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A LOW POWER MULTICHANNEL ANALYZER

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A Low Power Multichannel Analyzer

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Abstract

The instrumentation used in nuclear spectroscopy is generally large, is not portable, and requires a lot of power. Key components of these counting systems are the computer and the Multi-Channel Analyzer (MCA). To assist in performing measurements requiring portable systems, a small, very low power MCA has been developed at Pacific Northwest Laboratory (PNL). This MCA is interfaced with a Hewlett Packard palm top computer for portable applications. The MCA can also be connected to an IBM/PC for data storage and analysis. In addition, a real-time time display mode allows the user to view the spectra as they are collected.

I. INTRODUCTION

Due to the waste cleanup activities at the DOE Hanford site in Eastern Washington, it is necessary to perform nuclear spectroscopy measurements using small radiation detectors at remote locations and, in some cases, provide long term monitoring. The classical techniques require bulky hardware.

These measurements typically require three main components: a detector, a shaping amplifier, and a multichannel analyzer. In this paper we will focus on work performed to develop a small, light weight, and low power multi-channel analyzer.

II. System Description:

Figure 1 shows a system block diagram, where all components of the monitoring system are shown. We will focus on the MCA and its interface with the computer.

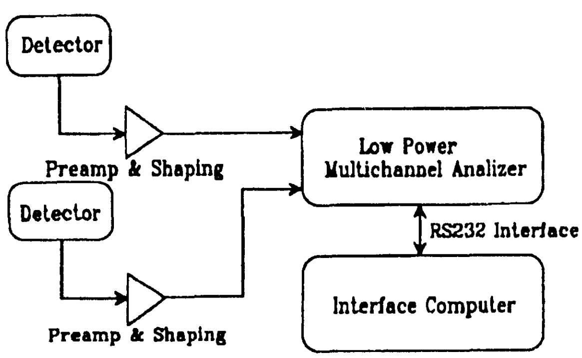

Figure 1: System block diagram.

The MCA has two inputs, a Scaler input and a Pulse Height Analyzer input. The computer interface is a standard serial RS232 port. The computer can be any IBM PC compatible, or a Hewlett Packard 95LX palm top with the only requirement being a serial port used for communications. The MCA has two main modes of operation: Local and Remote.

In the Local mode of operation, the computer is connected to the MCA, and data is transferred from the MCA to the computer on a real-time basis. This allows the user to monitor the graphics display of the spectrum on the screen as the data is collected. Figure 2 shows an example of the MCA real-time display screen. The user interface provides cursors to allow determining counts at a particular channel, and spectral areas. Data collected in the Local mode can be written to a data file for later analysis.

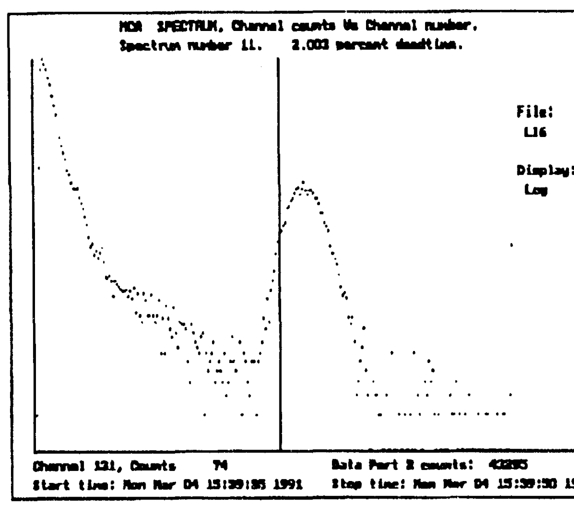

Figure 2: MCA real-time display of data.

In the Remote mode of operation, the user sets up the MCA using the computer and then automatic data collection is performed. The MCA can store several hundred spectra internally with user defined counting periods. The MCA will count for the defined length of time, store and time stamp the spectrum, and then start another counting period. If any MCA channel overflows, the spectrum is stored and counting is resumed.

All data collected by the MCA is stored in a battery protected RAM, with a lifetime of 10 years. The setup data is also stored in the same protected memory.

The MCA can be turned on and off without causing any loss of data. When the power is applied to the MCA, the software first looks through the spectra stored in its internal RAM. Once the last spectrum is located, the controller saves this address so as to store new data after the last used location. The RAM selected for this design allows over two hundred spectra to be stored before filling the memory.

The Remote mode of operation allows the MCA to be set up then turned off, transported to the measurement site, connected to the system, and powered up. Due to the MCA's low power consumption, a 9-volt battery will provide many hours of operation.

A computer program on a host PC or palm top computer allows control of all functions and modes of the MCA. Data collected by the MCA is read and stored in a file as well as displayed for analysis. This data is stored in a binary format to minimize disk space requirements. The interface program allows converting this data to an ASCII format to enable the user to analyze the data with other software packages.

The interface program is used by connecting the communications cable from the PC to the MCA, turning the MCA power on, and running the interface program on the PC. If the PC cannot establish communications with the MCA, the program continues to enable data viewing and analysis off-line. The PC communications program was developed in C. This program also provides the ability to produce hard copy when attached to a HP compatible laser printer. This interface program uses a very simple menu selection user interface, where a selection is made by entering a single letter defined by the menu. After the selection, the program will prompt the user for any addition data required.

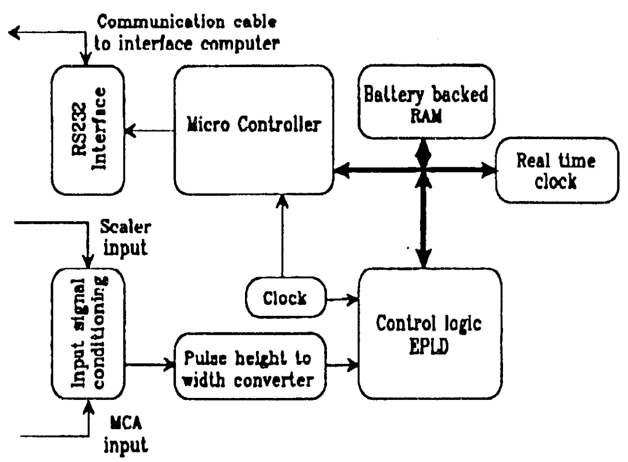

Figure 3: MCA functional block diagram.

III. MCA functional description:

Figure 3 illustrates the internal components of the MCA. The goal here was to produce a product using off-the-shelf components, which allows easy reproduction in small quantities at an affordable price.

The imbedded processor, Motorola MC68HC805, provides for all communications with the PC control program. This processor was selected for its low power consumption and its built-in serial interface port. The processor is used directly to perform the scaler function. The scaler function only requires counting events above a threshold. This is accomplished using a comparator to convert the input signal to a digital level, and this digital signal is then connected to the controller's interrupt input. The only processing required by this interrupt is to increment one value, which is performed by the imbedded controller software.

The pulse height analysis is performed using a pulse height to width converter,[1] the output of which gates a counter. The MCA function requires the input pulse height to be converted to a digital value (analog to digital converter function, or ADC). This value is used as an address into the spectrum, with the last step being to increment (add one) to the value in the location. The result is an array with the number of entries defined by the number of bits in the ADC. The ADC function must be performed on input pulses arriving at random times. The pulse height to width converter gating a counter preforms the ADC conversion function. One of the time critical operations is to complete the add-one operation as fast as possible. The time spent in the operation produces the dead time, which is time that cannot be used for input signal processing. There were two main philosophies to accomplish this: use the imbedded controller to perform this function in software, or design hardware. The software approach has the advantage of lower power and smaller size, but the disadvantage of lower performance. The solution chosen here was to design hardware. An Altera Erasable Programmable Logic Device (EPLD) was used to contain all of this logic, including the counter. The device selected is a 900 gate equivalent part that allows the add-one operation to be completed in a few clock cycles. Performing this operation in software would require over one hundred cycles, which would represent a major performance limitation.

A battery backed static RAM provides spectra storage, as well as storing system setup parameters. A real-time clock is included to allow time stamping of all stored spectra.

The imbedded controller's main function is to monitor the counting time, look for overflows, and provide the scaler function. At the end of a counting period, or an overflow, the controller saves and time stamps the spectra. General house-keeping function are also provided to insure there are no overflows in the storage RAM.

An additional unique feature of this controller is the program storage area. This controller has two electrically erasable program storage areas. In one area we developed a program to allow erasing and reprogramming of the second area. When power is applied to the controller, the program in the first storage area starts execution. This program listens to the serial communications port for a few seconds. If no requests are made, the second area is tested for the presense of a program, and if found, the second program execution is started. If no program is found in the second area, the startup program will wait for commands on the serial port. The interface code running on a PC, has a download function designed to allow reading a program from a PC file and downloading it to the second program area. The controller's program is designed and written on a PC and then cross assembled to a HEX file. This allows modifying and updating the controller's firmware. All controller software development was performed in assembly language.

Figure 4: The micro MCA system.

Surface mount components were used to provide a very small and light weight package. Several different packaging arrangements could be envisioned. Figure 4 shows the one we have selected. This system is only 2" high, 3.5" wide, and 7" long, including computer and battery pack. For operation in the remote mode, the HP 95LX can be removed, and the MCA operated autonomously.

IV. Conclusion:

This work has demonstrated the ability to produce a small low powered MCA using existing technology. The device can be reproduced inexpensively. This technology could be used for many other monitoring and data collection tasks by the redesign of the analog signal processing front end.

With the Hanford clean up task ahead, devices like this, will be required to perform long term autonomous monitoring. Periodic connections to a computer to transfer and save the data collected can be performed and data collection resumed. With low power consumption, solar power may be used where AC power sources are not available.

V. References

[1] G. Anderson, "Circuit Converts Pulse Height to Width", EDN, August 1989.

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