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CONSTANT FRACTION DISCRIMINATOR

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TIME-WALK CHARACTERISTICS OF AN IMPROVED
CONSTANT FRACTION DISCRIMINATOR

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Abstract:

A modification to a constant fraction discriminator design published earlier makes the observed time walk less than 30 ps over an input voltage range of 0.15 to 2.5 V. This performance makes time-walk corrections unnecessary in many situations.

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Many interesting aspects of heavy-ion reactions can be investigated by measuring both the atomic number and mass of the reaction products¹⁻⁴. Very thin silicon detectors with exceptional uniformity ($\Delta T/T < 1\%$) are now commercially available which allow the identification of atomic numbers up to $Z \sim 40$. Furthermore, these detectors have good timing properties such that, when coupled to fast electronics, signal risetimes of < 2 ns and time resolutions of < 100 ps have been achieved^{2,4}. Ideally, to retain this time resolution over a wide range of input signal amplitudes, amplitude-dependent time-walk effects should be sufficiently small so that off-line corrections for these effects are not necessary. We would like to report here a modification of a constant fraction discriminator design published earlier⁵ which produces a dramatic improvement in performance. The modification consists simply of replacing two integrated circuits (AMD⁶ AM685) in the original design⁵ with faster integrated circuits (Plessey⁷ SP9685).

The time walk characteristics of the original and modified constant fraction discriminators (CFD) were measured using a fixed amplitude signal from a pulser with a fast risetime (~ 1.0 ns). This signal was fed into a 50Ω splitter. One of the output signals was kept constant in amplitude for all the measurements and was connected directly to a reference CFD. The other output of the splitter was connected to a precision attenuator (Wandel & Goltermann type RT-1 specially selected for low walk, < 30 ps) which fed directly the second CFD which had a clipping time of 1 ns. A biased time-to-amplitude converter (TAC) was started by

the reference CFD and stopped with the delayed output signal from the second CFD. The time walk of the second CFD was measured by varying the attenuation factor and measuring the centroid of the TAC peak. The time scale was calibrated with a precision delay line (0.50 ± 0.01 ns). For such a measurement it is essential that the input signal risetime and pulse shape do not depend on the attenuation factor.

In Fig. 1 the measured time walk is plotted versus the input signal amplitude. For the unmodified CFD, the measured time walk (triangles) is 500 ps over an input voltage range of 0.1 to 2.5V. For the modified CFD, the time walk (circles) is substantially reduced to less than 30 ps over the same dynamic range. For small signal amplitudes (<500 mV) these results are dependent on the settings of the leading-edge and zero-crossing discriminators. In Fig. 2a the dependence of the time walk on the leading edge discriminator threshold is shown. The observed time walk is a slowly varying function of the input signal amplitude above 150 mV. Below 150 mV, the time walk increases rapidly with decreasing signal amplitude and is quite sensitive to the LE discriminator setting. For a LE threshold of 5 mV (solid curve), the maximum time walk is 100 ps for input signals varying in amplitude from 50 mV to 900 mV. By increasing the LE discriminator threshold, the time walk can be reduced to less than 30 ps for all signals greater than 150 mV.

The dependence of the time walk on the zero-crossing (ZC) discriminator setting is shown in Fig. 2b. For the same LE threshold setting (i.e. LE = 5 mV, dotted curve), somewhat better

walk characteristics are observed (60 ps for an input voltage range of 80 to 900 mV) if the ZC discriminator threshold is offset (<0 mV) to trigger in the lower half of the noise. Also shown in Fig. 2c is the FWHM of the TAC peak (dashed curve) as a function of the input signal amplitude. This FWHM is constant (~ 20 ps) for input voltages above 300mV. Below 300mV the FWHM slowly increases from 20 to 40 ps, as the noise begins to dominate the time resolution.

In summary, we have shown that an easy and inexpensive modification to our published design⁵ substantially improves its time-walk characteristics. By optimizing the LE & ZC discriminator settings, a time walk of less than 30 ps can be obtained for input signal amplitudes from 0.15 to 2.5V.

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Figure Captions

- Fig. 1. Measured time walk versus input signal amplitude for the unmodified (triangles) and modified (circles) CFD.
- Fig. 2. Measured time walk a) for several leading-edge (LE) discriminator settings and b) for several zero-crossing (ZC) discriminator settings. The electronic time resolution (FWHM) is also shown in part c) for discriminator settings of LE = 5 mV and ZC = 0 mV.

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Fig. 1.

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Fig. 2.