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TITLE: VIOLINIST: SOPHISTICATED PU FIELD MONITOR

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VIOLINIST:
SOPHISTICATED PU FIELD MONITOR

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SUMMARY

A new, smart, portable multichannel analyzer-based plutonium field monitor has been developed that will significantly improve field monitoring capability by accident response teams. Called the Violinist, the system uses the ever-popular thin NaI(Tl) detector developed some years ago. The electronics weigh 1.7 lb and fit inside a package 7"x5"x1-3/4" deep. The device has: 256 channel MCA; microcomputer control; 32x84 dot matrix LCD alphanumeric and spectral display; three independent cursor sets for region of interest definition; keyboard-entered constants (3); computation algorithms; and internal battery power (15 hr lifetime). The package has wide radiation monitoring applications.

INTRODUCTION

As a continuation of our work on small computer-based radiation spectrometers and dosimeters,²⁻⁶ Los Alamos has recently developed an even tinier multichannel analyzer (MCA) capable of radiation spectroscopy data acquisition and analysis in the field. While applicable to any standard radiation detector, the device described here is for use in monitoring low levels of transuranics via their characteristic gamma-ray and x-ray spectra.

For many years, the standard field detector for monitoring low energy photon emitters like plutonium has been a thin NaI(Tl) crystal, called a "Fidler" detector. The electronics has remained fairly constant and is based on a battery-operated single channel analyzer (one or several), signal amplifier, and detector high voltage supply. The system was difficult to calibrate, gave results only in cpm, and was "blind," i.e., it gave no spectral display for aiding in field calibration, system setup, and diagnostic checks. The instrument presented here, affectionately known as the Violinist, uses the same standard NaI detector, but improves dramatically on the electronics. It also automates the data acquisition and analysis procedures. Field calibration is also very simple and straightforward via visual displays indicating the appropriate window settings and, hence, correct energy calibration.

VIOLINIST: GENERAL DESCRIPTION

The tiny MCA is shown in Fig. 1. The new device has: a 256-channel multichannel analyzer (MCA), microcomputer control, 32x84 dot matrix LCD; algorithms; three independent cursor sets (for region of interest definition), keyboard-entered constants (3), real unit (e.g. $\mu\text{Ci}/\text{m}^2$ Pu) display and spectral display, and internal battery power. The entire unit weighs 1.7 lb and fits in a package 7"x5"x1-3/4" deep. For operation with a standard NaI detector, a commercial, internally battery-powered H.V. supply/preamp plug-on base fits onto the PMT of the NaI crystal. For general use, the system can also accept pulses from a wide variety of radiation detectors: alpha counters (Si surface barrier detectors), neutron detectors (³He detectors), etc.

A 12-key keypad provides control for the device. The keypad provides both functions (clear data, region

Fig. 1. Violinist and NaI detector combination. An ²⁴¹Am photon spectrum is shown on the display.

of interest cursors, etc.) and numeric data input (clock reset, algorithm constants, etc.). The LCD is used for both spectral data display (graphics) and alphanumeric display. When in the alphanumeric display, a semilog bargraph gives relative visual count rate data (in region "C") in addition to actual digital data display. The time of day (clock) is displayed on the LCD in the normal running mode, which also displays the actual plutonium and americium contamination levels in $\mu\text{Ci}/\text{m}^2$ units. Using a standard thin NaI detector calibrated in the usual manner for field transuranic surveys, the normal spectral display covers the photon energy region from ~5 keV - 85 keV. Two of the three regions of interest (ROI's "A" and "B") are set on the 17 keV and 60 keV photon regions characteristic of a typical ²⁴¹Am spectrum acquired with this detector. Region "C" is also defined by the user. Calibration of the detector system is performed at the 30 cm level above a planar contamination source. Using known sources (Pu and ²⁴¹Am), constants are then entered via the keypad to calibrate the Violinist in $\mu\text{Ci}/\text{m}^2$ units once the ROI count rates are acquired. Other analysis algorithms can be added via onboard read only memory (ROM) changes. Accordingly, the device is generic in application. For example, it would make an ideal alpha continuous air monitor (CAM) electronic package. Of course, the NaI detector is now replaced with a Si surface barrier detector. The entire system is powered by four AA batteries for 15 hours.

OPERATIONS

The operator interface to the Violinist is via a 12-key keypad and the dot matrix LCD. There are two basic modes of operation. The setup, or ROI, mode and the Run mode. In the setup mode, the display shows a spectral display such as you would view on a standard MCA. In this mode, the operator can set the limits of the 3 ROI's, enter the constants for the computations, display the average rates in the various ROI's, set the background rates, and set the time of day clock.

In the Run Mode, the display shows the results of the computed algorithms, the elapsed integration time, and a bar graph ratemeter based on the count rate in ROI "C." The currently used algorithms are designed to detect plutonium and americium. The formulas used are:

$$\left(\frac{(\text{Integral A} - \text{Background A})}{\text{Count Time}} - \frac{(\text{Integral B} - \text{Background B}) \times \text{Constant 1}}{\text{Count Time}} \right) \times \text{Constant 2}$$

$$= \frac{\mu\text{Ci}}{\text{m}^2} \text{ Plutonium}$$

$$\frac{(\text{Integral B} - \text{Background B})}{\text{Time}} \times \text{Constant 3} =$$

$$\frac{\mu\text{Ci}}{\text{m}^2} \text{ Americium}$$

These computed values are displayed on the LCD and updated every second. Start acquisition, Stop acquisition, and Clear Data keys are the operator interface in this mode.

ELECTRONICS DESIGN

The electronics which compose the Violinist are shown in the block diagram (Fig. 2). At the front end is a self-contained, battery-powered preamp-high

voltage supply. The signals from this are fed to the Violinist electronics package. The signals are first fed through a shaping amplifier and then applied to a Wilkinson-type 256-channel ADC. The ADC is coupled to a microcomputer consisting of a Motorola MC146805 microprocessor, 2K of RAM, and 2K of EPROM.

The incoming data are accumulated in RAM and the data are then analyzed in several ways by the microcomputer and displayed on the built-in 32x84 dot matrix liquid crystal display (LCD). The 12-key keypad provides operator access to the microcomputer. A Motorola 146818 real time clock/RAM chip is continuously powered and maintains time and date information as well as providing nonvolatile storage for the constants used in the algorithms for computations.

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Fig. 2. Violinist block diagram.