Computers

REMOTE ACQUISITION OF GAMMA-RAY PULSE HEIGHT SPECTRA† Conf-750483--2

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ABSTRACT

The acquisition of pulse height spectra data in the industrial environment has traditionally evolved along two paths. The first required the transporting of a radioactive sample from the place of production to a computer system for counting and analysis. This method results in a degradation of the data due to the time delay between sample production and subsequent counting. The second path was taken to count the sample at the place of production and transport the data in the form of paper or magnetic tape to a computer for analysis.

Automation of the traditional methods is usually impractical. This paper describes two methods of remote data acquisition developed at the Idaho National Engineering Laboratory which were formulated to mechanize the complete process from data gathering to analysis. Both methods utilize voice grade telephone links between the data gathering device and a PDP-9 computer. The two methods differ in the type of device used to acquire the data. The first is a completely hardwired system. The second is a computer based system utilizing a PDP-8/E. Differences between the two systems are described and evaluations made as to cost versus versatility.

1.0 INTRODUCTION

The operation of large nuclear installations involves significant inventories of radioactive materials. Effective monitoring of effluent streams to permit evaluation of potential hazards which might result from discharge of radioisotopes is a requirement for safe operation of such facilities. The purpose of this paper is to present a summary of a program being conducted at the Idaho National Engineering Laboratory (INEL) to apply gamma-ray spectrometry to real-time isotopic monitoring of nuclear installations.

The development of such a system requires a reliable method of data accumulation remote from a larger computer system which has the responsibility for verification, analysis, and interpretation of the data. In designing such a system, three goals were established:

1. The data accumulation and transfer of data must be completely automated and under control of a central processor. The automation of the data transfer is essential for routine monitoring of a source. Manual manipulation of the large amounts of data is time consuming and error prone.

2. The remote system must be able to monitor and verify its own operation. Operation of gamma-ray spectrometers is subject to several types of problems which effect the quality of the data being acquired. Among them are power failures, gain and zero shifts, and other effects due to wide variation in the intensity of radiation incident upon the detector. The remote system should be able to detect these problems and report them upon command.

3. The remote system must be able to control external devices. Several applications of the remote system in an industrial environment require control of the source of data that is being acquired, such as the routing of gas or liquids from various parts of the plant to the detector. Moreover, if quantitative analysis is to be performed, the remote system has to be able to provide information from flow meters, pressure gauges, etc.

To accomplish these goals, a two phase approach was initiated. In the first phase a completely hardwired system was developed. This system was used primarily as a vehicle to study the requirements for a remote spectrometer in an actual industrial environment. The second phase was the development of a computer based remote system utilizing a PDP-8/E computer.

A common point in all phases of development has been the use of ordinary voice grade phone lines for communication between a fairly large PDP-9 data system and the remote spectrometer. The phone lines are operated half-duplex, asynchronous at 1200 baud, with automatic answer at the analyzer and (optionally) automatic dialing from the central computer.

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2.0 THE HARDWIRED REMOTE SYSTEM

A block diagram of the hardwired system is shown in Figure 1. A 4096-channel Pulse Height Analyzer (PHA) is a Northern-Scientific analyzer containing a 24 bit memory with all control and readout functions accoplished electronically via 24-pin connectors located on the back plane of the analyzer. The detector, pre-amplifier and amplifier are standard commercially available items.

The data multipler-controller controls the operation of the PHA and phone lines via commands received from a PDP-9 computer. The commands received from the PDP-9 are specific bit patterns which are loaded into a 16 bit command register. A separate execute command causes the command previously loaded in the register to be executed. This register can be interrogated by the master computer, allowing a validity check on the command sent to the remote system before execution. A 3 bit register, which gives an indication of the current PHA status, can also be interrogated by the computer.

The functions which can be performed by the remote system include:

1. Set a live timer to one of three preset live times. Data can then be accumulated for a preset live time.
2. Select one of two PHA ramp slopes to provide step gain selection.
3. Clear memory.
4. Read out data in several modes including redundant modes, data and channel mode, and data only mode.
5. Start data accumulation.

The data multiplexer-controller was build from DEC M-series logic. The logic requires one standard double height bin. The total acquisition cost for this system was approximately $15,000, not including the detector, amplifier, modem and engineering costs.

3.0 THE COMPUTER-CONTROLLED REMOTE SPECTROMETER

Figure 2 is a block diagram of the computer based remote system. The detector, amplifier and ADC are all standard, commercially available items. The live timer, multiplexer, pulse generator and modem controller were designed and fabricated at INEL. All logic was constructed from DEC M-series logic.

The software implemented in the PDP-8/E was written in assembly language and is designed to run in Read-Only Memory. All controlling commands received from the PDP-9 master computer are in ASCII code. The functions performed by the computerized system include all those which can be performed in the hardwired version, with the addition of the following:

1. Implementation of a precision pulse generator, which is utilized for energy scale determination and system performance verification.
2. Five general purpose digital I/O interfaces (DR8-Es) for detection of external events and control of external devices.
3. Power fail which allows the system to detect and report power failures.

4.0 OPERATING EXPERIENCE

The hardwired version of the remote system has proved to be quite reliable. The system has been in operation for over a year monitoring effluents from the Advanced Test Reactor at INEL. The system provided a vehicle for the testing and operation of a remote system using voice grade phone lines. The computerized remote system implemented several functions which could not be implemented on the hardwired system. Of these, two important items stand out: the addition of a precision pulse generator and several general purpose digital I/O interfaces. The precision pulser generates pulses of known amplitude which are injected into the pre-amplifier. Appropriate gates are simultaneously set to indicate the presence of a pulsed event. An interrupt is generated in the computer so the pulsed event can be read separate from the gamma data. The pulser spectrum is stored in memory and transmitted to the control data system upon command. From a prior determination of the equivalent energy of a pulse height, an energy scale for the gamma spectrum can be computed from the pulser spectrum. Moreover, the remote system can monitor (in real time) the pulser events to detect, among other things, gain and zero shift of the spectrometer; which give an indication of the quality of the data collected.

Different formats were used in the transmission of data and commands in the two versions of the remote systems. The communications format for the hardwired system was special bit patterns for commands and 4 bit BCD for the data. The code for the computerized version is ASCII for commands and data transmission.

The use of complete ASCII format has many advantages over special bit patterns. The master computer is not required to construct complicated bit patterns, but merely to transmit a mnemonic command using routines similar to those used to print messages on a teletype. Moreover, a teletype can be used to run the remote system at the remote location without any software modification. The data transmission times using ASCII are acceptable if leading zero suppression is performed. The 4 bit BCD two digits/word format used in hardwired system requires 116 seconds to transmit a 4096 channel spectrum. The ASCII leading zero suppression format takes approximately 140 seconds to transmit a typical spectrum whereas the transmission time for a spectrum without leading zero suppression is approximately 360 seconds. Suppressed zero transmission is obviously a function of the number of counts in a channel. The 140 second time represents the transmission of a typical spectrum collected at the stack of the Advanced Test Reactor with a maximum count in any channel of less than 200,000 counts. The data is also transmitted in a line oriented format which allows receiving software to re-synchronize with the transmitted data in case of loss of words in transmission. The conversion from ASCII to binary is easily performed using numeric data input routines contained in almost any operating system, and with the ASCII code parity can be checked by the receiving computer. The suppressed zero transmission format appears to be a reasonalbe compromise between standardization and other more efficient formats.

5.0 SUMMARY

This paper has been directed to reporting status in a program for the development of a remote pulse-height spectrometer system. In doing so, the most formidable problem associated with the use of gamma-ray spectrometry has been ignored, that is, of how to analyze the data to obtain desired information. For a discussion of these problems, the reader is referred to references 1-7.

At the present time, the computerized version of the remote spectrometer system is undergoing field tests with the objectives of projecting the system into a 12-bit or 16-bit microprocessor configuration. An objective of this developmental effort will be to provide complete design criteria for commercial production of remote pulse-height spectrometers for routine use in industrial applications at a cost of between five and ten thousand dollars.

6.0 REFERENCES

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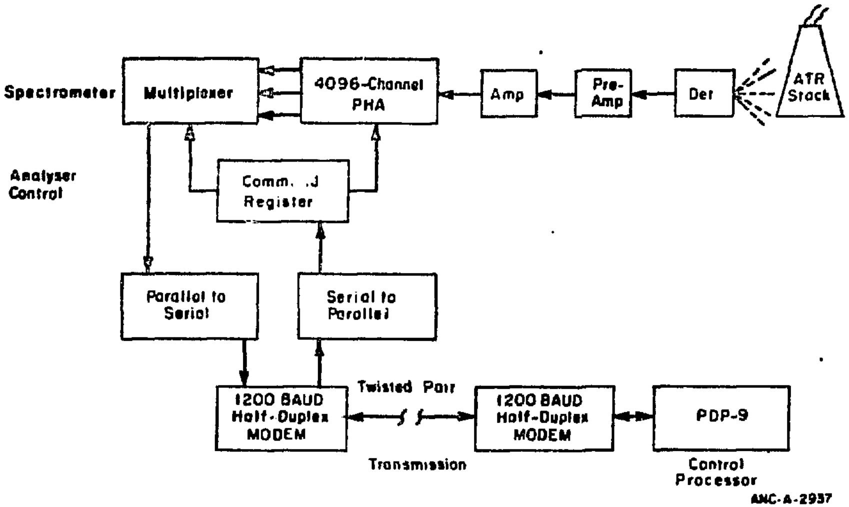

Figure 1. Hardwired remote analyzer block diagram.

COMPUTERIZED REMOTE SYSTEM BLOCK DIAGRAM

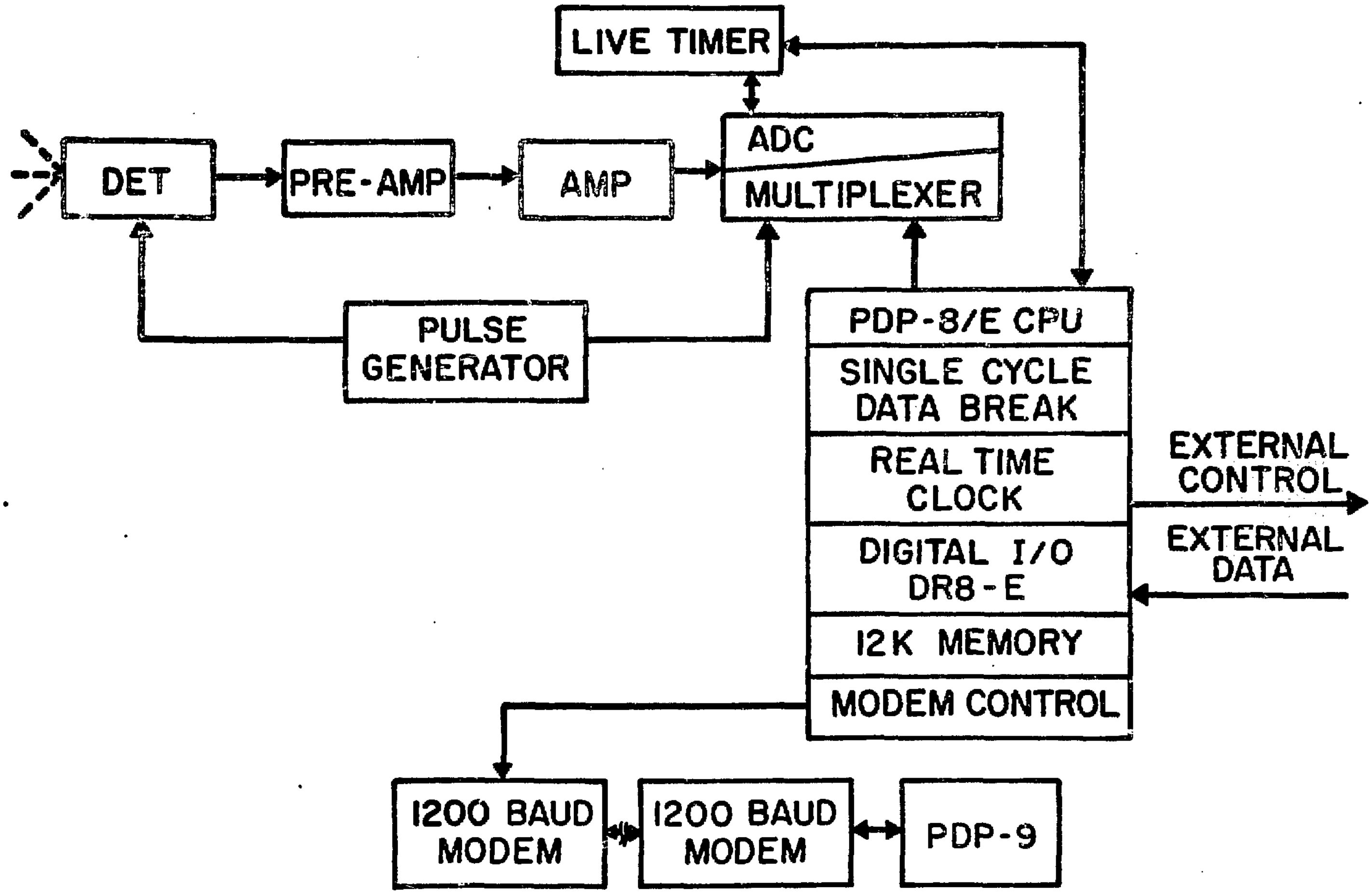

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Figure 2.