DESIGN OF A NETWORKED MULTICHANNEL ANALYZER (nMCA)

P.-H. Lefebvre, M. Clar, H.-P. Garnir, I.P.N.E., Liège, Belgium
Université de Liège, Sart-Tilman, B15, B4000 Liège, Belgium

Abstract

We have designed an inexpensive networked multichannel pulse height analyzer (nMCA) adapted to remote nuclear spectroscopy experiments. Our instrument is divided into two parts. The first one is a custom developed electronic hardware containing the analogic electronics, the analog to digital converter (ADC) and the microcomputer interface. The second part mainly consists in software: a computer program reads the results of the conversion, constructs the histogram of the pulse height distribution and presents these data to the network. The nMCA is connected to the Internet and can be remotely operated through the network. The integrated microcomputer hosts the acquisition program and a WWW server enables the distribution of a html page in which a JAVA applet is embedded. A JAVA capable browser can be used as a remote control for nMCA from anywhere on the Internet and displays the spectrum in real time.

1 INTRODUCTION

The multichannel analyzer (MCA) is the heart of most nuclear spectroscopy experiments. It collects and analyses data obtained by nuclear detectors. High performance MCAs are commercially available, but they are usually very expensive. We have designated a circuitry which, coupled with a micro-computer, could be used as a simple and cheap (less than $100) alternative to a conventional MCA [1]. It could be used, for example, in student laboratories or as an alternative to conventional MCA system for low performance measurements. This modern approach has been proposed before [2,3]. However, our system is simpler because it does not require a memory buffer on the MCA interface.

Nuclear particle detectors produce signals which are pulses of current. After proper amplification and shaping, these pulses have always the same appearance: a fast rise-time and a slow fall time of a few microseconds. The information (for energy sensitive detectors) is contained entirely in the maximum amplitude of the pulse (surface or shape are not relevant). The Multichannel analyzer is a device that constructs the histogram of the sequentially arriving pulse amplitudes. This histogram represents the spectrum of input pulse heights which corresponds to the energy spectrum observed by the detector.

Our MCA is divided into two parts. The first one is a specially developed electronic card which contains the analogic electronics and the Analogic to Digital Converter (ADC) which converts the amplitude of an analog signal to a digital number. The second part is mainly software. A computer program reads the results of the conversion and constructs the histogram of the data.

2 DESCRIPTION OF THE CARD OPERATION

A bloc diagram of our card is presented on fig.1.

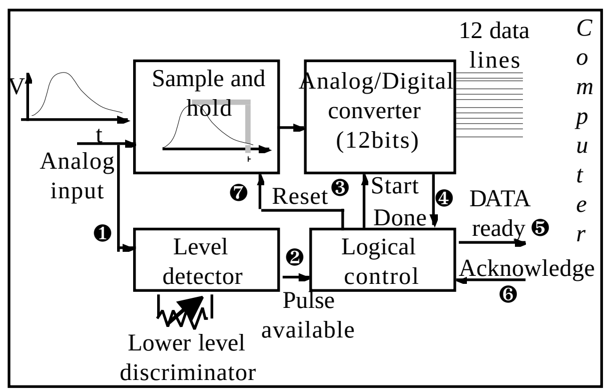

figure 1: Bloc diagram of our MCA interface

As soon as the input signal ❶ is above the lower discriminator level, the level detector tracks the signal shape up to its maximum. Then a “hold” signal is fed to the sample and hold ❷ and the logical control circuitry starts the ADC cycle ❸. After the conversion, the data lines are valid ❹ and a “data ready signal” is sent to the computer ❺. This signal triggers an interrupt routine that reads the data lines through a peripherical interface adaptator (PIA) interface and acknowledges the reading ❻. The logic controller resets the sample and hold ❼ and gets the card ready for the next pulse.

3 THE COMPUTER PROGRAMS

3.1 GesSpectre

A computer program called GesSpectre reads the results of the conversion and constructs the histogram of the data. It’s a general purposes nuclear spectra display and handling program [4]. We will describe here only the working of the small driver which reads the data and updates the spectrum on real time.

As soon as a conversion is finished, the "pilot" line of the card goes to 0. This signal is connected to the interrupt line of the computer interface card. If the card interruption flag is enable, this change triggers the execution of an interruption routine that reads the 12 data lines, generates the acknowledge signal to reset the ADC card and adds a unit to the channel pointed be by the number deduced from the data.

A trick has been implemented in the program to give feedback to the user by displaying in real time the spectrum evolution. The result of the conversion is placed by the interrupt routine in channel zero of the spectra buffer. During an acquisition, the program, when idle, pools the channel zero and, if a non zero value is found, updates the display of the channel indicated by the content of the channel zero before clearing it. At low count rate, this scheme allows the display to follow correctly the acquisition process whereas, at high count rate (or when the program is busy), the display lags on the real content of spectra. That's why, every 30 seconds, the display is updated disregarding the real time process.

3.2 MCA software server

GesSpectre, has been modified in order to respond to WWW requests [5]. The program opens a socket on IP port number 5521 and waits for requests. If the request comes from a browser, GesSpectre responds in a format compatible with the WWW practices, so that it is made possible to control GesSpectre directly from a browser just by calling fake "files".

A more efficient way of dealing with the program is to download the applet that controls the program. However, the client computer should have a JAVA virtual machine running (at least JAVA 1.1).

3.3 The micro WWW server

In order to distribute our files from the server, the small dedicated computer has to be able to respond to WWW requests. Commercially available server programs are big, expensive and complex. We have written a very simple server which could handle simple requests with efficiency. Our code is only 40k and runs in a partition of less that 150k. It works on all Macintosh computers having a TCP/IP driver. The source is written in Pascal and relies on the TCP Libraries written in 1992 by Peter Lewis [6].

3.4 The remote control Applet

This applet is written in then JAVA language and offers to the user a control panel which displays the spectra in real time. A screenshot of the applet is shown on fig. 2.

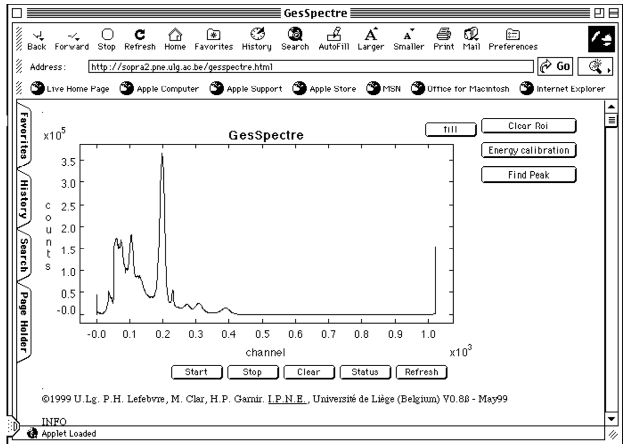

Figure 2: Browser window displaying the GesSpectre applet

The spectrum appears in a window surrounded by different buttons controlling the remote MCA. We have tested the Applet with Netscape and Internet Explorer running on on different operating systems. The display relies on a graphical library written in JAVA which belongs to a free graphical package written under the supervision of The Ptolemy Project [7].

4 TEST OF THE MCA

4.1 Linearity

The linearity of the MCA has been verified by using a calibrated pulse generator (Ortec 448). Pulses of known amplitude between 0.1 and 9.5 V have been recorded. The maximum difference between a fitted straight line and the interpolated values of each peak summit is always less that 1 channel.

4.2 Stability

The time stability of the MCA chain has been verified by recording for very long periods the pulse of the generator. No drift has been observed in measurements lasting many hours. (This indicates also that temperature coefficient is very small.)

4.3 Resolution & Noise

The spectrum of a source of Fe* (giving the Mn Kα and Kβ) has been recorded simultaneously with our "home made" MCA and with a commercial MCA (Canberra S35 and 8077 Fast ADC). No difference between the two recordings could be discerned. This indicates that no pulse is lost (same amplitude) and that no spurious noise is induced by our circuitry (same shape).

4.4 Maximum Conversion Rate & Dead Time

Detection of the maximum of the pulse followed by the AD conversion takes typically 25μs (rise time of 2μs) and is independent of the pulse amplitude. The computer response time to the interrupt signal is about 35μs (on a 25MHz 68040). Thus, the time between the pulse and the acknowledge strobe is ≈60μs. This gives a (theoretical) maximum conversion rate of ≈16kHz. In practice, we have been able to record spectra at a counting rate of ≈12kHz without appreciable degradation of the performance of the computer. Above that, the linearity of the detector and of the amplifier chain was strongly reduced.

The dead time of the MCA chain has been measured as a function of the counting rate. A NaI detector has been used to record spectra of a Cs* source placed at different distances from the detector. Simultaneously, the surface of the peak induced by a fixed rate pulse generator (placed above the maximum energy of the Cs spectrum) has been evaluated as the function of the total counting rate. As the counting rate increases, the dead time of the MCA reduces the surface of the generator peak. From these measurements, we have estimated the dead time evolution of a function of the counting rate (Fig. 3). In real measurements, count rate of less that 5kHz are usually mandatory to avoid “pile up”.

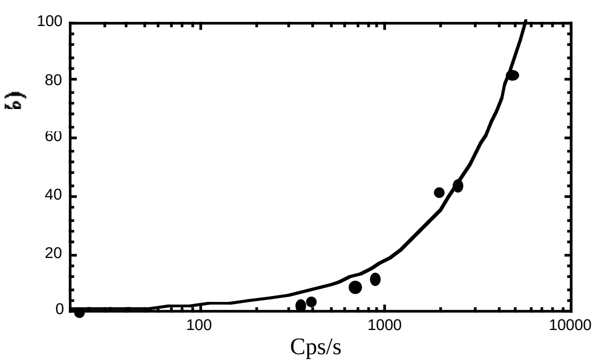

Figure 3: Dead time of the MCA chain as a function of the counting rate

5 TECHNICAL INFORMATION

The source of the programs (GesSpectre, WWW server and the JAVA applet) as well as the schematic, the electronic layout and the component list can be obtained on request [8] (E-mail: hpgarnir@ulg.ac.be & PH.Lefebvre@ulg.ac.be). All the electronic components used on our card are easily available. The ADC is an ANALOG DEVICES AD1674 (12bit 100kSPS) which contains a sample and hold and a fast converter working on the DAC-ADC scheme [9].

6 REFERENCES

[1] Etude et réalisation d’un système de spectroscopie nucléaire informatisé, P.H. Lefebvre, *Mémoire de licence*, Univ. Liège 1998 (*Unpublished*)

[2] *Physics Experiments using PCs Part V*, J.S. Braunsfurth (p251 ff), circuitryH. Staundenmaier (Ed.), Springer, 1995

[3] Pauly S.W., Nucl. Inst. And Meth. **A 422** (1999) p379

[4] GesSpectre (http://www.ulg.ac.be/ipne/nMCA)

[5] Momal F., Pinto-Pereira C., *Using the World Wide Web for control system*, Proc. ICALEPCS’95 Chicago, 1995. Available at : http://mish231.cern.ch/ Docs/ICALEPCS/1995/icalep95.htm

[6] TCP Libraries in Think Pascal for Macintosh (original version) P. Lewis, Stairways Inc. (1992) ftp://ftp.stairways.com/stairways/source/ tcpexample.sit.bin

[7] The Java Plotter Ptplot (part of The Ptolemy Project) E. Lee, C. Hylands, Dept. of Elec. Engineering UCB, (1999), http://ptolemy.eecs.berkeley.edu /ptolemyII/ptII0.2/ptII0.2devel/ptolemy/plot/doc/ index.html

[8] The GesSpectre, program and applet, as well as the source files are described and downloadable from: http://www.ulg.ac.be/ipne/nMCA

[9] *The art of electronics*, P. Horowitz & W. Hill, Cambridge U. press, pp621-624 (1994)