LOSS-FREE GAMMA-RAY COUNTING ON THE VMEbus

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ABSTRACT

An add-N histogram memory controller has been designed to histogram gamma-ray data using conventional pulse-height spectroscopy ADCs into VMEbus memory. The weight factor, N, is derived from the instantaneous counting losses present in the system.

1. Introduction

Loss-free gamma-ray counting is a technique of correcting for system counting losses in real-time. The technique is particularly useful when measuring mixed radionuclides with very short half lives. In order to perform accurate quantitative pulse-height analysis measurements of short-lived neutron activation products under conditions of rapidly varying count rates, we have designed a loss-free counting module which interfaces pulse height nuclear ADCs to VMEbus memory. Several techniques for real-time correction of counting losses have been developed.[1-3] All employ add-N histogram memory where the integer weighting factor, N, is derived from the instantaneous counting losses present in the system.

The loss-free counting module provides the basis for a replacement control and data acquisition system at the Los Alamos Omega West Reactor. The system which has been in use for a number of years has been described elsewhere.[4] In short, the system is designed to automatically control sample irradiations and gamma-ray counting. The system utilizes a PDP-11* computer, a UNIBUS* programmable CAMAC branch driver, and several CAMAC crates. It is planned to replace all the above with a VMEbus based microcomputer. A VMEbus

* PDP-11 and UNIBUS are trademarks of the Digital Equipment Corporation.

system provides the versatility and excellent mechanical specification desirable for a replacement system. Most VMEbus system components required for this system are now commercially available; a suitable ADC interface is not.

2. Real-Time Correction of Counting Losses

Real-time correction of counting losses requires the generation of consecutive weighting factors W(t) of high statistical accuracy in millisecond time intervals. The weighting factors are generated from a clock signal (4MHz SERCLK) and a gating circuit which transmits clock pulses to a preset counter only during live-time intervals of the pulse-height analysis system. The number of clock ticks accumulated during this time in a second counter is equal to the value of the preset counter divided by the system live-time. The instantaneous weighting factor is just the accumulated clock ticks divided by the preset (gated) counter value. In order to generate an integer weight, the integer part of the weighting factor is added to histogram memory and its fractional remainder is added to the next weighting factor thus forming a new integer approximation of the true weight with each stored conversion.

As with any live-time generation system, the accurate derivation of system busy is crucial. We have included provisions for generating an extended busy signal as described by Westphal[5] in his Virtual Pulse Generator Method, and have utilized the same weight generation methods.

3. Loss-Free Counting Module

An add-N histogram memory controller was designed to histogram gamma-ray data using conventional pulse-height spectroscopy ADCs with a VMEbus computer system. As shown in Fig. 1, the controller is designed to interface to VME/VMXbus compatible dual ported memory. Our application utilizes a commercially available 128K byte static RAM module.[6] A block diagram of the module is shown in Fig. 2. The module employs a single VMEbus control register which specifies storage memory offset, ADC enable lines, and mode of operation bits. Mode bits allow add-1 or add-N histogramming and enable or disable extended busy generation.

The module uses an 8-bit adder with carry increment in order that memory may be incremented by weight factors of 1 to 255 in the modify portion of the

VMXbus Standard Indivisible Single Address Cycle. This allows the loss-free counting techniques described above to be utilized in addition to conventional add-1 histogramming. The weight generation circuitry is shown in Fig. 3. A new integer weight, N, is generated with each ADC conversion.

The controller is a VMXbus D32, IMA Master which accesses 32-bit longword locations in the accompanying memory. Since the ADCs are typically set for use at their maximum 13-bit conversion gain, 32Kbytes (8K longwords) of memory are utilized per spectrum, and up to four spectra can be accumulated in the histogram memory.

4. Summary

With the inclusion of multiple detector gamma-ray histogram capability on the VMEbus, a VMEbus based microcomputer system is being configured which will replace a PDP-11/CAMAC based data acquisition system. It is expected that UNIX** System V operating system software has all the "real-time" implementations necessary for our applications. Specifically shared memory segments, memory locking, and semaphores will allow software similar to our current RXS-11-based data acquisiton software to be written.

** UNIX is a trademark of Bell Telephone Laboratories.

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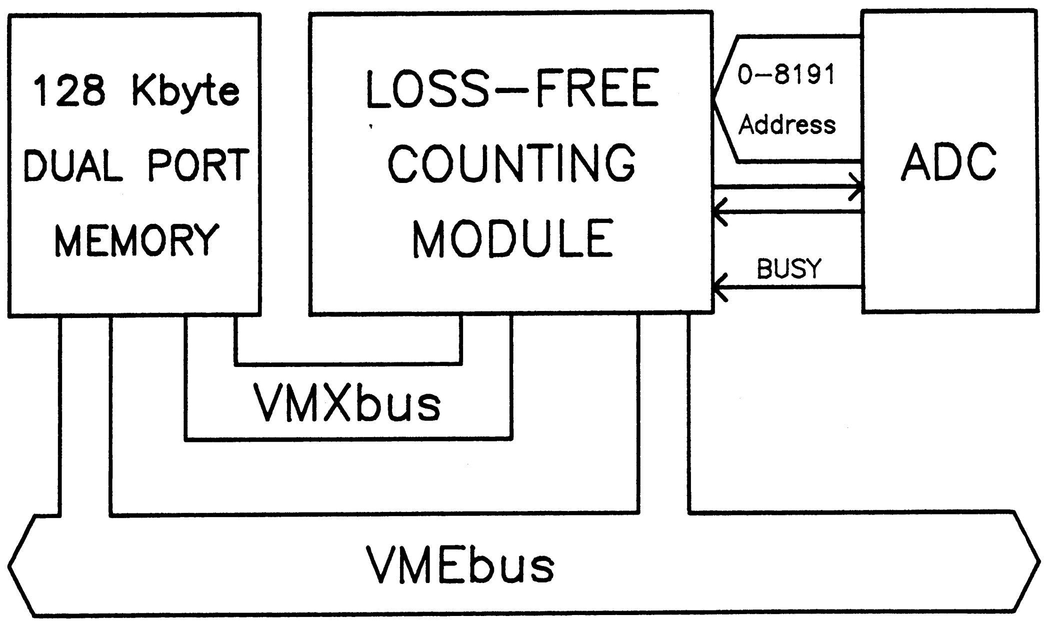

Fig. 1. Loss-Free Counting Module.

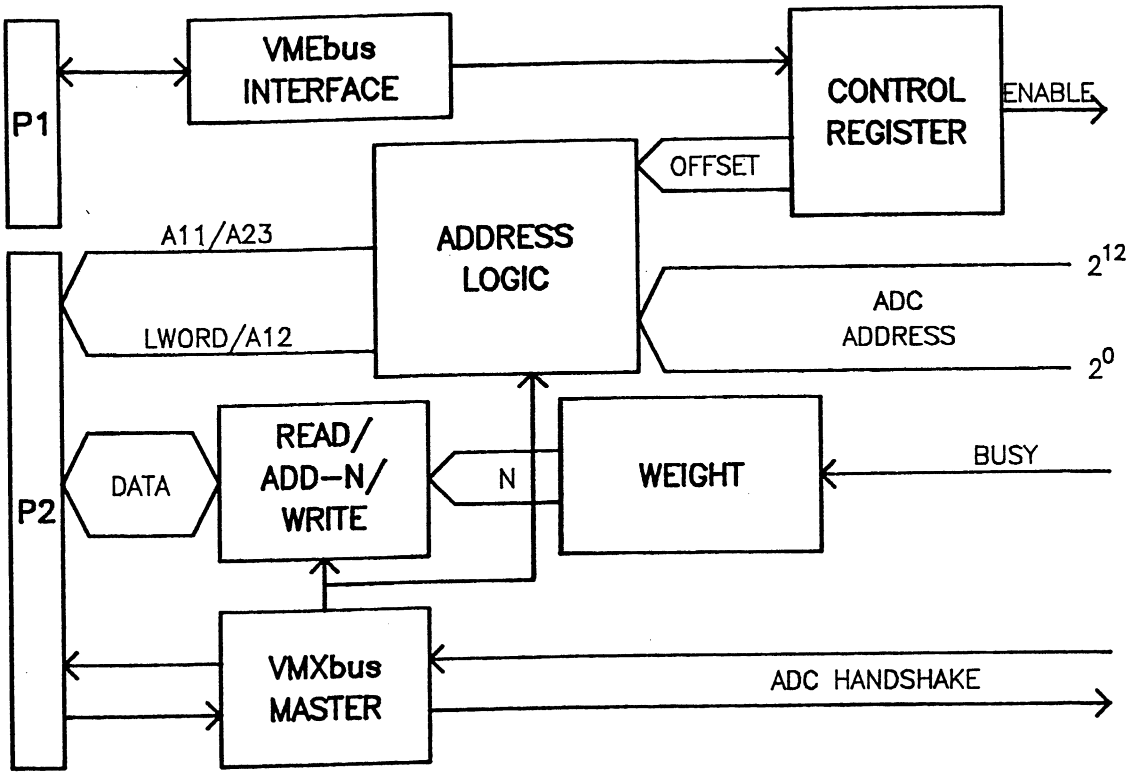

Fig. 2. Los-Free Counting Module block diagram.

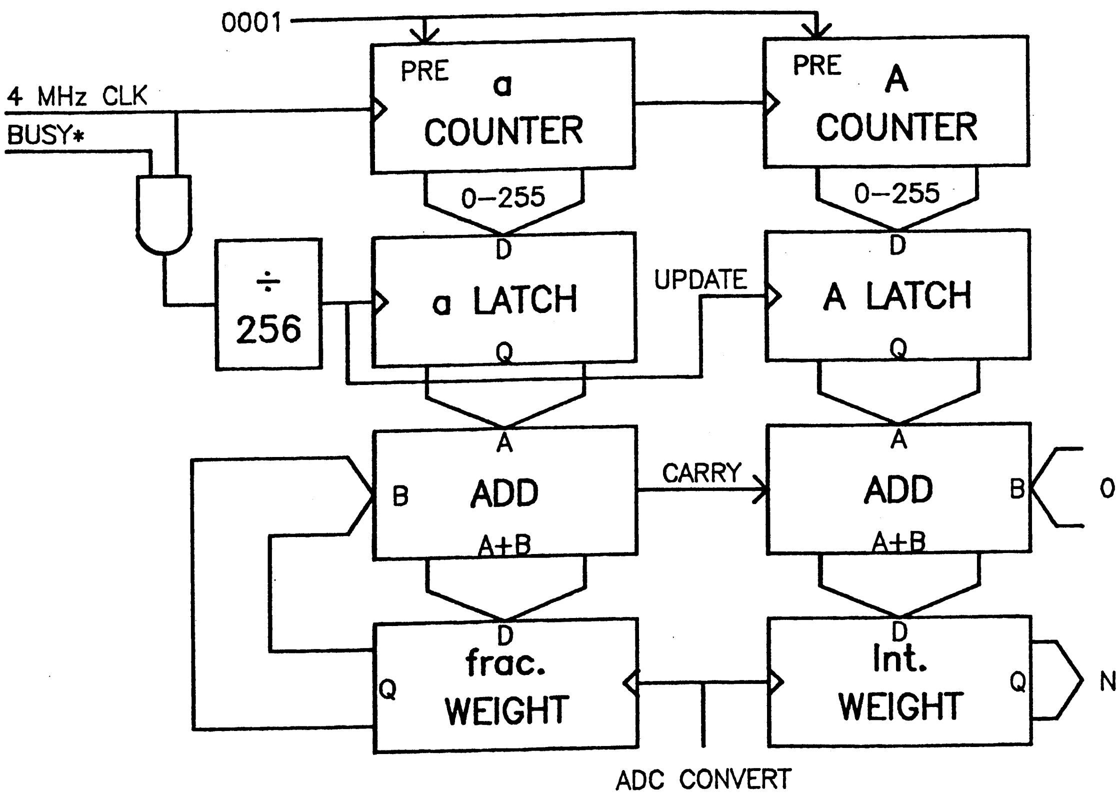

Fig. 3. Weight factor circuit block diagram.