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Multiplicity Sorter for Shift-Register Coincidence Electronics

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by

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ABSTRACT

A multiplicity sorter for the latest Los Alamos National Laboratory version of shift-register coincidence electronics is described. The multiplicity information taken from the coincidence-gate up-down counter is decoded and gated onto the output lines by prompt real-plus-accidental (R+A) and delayed accidental (A) strobes. Multiplicities of 0-7 and ≥ 8 are sorted for both the R+A and A gates.

I. INTRODUCTION

The latest Los Alamos National Laboratory shift-register coincidence electronics system for thermal neutron counters has been described in detail.^{1,2} For studies of neutron multiplication, it is desirable to measure the coincidence gate multiplicity distributions.³

A block diagram of the coincidence circuit and the multiplicity sorter is shown in Fig. 1. Every incoming pulse effectively opens two coincidence gates, one prompt and one delayed. The contents of the gates are monitored by the up-down counter. The prompt input pulse strobes the contents of the up-down counter into the real-plus-accidental (R+A) accumulator; after 1024 μ s, the delayed input pulse strobes the contents of the up-down counter into the accidental (A) accumulator.

The multiplicity distributions are obtained by decoding the contents of the up-down counter and gating the output lines with the R+A and A strobes. The lower six bits of the up-down counter, the R+A strobe, and the A strobe are buffered in the coincidence electronics package and are brought out on a ribbon

cable to a multiplicity decoding package, which is a custom-wired, double-width NIM module (Fig. 2).

After additional buffering in the nuclear instrument module (NIM), the multiplicity data are decoded and strobed onto nine output lines (0-7 and ≥ 8) for both the P+A and A gates. These 18 output lines are wired to LEMO connectors on the front panel of the NIM module.

A block diagram of the experimental multiplicity counting system is shown in Fig. 3. The 18 multiplicity output lines are connected to 3 CAMAC hex scalers (Kinetic Systems 3615) controlled by a Kinetic Systems 3988 crate controller. The entire system is under the control of an HP-85 desk-top computer, which is interfaced to the CAMAC crate on an HP-IB bus and is interfaced to the coincidence electronics package on an RS-232 line. The coincidence package has the new version of the PROM software that allows bidirectional communication on the PS-232 line.⁴

A. Circuitry

A schematic of the buffer circuitry added to the coincidence electronics package is shown in Fig. 4. Three sockets were installed in spare locations on the shift-register circuit board. Two of these hold 74LS366 hex drivers; the other is the socket for a 3-m-long, 16-wire ribbon cable that connects the coincidence package to the multiplicity decoding package.

The designations 3C, 2B, etc., refer to the integrated circuit location on the shift-register board. The pin numbers are indicated beside each wire. A schematic of the original shift-register board is shown in Ref. 5 (Dwg. No. D200734).

The up-down counter consists of two decade counters; the lower six bits therefore carry a maximum count of 39. (It was assumed that multiplicities >39 would be negligible.) The six bits corresponding to the 1, 2, 4, 8, 10, and 20 lines plus the R+A and A strobes are buffered and inverted by the 74LS366 drivers before being sent to the decoding module. The ribbon cable used for the transfer is wired for alternate signal and ground wires and is brought out of the coincidence package just under the top cover plate.

A schematic of the multiplicity decoding module is shown in Fig. 5. The eight incoming signal lines are terminated with 330- Ω resistors. All but the $\overline{10}$ and $\overline{20}$ lines are buffered by 74LS14 hex Schmitt-trigger inverters, whereas the $\overline{10}$ and $\overline{20}$ lines are buffered by a 74LS132 quad Schmitt-trigger NAND gate.

Two 74LS174 hex D-type flip-flops latch the multiplicity data when clocked by the R+A and A strobes; the latches store the multiplicity data for the duration of the R+A and A strobe pulses. After a 100-ns delay to allow the outputs of the latches to settle, the R+A and A strobes gate on the 74LS138 3-to-8 line decoders. Because the LS138s decode the 1, 2, and 4 lines to 0-7, multiplicities ≥ 8 must inhibit the decoder; this is accomplished by using the 8, 10, or 20 signals. Two 74LS240 octal buffers are used as line drivers for the 0-7 multiplicity pulses, which are sent through 50- Ω resistors to front-panel LEMO connectors for transfer through coaxial cables to the multiplicity scalars.

Two 74LS28 quad NOR buffers generate outputs for multiplicities ≥ 8 and ≤ 39 . The output buffer is enabled whenever 8, 10, or 20 is logical 1; the R+A and A strobes then produce the output pulses to the LEMO connectors.

The NIM module is powered from the +6 V supply; the +5 V supply voltage is obtained from an MJE3055 operated as a power diode.

B. Measurements

Table I shows a multiplicity measurement made with a PuO_2 sample in a thermal neutron counter. The total neutron counting rate was 29 250 pps and the coincidence gate length was 32 μs . The time, total counts, R+A coincidence counts, and A coincidence counts are from the standard coincidence electronics package; the multiplicities are from the new multiplicity sorter and CAMAC scalars. The maximum count per channel in the Kinetic Systems 3615 hex scalars is 2^{24} , so the overflows were scaled with HP-85 software.

Because every input pulse produces an R+A and A coincidence strobe, the sum of the multiplicity counts for either the R+A or A distributions must equal the total counts if the system is working correctly. This is easily verified for the example in Table I. No failure of this test has occurred in the first 6 months of operation.

C. Conclusions

The multiplicity sorter can be used to obtain reliable multiplicity data from shift-register coincidence electronics, with minor modification of the original shift-register board. The decoding, scaling, and readout circuitry can probably be packaged in a NIM module to avoid the use of a CAMAC system.

TABLE I
SAMPLE MULTIPLICITY DATA

Measurement time (s)	76 000
Total counts	2 226 135 758
R+A counts	2 299 510 651
A counts	2 086 564 893

Multiplicity	Counts	
	<u>R+A</u>	<u>A</u>
0	823 605 527	903 540 582
1	787 936 230	783 595 250
2	407 018 425	369 842 869
3	149 965 354	125 386 442
4	43 919 007	34 041 080
5	10 827 279	7 818 722
6	2 327 067	1 572 969
7	445 039	283 129
<u>>8</u>	91 830	54 715

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Fig. 1.
Block diagram of shift-register coincidence circuit and multiplicity sorter.

Fig. 2.
Modified shift-register board with cable and
custom-wired double-width NIM module.

Fig. 3.
Block diagram of experimental multiplicity counting system.

Fig. 4.
Schematic of buffer circuitry added to coincidence electronics package.

Fig. 5.
Schematic of multiplicity decoding module.