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A Computer Interface for Radioisotope Data Processing*

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Abstract

An interface for use with radioisotope disintegration counting has increased the efficiency and expanded the uses of radioisotopes in the study of dynamic phenomena. Counting periods as short as 0.1 sec can be used for several channels simultaneously providing rapid data acquisition and permitting storage on digital magnetic tape and/or real-time data analysis with a general purpose digital computer. Disintegration rates from several radioisotopes can be sampled simultaneously enabling corrections for count spill-over and background in real time. In the system described there are 6 channels (for up to 6 radioisotopes) but 12 may easily be incorporated.

INTRODUCTION

The most common applications of radioactivity detection techniques have involved low count levels and long counting times. Radioisotope detecting equipment is, accordingly, usually designed for slow output rates using devices such as numerical displays, from which values must be read and dealt with manually. These systems are inadequate for studying the dilution of isotopically labelled substances in organs or at some point in the cardiovascular system where isotope count rates must be measured more frequently (up to 10^{-1} second for each isotope). Several methods have been devised to temporarily store these count rates on magnetic tape (1–3).

It is the purpose of this paper to present a system that not only preserves count rates on computer compatible magnetic tape, but also gives a visual numeric readout and interfaces to a digital computer for real time data reductions. The system provided by Canberra Industries¹ is nuclear instruments module (NIM) compatible and is available in a variety of configurations.

METHODS

Figure 1 shows, schematically, the configuration to be described. The six scalers accept randomly occurring pulses from six pulse height analyzers and count them over a time period determined by timer A. At the end of each count period the accumulated count values are transferred to the buffers, the scalers are reset, and counting is again resumed. The value from a constantly increasing clock, timer B, is also transferred to a buffer. The scalers and buffers for each channel consist of twenty-four bits each and are used in a four bit BCD configuration, thus allowing six digits per channel.

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The BCD characters are serially gated from the buffers to a four-line data buss by the magnetic tape controller and can be stored on the PEC2 incremental, digital tape, one BCD character per tape record. The Control Data Corp. 3500 digital computer senses 12 external data line levels on one read command, hence a special module was designed that transmits an interrupt, or read command, to the computer only after three BCD characters, 12 bits of information, are accumulated in a holding register. Also transmitted to the computer in the "chain of characters" are two additional channels of information used to identify experimental events: (1) A manual data input module, consisting of six numerically coded thumb wheel switches, for identification data, i.e., experiment number, run number, date, etc.; (2) Timer B that increases with 0.1 sec or 0.1 min increments until manually reset to zero, the time to which all subsequent events can be referenced. Typically, Timer B is reset to zero at the time when the state of the experimental preparation is perturbed, as by the injection of the isotopic label. The modules labelled "display" in Fig. 1 provide visual, numeric readouts of the contents of any of the buffers within their respective display groups. The buffer to be displayed is selected with a push button switch on the buffer. The modular composition of the Canberra system makes the addition of more data channels a matter of merely plugging in the new modules and rearranging the patch cables.

APPLICATIONS

1. The most frequent application of the isotope monitoring system has been the recording of γ emitting isotope dilution in the cardiovascular system and the washout of a γ emitting isotope from an organ (4,5). In both applications the concentration is time-varying and usually two or more isotopes are sampled simultaneously. With six pulse height analyzers and scalers it is possible to determine the average fraction of the disintegrations attributable to each of six isotopes, or to each of three isotopes at two different sites (e.g., in outflowing blood or remaining in the organ). The energy window of each pulse height analyzer is set to accentuate the disintegration counts due to a particular isotope, however, the overlap of the energy spectra prohibit complete separation without mathematical manipulation. With the isotope detecting equipment interfaced to the digital computer, the mathematical corrections can be performed to give the fractional concentration of each isotope in the sample, immediately following the acquisition of the composite sample spectrum (6). Immediate graphical display of corrected isotope dilution curves, by driving a storage oscilloscope³ from the computer, is a valuable asset in choosing the optimum course of the experimental procedure. It provides a running assessment of the effectiveness of the experimental procedure and the perturbations imposed on the experimental subject. Furthermore, computations of tracer escape rates and blood flow can be made on-line (7). The data stored on the digital tape is a valuable back-up in the event of computer nonavailability at a critical time in the experiment data collection. The tape is also used for more elaborate and time consuming calculations that are to be done, at some later time (after all of the experiment data has been collected).
2. In some experimental preparations it is desirable to infuse substances at a rate that maintains a predetermined concentration of the tracer substances at some point in the vascular system (8). This control is made difficult by the constant recirculation of tracer past the infusion site thus, the infusion pump rate can be constant only in a total equilibrium state. Closed loop infusion pump control has been used previously with analog signals from a rate meter and a dc pump control signal produced with

²Model 1807-7, Peripheral Equipment Corporation.

³Model 564—Tektronics.

an analog computer (8). The digital system is more precise, eliminates scaling problems and with a digital computer in the feedback loop, simplifies the use of more than one isotopically labelled substance.

3. Another application of the isotope detecting system is the simulation of a multichannel analyzer. With a 32,000 word memory of the digital computer at hand the possible number of energy windows (channels) is far more than adequate. The spectrum acquisition time is longer than with a conventional multichannel analyzer, however, by a factor of N , where N is the number of channels used. The increased acquisition time is a result of using only one pulse height discriminator, and changing its energy window rather than using N discriminators with fixed energy windows. The position of the pulse height analyzer⁴ energy window on the energy spectrum is determined by a dc reference voltage from a D/A converter of the digital computer. After the desired counting time, the accumulated count for a particular window is stored in the computer memory and/or on the PEC tape: the pulse height reference voltage is then increased and counting is resumed for the new window. When the entire spectrum has been scanned, the resultant frequency versus MeV curve can be displayed, numerically or graphically, with any of the normal computer output devices, including the storage oscilloscope. The capability of collecting spectra with the digital computer suggests the possibility of automatic computation of the optimum pulse height window settings for multiple isotope sampling. Automatic window setting computation would replace tedious trial and error methods and would increase the accuracy of isotope concentration measurements.
4. The system can also serve as an off-line or on-line, to the computer, analog-to-digital converter. This allows data such as dye dilution curves, pressure pulses and other analog signals to be transmitted immediately to the digital computer along with the isotope count rate values and/or preserved on the digital tape with the isotope count rate values. Previously, all analog waveforms were preserved on a FM analog tape, whereas now all simultaneously obtained data can be preserved in synchrony on one permanent record. Extraneous noise related to data transmission is also reduced when the waveforms are digitized at the collection site. Analog-to-digital conversion is accomplished with a voltage controlled frequency generator⁵ that produces pulses with a frequency proportional to the controlling voltage (in this case, the waveform to be digitized). The scalers then treat the train of pulses in the same fashion as the isotope disintegration pulses, i.e., determine the pulse rate, then store it on the digital tape and/or transmit it to the computer. Since six channels of data can be simultaneously transmitted, N channels can be used for the isotope count rates and $6-N$ channels remain for the digitized waveforms.

SUMMARY

The system described herein provides a means of storing radioisotope disintegration rates on computer compatible magnetic tape and also interfacing directly to the digital computer to allow real-time data processing. Data can now be analyzed more accurately with a significant reduction in time and effort. Many new laboratory experiments have been made possible with the addition of real-time data analysis. The system has also been valuable for analog to digital conversion in the analysis of data other than radioisotope disintegration rates.

⁴Model NC-11, Hamner Electronics Co. Inc., Princeton, New Jersey.

⁵Model 111, Wavetek, San Diego, Calif.

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ISOTOPE DATA ACQUISITION/STORAGE SYSTEM

FIG. 1.
Block diagram of the computer and digital magnetic tape interface.