2021 International Nuclear Atlantic Conference – INAC 2021
Virtual meeting, Brazil, November 29 – December 2, 2021

ISBN: 978-65-594-1256-3

Study of the Energy Spectrum for Radiation Detectors with Digital Oscilloscope and Worksheet Software

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1. Introduction

There is a variety of radiation detectors that produce a pulse, with amplitude proportional to the energy of the incident radiation. This characteristic allows that, through equipment known as multichannel analyzers (MCA), graphs of the energy distribution of the radiation incident on the detector may be constructed. These graphs are known as energy spectrum and allow to observe the characteristics of the radioactive source the detector is subject to [1].
In this work, it is proposed the replacement of the MCA by an acquisition system composed of a digital oscilloscope sending data on the sampled pulses to an Excel® spreadsheet, which properly configured enables the construction of the energy spectrum for a radioactive source and the associated detector.

2. Methodology

The detector used was a PIN-type silicon semiconductor detector (Hamamatsu S5106) [2], with a charge sensitive preamplifier (Amptek A250F) [3], an amplifier (Ortec 450) [4] with integrating and differentiating filters. To build the spectra, the pulses after the amplifier (Ortec 450) were simultaneously sent to the MCA (Ortec 918A) [5] and to a PC, with the dedicated Maestro® software and to the digital oscilloscope (Tektronix TDS 3032B) [6], then, from this to a second PC to the Excel® spreadsheet, as shown in Figure 1.

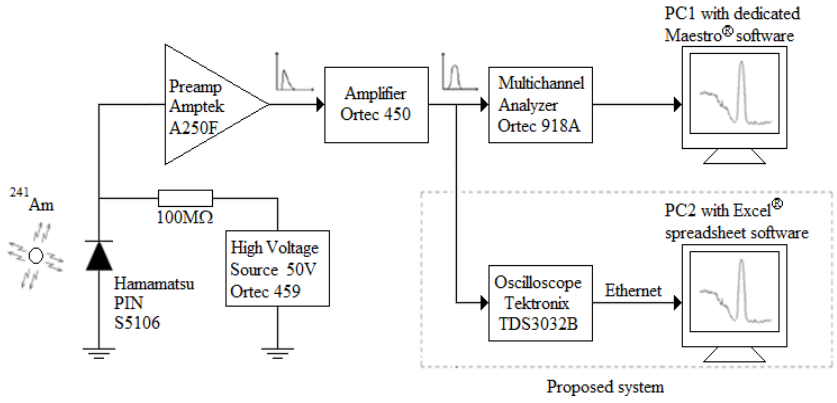

Figure 1: Block diagram for obtaining the energy spectrum using multi-channel analyzer (MCA) or digital oscilloscope and spreadsheet.

As the detector used was the PIN type silicon, which presents good detection efficiency at low energies [7], the radioactive source chosen to obtain its spectrum was the ^{241}Am. This source presents the emission of several characteristic X-rays between 13.9 keV and 26.4 keV, and gamma of 59.6 keV [7], producing a spectrum with a certain complexity, desirable to make the comparison between the spectra of the MCA and the proposed system.

The process proposed in this work uses the availability of the amplitudes (voltage) of the pulses digitized by the oscilloscope to be sent sequentially to the Excel® spreadsheet through an Ethernet communication port for the PC with the aid of an auxiliary communication software provided by the manufacturer of the oscilloscope. This auxiliary software, installed as an Excel® toolbar, allows, in addition to the communication process, the selection of characteristics of the acquired pulses, which in this case is maximum amplitude (Vmax). In addition to these features, this toolbar allows the selection of the number of desired acquisitions, that is, the number of pulses used to build the energy spectrum. These acquisitions are inserted in the cells of column A of Excel®, sequentially, at an acquisition rate of the order of 2 pulses/second.

In order to use the proper mathematical treatment in the construction of the energy spectrum, an auxiliary column, called Block, must be created. In this column, values between zero and the maximum voltage are inserted, with 0.01 V intervals, defined by the limit of the amplitude observable on the oscilloscope screen and available in column A. Then, an Excel® instruction allows the construction of a histogram of distributions, relating the values of columns A and B. This histogram is given by the number of times the amplitude values presented in column A occur in the intervals defined in column B. With these data, Excel® delivers a new spreadsheet with the Block and Frequency columns, which will function respectively as the Channel and Counts axes of an MCA.

3. Results and Discussion

For comparison purposes, Figure 2 shows the energy spectrum obtained with MCA and indicated software. The MCA is set to 1024 channels and has a channel width of 0.24 keV/channel and 300 seconds live acquisition time.

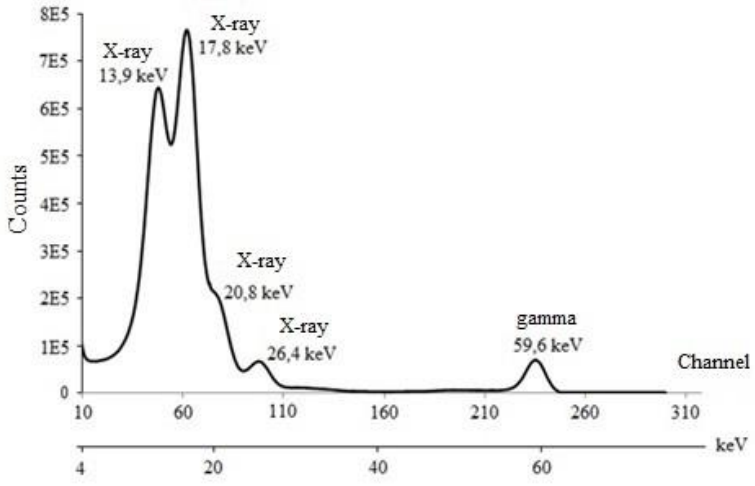

Figure 2: ^{241}Am energy spectrum obtained with a multi-channel analyzer (MCA) system and channel width of 0.24 keV/channel.

Figure 3 shows the energy spectrum obtained through the system proposed in this work, using a digital oscilloscope and an electronic spreadsheet, with number of acquired pulses of 64000. As it may be seen, comparing the spectra in Figures 1 and 2, the proposed method allows the replacement of the MCA and showed similar or better results of photopeak resolution, in comparison with those obtained with the conventional system.

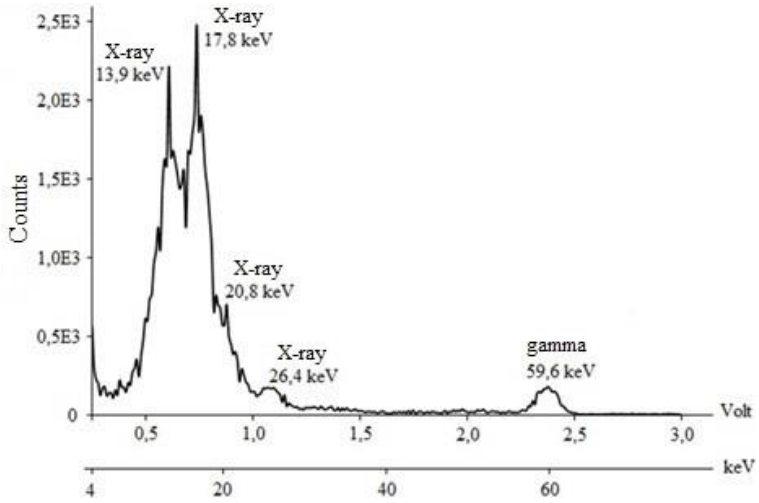

Figure 3: ^{241}Am energy spectrum obtained through a digital oscilloscope and spreadsheet with a block width (channel) of 0.01 V or 0.26 keV/block.

Comparing Figure 2, which is the energy spectrum obtained with the MCA (0.24 keV/channel), and Figure 3, which is the spectrum with the oscilloscope and spreadsheet (0.26 keV/block), it is observed that photopeaks with lower energy have higher resolution. This result allows us to state that even compromising the block width, which is the highest value, the system proposed in this work presents results similar to an MCA.
Table 1 shows the comparison between the energy resolution results obtained for the MCA spectrum and for the oscilloscope and spreadsheet spectrum. As well as the visual comparison of Figures 2 and 3, the calculated energy resolution results also show this superiority.

Table 1: Energetic resolutions for some ^{241}Am photopeaks, with energy spectra obtained with MCA and with digital oscilloscope and electronic spreadsheet.

	Method of Obtaining the Energy Spectrum	
Photopeak (keV)	MCA	Oscilloscope and Spreadsheet
	1024 channel 0,24 keV/channel	block de 0,01 V 0,26 keV/block
13,9 keV	R = 63%	R = 44%
17,8 keV	R = 33%	R = 21%
56,9 keV	R = 5%	R = 5%

4. Conclusions

In the absence of a multichannel analyzer (MCA), the use of a digital oscilloscope resources and a spreadsheet enables energy spectra with radiation detectors. For the oscilloscope used, the acquisition rate of 2 pulses/second is a limiting factor, making the action of obtaining the energy spectrum a slow process when compared to an MCA. The availability of oscilloscopes with higher acquisition rates may make this system very competitive, compared to an MCA. Anyway, acquisitions of the order of 6000 pulses, already allow a good spectrum visualization.

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