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DESIGN OF ELETRONIC SYSTEM WITH SIMULTANEOUS REGISTERING OF PULSE AMPLITUDE AND EVENT TIME APPLIED TO THE 4πβ-γ COINCIDENCE METHOD.

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ABSTRACT

In the present work, a new data acquisition electronic system for 4πβ-γ coincidence measurements is proposed which allows the simultaneous recording of pulse height and time of occurrence for each nuclear event. This work discusses the conceptual design of the microcontroller-based electronic unit that shall be specifically developed for this system, focusing on reliability and low cost.

1. INTRODUCTION

The 4πβ-γ coincidence method for absolute radionuclide activity measurement has been considered a primary standard in Nuclear Metrology for its accuracy and because it depends only on observable quantities for obtaining its results. Usually, a system of this type is composed of a proportional detector in 4π geometry for the detection of x-rays, electrons and alpha and beta particles, coupled to a scintillator or semiconductor gamma spectrometer.

One of the problems in this method is the attainment of the activity value with high accuracy. This is usually done by the Linear Extrapolation Method [1], where one measures the behavior of the radioactive source as a function of a parameter associated to the efficiency of the 4π detector, and the extrapolated value for unitary efficiency corresponds to the activity of the sample. The accuracy in this extrapolated value depends on the behavior of the curve and on the number of experimental points in the fit; usually tens of points are required, which demands measurements than span for several days to accomplish the desired accuracy.

In reference [2] and [3], some acquisition systems have been proposed that allow the simultaneous recording of pulse height and time of occurrence for the events of each of the ways, beta and gamma. This way, the analysis of the beta and gamma counts, as well as that of the coincidence counts, can be performed after the measurements is complete; as the system has all the event information required for the analysis, the extrapolation for the determination of the activity curve can be obtained in a single measurement, making the process much quicker. This aspect reduces the number of human interventions needed making the data acquisition much easier.

In order to improve these 4πβ-γ coincidence systems, the Laboratório de Metrologia Nuclear (LMN) of Instituto de Pesquisas Energéticas e Nucleares (IPEN) is developing a Digital Coincidence System (DCS), including the design of the proper electronics for data acquisition and recording, as well as special software, for hardware control and data analysis. The DCS design is based on a recent methodology, known as Digital Coincidence Counting or Software Coincidence Counting.

The radioactive sample activity is determined in two steps:

- Data acquisition: the nuclear pulses (beta, gamma, etc) are digitized and recorded on disk.
- Analysis: the beta, gamma and coincidence counting are determined from recorded data.

Some system parameters (such as delays and time fluctuations) can be set into the analysis program, providing a software adjusting capability. Thus, any changes in the system can be matched by the proper parameter setting, in the analysis step.

When the Efficiency Linear Extrapolation Method is used, usually, many measurements are required, setting different beta detector efficiencies. In some cases, the efficiency setting is reached by changing the beta detection threshold level. With the proposed system, the extrapolation curve can be obtained from a single measurement, by software emulation. In addition different extrapolation curves can be obtained, for different gamma energy ranges; moreover, conventional modules (discriminators, TAC and MCA) are not needed.

2. DIGITAL COINCIDENCE SYSTEM (DCS)

The pulse height and the time information for each event are collected and all data are transported to a PC. Signals from up to eight detectors are processed by a board with a microcontroller - PIC (Programmable Interrupt Controller). Each channel is independent and possesses a PIC, thus is possible to extend the number of channels modularly.

The DCS consists of: Nuclear Detection Electronics (NDE), Peak Detect and Hold (PDH), Microcontroller (PIC), Communication Interface (CI) and Personal Computer (PC). The scheme of each channel the DCS electronics is shown on Figure 1.

The NDE is composed of radiation detectors and includes biasing, pulse shaping and amplification. A detector output (detection channel) is a BUS line of the Nuclear BUS (N).

The PDH is composed by the Peak Detect and the Hold; this block is composed by the analog units:

- Peak detection (PD), for the logic PIC controlling;
- Sample & Hold (S&H), for pulse height sampling;

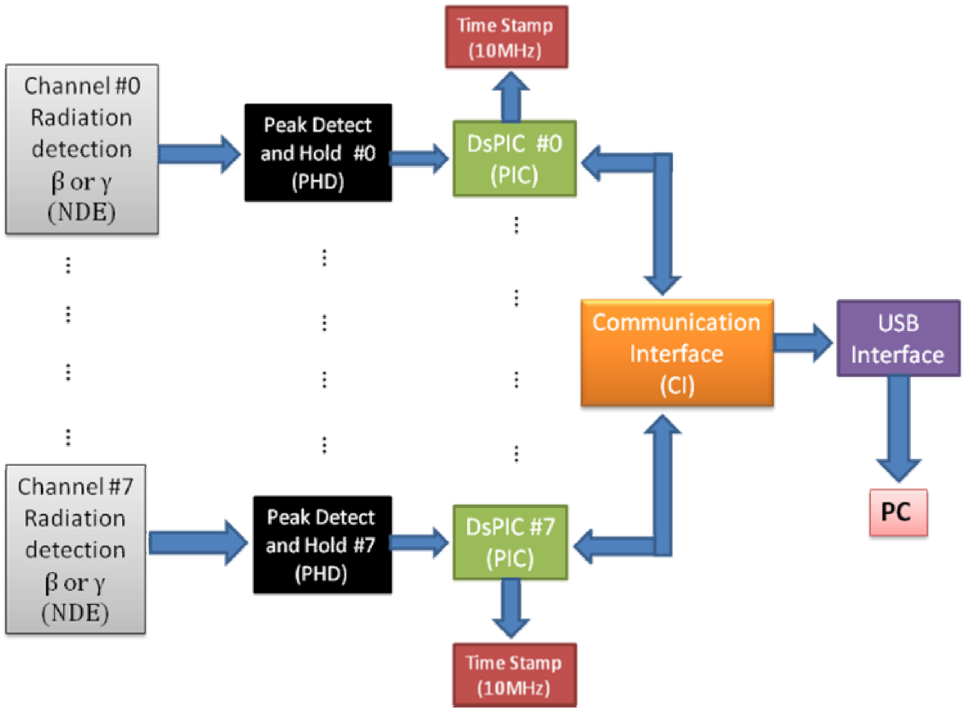

Figure 1 – Digital Coincidence System Block Diagram.

The PIC is an integrated circuit (IC) produced by Microchip Technology Inc. [4] and belongs into the microcontroller group, meaning that it is a single-piece integrated component that contains all of the necessary circuits to perform a complete programmable digital system. This chip has a series of auxiliary devices, as a clock generator, a 10-bit analogic-to-digital converter, bus, counter, and so on. The availability of all these devices in a very small space makes these ICs very versatile and useful, allowing the designer to build systems in a much faster and less expensive way, with the use of very few external components.

The IC used is made by National Instruments [5], and the proposed PC connection will be made using the USB port.

2.1. Coincidence Data Analysis Program

Each data record contains the data of each of the eight inputs; the data corresponding to a group of pulses arriving at the channel inputs at a time interval of 2 µs. The dead time is composed by a constant-length part and a part that varies with the pulse arrival time. The constant part (of approximately 8 µs) is common to all channels and is set to a value that should be sufficient for the processing of all pulses. The conception of the hardware of this system establishes a limit for the band of coincidence to an internal of time of 2 µs, making possible a relative simplification of circuit and software. For most of the measurements, this characteristic does not represent a restriction that affects the results; being, however, improper, when transitions with metastable levels are to be analysed, where half-lives larger than 2µs are frequently found. The other purpose of this work, the implementation of coincidence analysis software, is now discussed. By reading the data from the beta/gamma pair files, the program searches for the coincidence pair instants, taking into account the beta-gamma time jitter (in real cases, that jitter depends on the electronics delays and time fluctuations). Then, software determines the beta, gamma and the coincidence total counting.

3. CONCLUSIONS

The concept of digital coincidence counting has been introduced and a system was described which can be produced. The prototype system described comprises a custom-built data acquisition card and associated PC software, independent card to channels with a resolution of 10-bits. Continuous sampling and storage of the pulse trains are achieved through hardware compression of the data. Stored pulse trains are processed "off-line" using software, so the system is extremely versatile. It is anticipated that the development of such system will lead to the introduction of improved methods and enable new areas to be investigated.

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