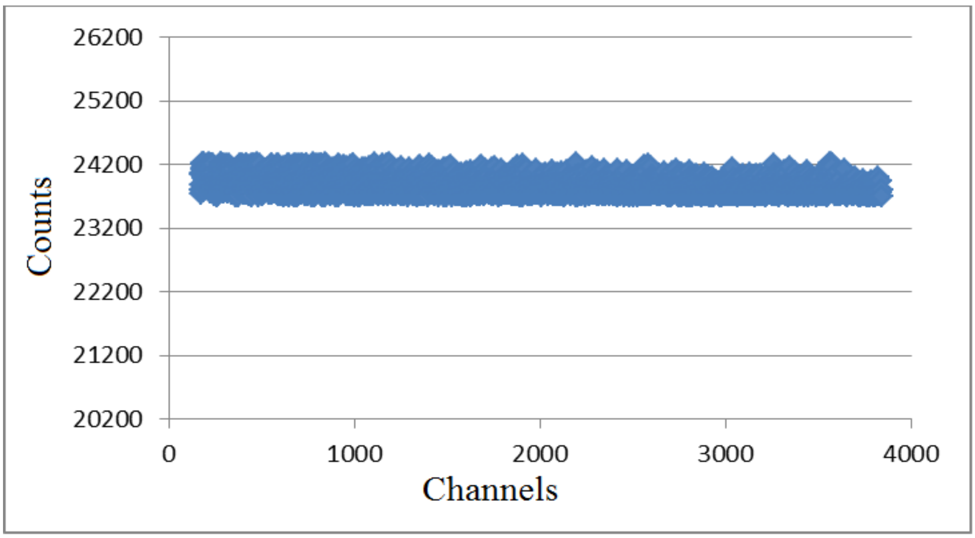

Fig.7. Calculation of differential nonlinearity

Thus, we have designed and fabricated a complete multi-channel analyzer with the following parameters:

- 4000 channels resolution.
- 5µsec conversion time.
- The integral nonlinearity is 0.022%.
- The differential nonlinearity is 1.48%.

IV. CONCLUSION

With the optimal choice of components and electronic circuits, along with requirements set out thematic problem has accomplished the following:

Design, construction and correction spectroscopy amplifier block performing the amplifier and shape of pulse signals from radiation scintillation detector and can set the digitized gain of amplifier.

Design, construction and correction analog to digital block performing the convertion of the pulse signal from the amplifier output to a digital signal for data acquisition, calculation and analysis, along with processing software have been a multi-channel analyzer of stable performance and fast conversion time.

ACKNOWLEDGMENT

We gratefully acknowledge the financial support of the project KC.05.16/11-15. We would like to thanks to the Institute of Nuclear Science and Technology, Vietnam Atomic Energy Institute and Ministry of Science Technology for their support to implement the project.

REFERENCES

1. IAEA-TECDOC-426; Trobleshooting in Nuclear Instruments, 1987.
2. Dušan Ponikvar; Digital electronics, Slovenia, 2001.
3. Heinz Rongen; Universal Analog/Digital and SCA/MCA, 2006.
4. Dušan Ponikvar; Multichannel Analysers, Slovenia, 2001.