

Single-Channel Pulse-Height Analyzers

The amplitude of the analog pulse at the output of a spectroscopy amplifier is typically proportional to the charge released in the detector or to the energy of the detected event. Selection of a range of signal levels at the output of the amplifier is equivalent to the selection of a range of energies or charge for these events. This selection can be accomplished by the use of discriminators and single-channel analyzers (SCAs). A discriminator produces an output logic pulse only if its input signal exceeds a preset threshold level. A single-channel analyzer produces an output logic pulse only if the peak amplitude of its input signal falls within the pulse-height window that is established with two preset threshold levels.

Figure 1 shows three pulses that might be provided from a main amplifier to an integral discriminator. The first pulse has an amplitude less than the adjusted discriminator threshold and generates no output logic signal. Each of the last two pulses has sufficient amplitude to produce an output logic signal. The output signals indicated in Fig. 1 are generated when the leading edge of the input signal crosses the discriminator threshold level. Therefore, the time of the output response is a function of the amplitude and rise time of the input signals. This amplitude and rise time dependence leads to "time walk" of the output signal relative to the beginning of the input pulse. The discriminator output is produced earlier by pulses with larger amplitudes and later by pulses with lower amplitudes.

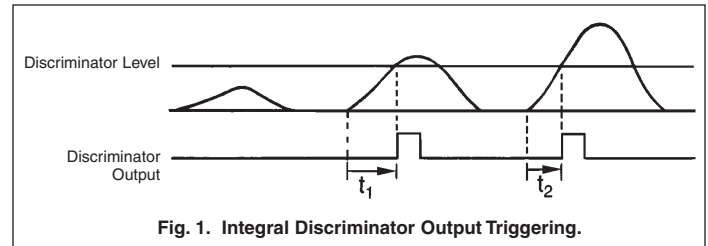


Fig. 1. Integral Discriminator Output Triggering.

Figure 2 shows three pulses that might be provided from a main amplifier to an SCA. Only the B pulse satisfies the conditions necessary to produce an SCA output logic signal.

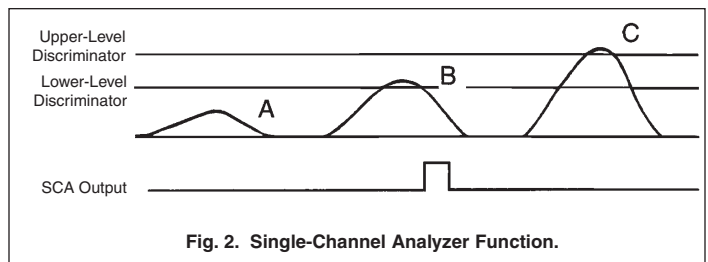


Fig. 2. Single-Channel Analyzer Function.

Removal of the upper-level-discriminator restrictions from the SCA allows it to be used as an integral discriminator. If the upper-level restrictions were removed from the unit whose output is shown in Fig. 2, both pulses B and C would be marked by logic outputs.

Three primary modes of discriminator operation are available in ORTEC SCAs: Integral, Normal, and Window. In the Integral mode of operation, the SCA can function as an integral discriminator, as indicated in the preceding paragraph. In the SCA Normal mode of operation, the upper-level and lower-level thresholds are independently adjustable. In the SCA Window mode, the upper-level threshold control is used to establish a voltage level that is added to the lower-level threshold voltage to yield the upper-level discriminator (ULD) threshold level. Thus, when the lower-level setting is changed, the upper-level threshold changes by the same amount. An external voltage reference for the lower-level discriminator (LLD) can be supplied to scan the window through a preselected range of pulse heights.

Unlike an integral discriminator, the output logic signal from a single-channel analyzer must be produced after the input pulse reaches its maximum amplitude. This timing sequence must provide sufficient time for the SCA logic circuitry to determine if the input signal exceeded the upper-level threshold.

ORTEC provides two basic types or classifications of SCAs: non-timing SCAs and timing SCAs. The technique used to produce the output logic signals from an SCA determines its classification. Non-timing units, such as the Models 550A, and 850, produce an SCA output pulse if the input signal is within the window settings. The output occurs when the trailing edge of the input signal recrosses the lower-level threshold. Figure 3 shows two superimposed output pulses from a main amplifier that meet the window requirements of the single-channel analyzer. The output from the non-timing SCA for each pulse is shown below the pulses. Since the linear input pulses

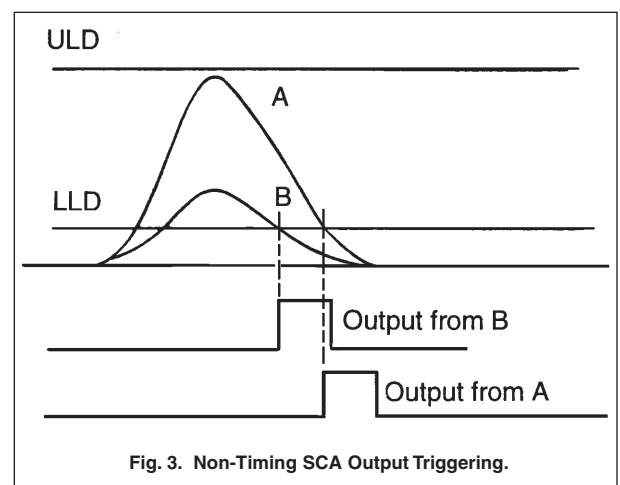


Fig. 3. Non-Timing SCA Output Triggering.

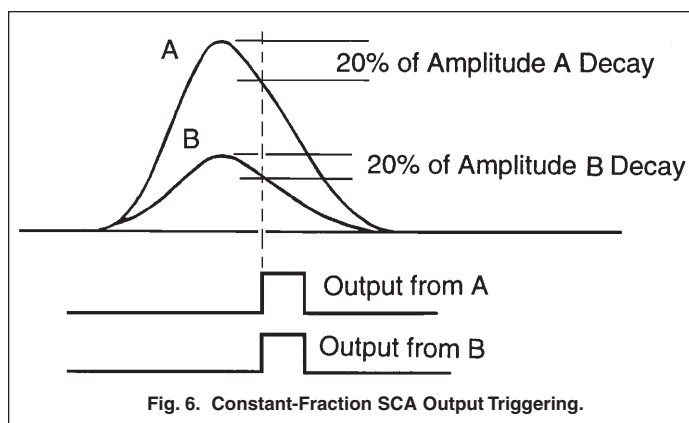
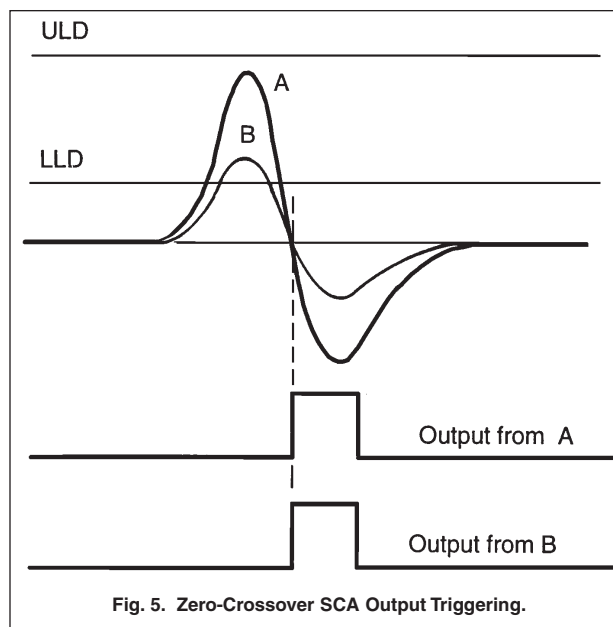
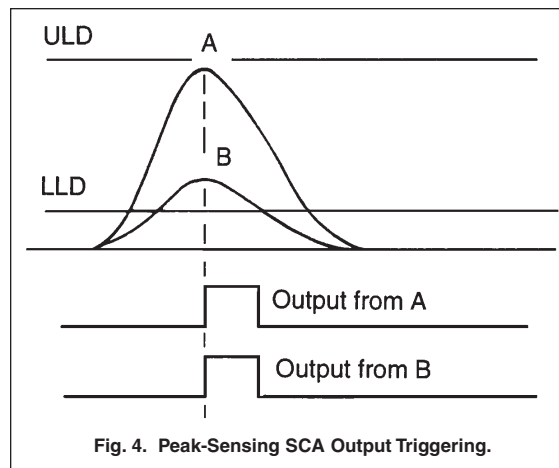
are referenced to the same starting time, it is clear that the output logic signals exhibit "time walk" relative to the input pulses.

Timing SCAs, such as the ORTEC Models 551, 552, and 590A, produce SCA output logic signals that are precisely related in time to the occurrence of the event being measured. This time relationship implies that the time of occurrence of the SCA output signal is "walk-free" or nominally independent of the amplitude of the input signal, for a given rise time. In addition to simple counting applications, the time-related output can be used for coincidence measurement, pulse-shape discrimination, and other applications where the precise time of occurrence is important.

Figure 4 shows two pulses from a main amplifier and the response for a peak-detection single-channel analyzer such as the Model 590A Amplifier and Timing Single-Channel Analyzer. Although the amplitudes of the amplifier pulses differ, their peaks occur at approximately the same time, and the SCA outputs are produced when the peaks of the input pulses are detected.

The conventional zero-crossing technique has been widely used for timing single-channel analyzers. This technique utilizes the zero-crossing of the bipolar output signal from a pulse-shaping amplifier to derive timing information, and uses the peak amplitude of the pulse for the energy range information. Figure 5 shows two bipolar pulses provided from a main shaping amplifier. Both pulses meet the SCA window requirements. Each output signal is generated when the corresponding input signal crosses the baseline. Figure 5 illustrates that the time of occurrence of the SCA output signals is precisely related to the occurrence of the detected event and is independent of input signal amplitude. Either double-delay-line-shaped pulses or RC-shaped pulses may be used, but the former provide better timing resolution. The bipolar output from delay-line amplifiers such as the Model 460 is well suited to zero-crossover timing with the ORTEC Model 552, because the input signal crosses the baseline with a large slope even when the pulse amplitude is low.

The bipolar output signal from a double-delay-line shaping amplifier crosses the baseline at a fixed fraction that is effectively 50% of the charge collected from the detector. Thus, conventional zero-crossing timing can be considered as timing at a constant fraction of the input signal amplitude. A trailing-edge constant-fraction technique* can be used with either unipolar or bipolar signals to derive a time-pickoff pulse after the peak time of the signal from the shaping amplifier. This technique is extremely useful when incorporated in timing single-channel analyzers. Figure 6 illustrates the trailing-edge constant-fraction technique for two unipolar input signals of identical rise times but different amplitude. The time of occurrence of the output signals is independent of output signal amplitudes.



*The basic circuit for implementing this technique is patented by ORTEC, U.S. Patent No. 3,714,464.

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The trailing-edge constant-fraction timing technique is available with two ORTEC SCAs: Models 551 and 552.

The Model 552 can also be used as a pulse-shape analyzer. The best known application of this technique is in the separation of the neutron and gamma responses of some scintillators. Collection time differences for the two types of radiation result in shape or rise time variations in the signals from a spectroscopy amplifier. When used with an ORTEC Time-to-Amplitude Converter, the Model 552 can resolve these shape variations over a 200:1 dynamic range of input signal amplitudes. The Model 552 accomplishes the shape measurement of the input signals by evaluating the timing at two different fractions.

The SCA function can also be applied to fast analog signals in rising-edge constant-fraction discriminators.

Single-Channel Analyzer Applications Guide

Model	Recommendations
550A	Versatile, economical, general-purpose counting.
551	SCA plus constant-fraction timing.
552	SCA plus constant-fraction timing and pulse-shape analysis.
583B	SCA function in a fast-timing constant-fraction discriminator for signals from a photomultiplier anode.
590A	Cost efficient, includes built-in amplifier.
850	Economical, four SCAs in a single-width module for general-purpose counting.

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Single-Channel Analyzer Selection Guide					
Model	550A	551	552	590A	850
SCA Output Trigger	LLD reset	Constant fraction (50%)	Selectable constant fractions (2), or zero crossing	Peak detect	LLD reset
Modes	Asymmetric window, symmetric window, normal or integral	Window, normal or integral	Window, normal or integral	Window or integral	Window, normal or integral
Lower-Level Range (V)	0.02–10 (10-turn)	0.05–10 (10-turn)	0.04–10 (10-turn)	0.05–10 (10-turn)	0.02–9.99
Upper-Level Range (V)	0–10 or 0–1 (10-turn)	0–10 or 0–1 (10-turn)	0–10 or 0–1 (10-turn)	0–10 or 0–1 with internal jumper (10-turn)	0.02–9.99
Delay Range	None	0.1–1.1 μ s 1–11 μ s (10-turn)	0.1–1.1 μ s (10-turn)	None	None
Input Coupling	dc	ac or dc	dc	Input directly coupled to amplifier output	dc
External Strobe	No	Yes	Yes	No	No
External Baseline	Yes	Yes	Yes	Yes	Yes
Integral Non-Linearity (%)	$\leq \pm 0.25$	$\leq \pm 0.25$	$\leq \pm 0.25$	$\leq \pm 0.25$	$\leq \pm 0.25$
SCA Output Polarity	Positive	Positive and Negative	Positive and Negative	Positive	Positive

Specifications subject to change
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