CONF-951073--5

A CMOS INTEGRATED CIRCUIT FOR PULSE-SHAPE DISCRIMINATION*

S. S. Frank, M. N. Ericson, M. L. Simpson, R. A. Todd, and D. P. Hutchinson
Oak Ridge National Laboratory, Oak Ridge, TN 37831

Abstract and Summary Submissions for:
IEEE Nuclear Science Symposium
San Francisco, CA
October 21-28, 1995

*Research sponsored by the U.S. Department of Energy and performed at Oak Ridge National Laboratory, managed by Martin Marietta Energy Systems, Inc. for the U.S. Department of Energy under Contract No. DE-AC05-84OR21400.

A CMOS Integrated Circuit for Pulse-Shape Discrimination

S. S. Frank, M. N. Ericson, M. L. Simpson,
R. A. Todd, and D. P. Hutchinson
Oak Ridge National Laboratory, Oak Ridge, TN 37831

A CMOS integrated circuit (IC) for pulse-shape discrimination (PSD) has been developed. The IC performs discrimination of gamma-rays and neutrons as part of a system monitoring stored nuclear materials. The method implemented extracts the pulse tail decay time constant using a leading edge trigger for identifying the start of the pulse and a constant fraction discriminator (CFD) to determine the zero crossing of the shaped signal. The circuit is designed to interface with two photomultiplier tubes -- one for pulse processing and one for coincidence detection. Two outputs from the IC, a start and stop, can be used with a high speed timing system for pulse characterization with minimal external control. The circuit was fabricated in Orbit 1.2μm CMOS and operates from a 5-V supply. Specifics of the design including overall topology, charge sensitive preamplifier and CFD characteristics, shaping method and time constant selections, system timing, and implementation are discussed. Circuit performance is presented including dynamic range, timing walk, system dead time, and power consumption.

ABSTRACT

Corresponding Author's Information:

S. Shane Frank
Oak Ridge National Laboratory
Bldg. 3500, MS 6006
P.O. Box 2008
Oak Ridge, TN 37831-6006
Ph. (615) 574-7660
Fax (615) 576-2813
e-mail: frank@icsun1.ic.ornl.gov

Topic: Nuclear Science Symposium: Analog and Digital Circuits
Note: Author would prefer a poster presentation.

A CMOS Integrated Circuit for Pulse-Shape Discrimination

S. S. Frank, M. N. Ericson, M. L. Simpson,
R. A. Todd, and D. P. Hutchinson
Oak Ridge National Laboratory, Oak Ridge, TN 37831

In some scintillators the pulse evolution characteristics are dependent upon the type of incident radiation. An analysis of the pulse shape from these scintillators can be used to identify the interacting particle[1]. Two methods employed for pulse-shape discrimination (PSD) are charge integration and tail pulse comparison. The charge integration method integrates the pulse at two different time-constants. The integrator with the largest time constant will collect most of the charge while the other will collect a smaller amount of charge. The fraction of total charge collected with the smaller time-constant integrator is used to differentiate between particles. This method has the disadvantage of being energy dependent. The tail pulse comparison method uses the decay time of the pulse to differentiate between particles and is independent of the pulse amplitude[2].

This paper presents a monolithic PSD for the Continuous Automated Vault Inventory System (CAVIS)[3]. The IC was optimized to perform discrimination of gamma-rays and neutrons as part of a system for monitoring stored nuclear materials. The circuit extracts timing information from pulses received from the photo-multiplier tube (PMT). Constant-fraction timing techniques are used to remove the pulse height dependence of the measurement[4]. Start and stop signals are collected using a multichannel scaler in another IC.

Fig. 1 shows a high level diagram of the PSD. Charge from the PMT is integrated by a pulsed-reset charge-sensitive preamplifier. The output of the preamplifier is differentiated, amplified by several gain stages, and then compared to a threshold voltage. If this signal is above the threshold and the coincidence signal is true, a start signal is generated and the zero-crossing comparator is armed. The coincidence circuit, shown in Fig. 2, is used to supresses noise firings of the start signal.

The output of the preamp is also bipolar shaped and the zero crossover is detected by the zero-crossing comparator. This zero-crossing time is dependent on the decay time of the input pulse and independent of the pulse amplitude. A stop signal is produced by the zero-crossing comparator if armed. The time between the start and stop signals is proportional to the decay time of the input pulse.

The start and stop signals can be used with a high speed timing system for pulse characterization with minimal external control. The circuit was fabricated in Orbit 1.2μm CMOS and operates from a 5-V supply. Specifics of the design including overall topology, charge sensitive preamplifier and CFD characteristics, shaping method and time constant selections, system timing, and implementation are discussed. Circuit performance is presented including dynamic range, timing walk, system dead time, and power consumption.

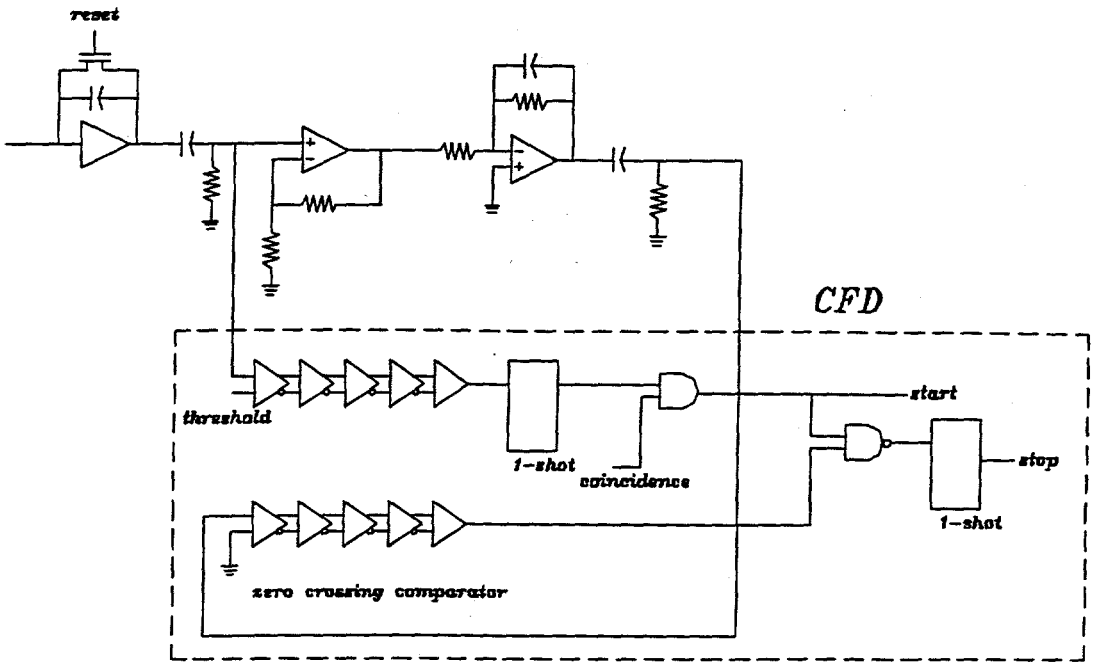

Fig. 1. PSD Integrated Circuit Diagram

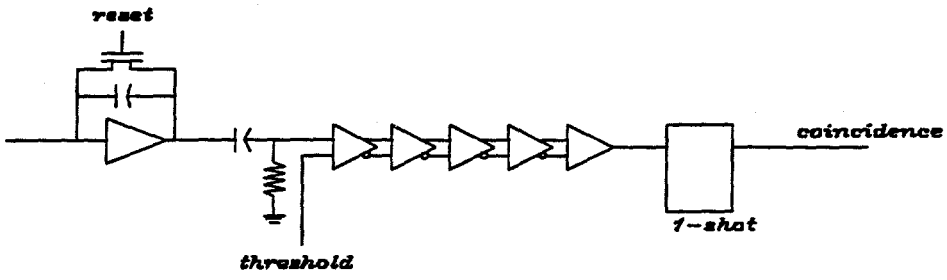

Fig. 2. Coincidence Circuit Diagram

References:

1. Bangjiao Ye et al., "Development of a pulse shape discrimination circuit", *Nuclear Instruments and Methods in Physics Research A345* (1994) 115.

2. Z. He, et al., "A ratio pulse-shape discriminator", *Nuclear Instruments and Methods in Physics Research A336* (1993) 236.

3. C. A. Pickett, et al., "A Continuous Automated Vault Inventory System (CAVIS) for Accountability Monitoring of Stored Nuclear Materials", Oak Ridge Y-12 Plant, Report Y/DW-1351.

4. M. L. Simpson, et al., "An Integrated, CMOS, Constant-Fraction Timing Discriminator for Multichannel Detector Systems", *Proceedings of the 1995 IEEE Nuclear Science Symposium and Medical Imaging Conference*, 1995.