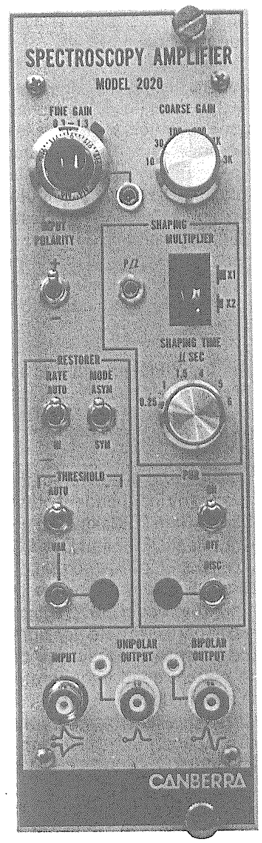
Model 2020 Spectroscopy Amplifier



Features

- Pile up rejection/Live time correction
- 12 selectable shaping time constants
- Super Fine Gain Control
- Unique active baseline restorer with:
  1. Automatic or fixed restorer rates
  2. Automatic or manual threshold
  3. Selectable symmetry
- Noise $\leq 3.4\ \mu V$
- DC drift $\leq \pm 10\ \mu V/°C$

Description

The Canberra Model 2020 Spectroscopy Amplifier offers the modern spectroscopist more performance, features and flexibility than any other nuclear pulse amplifier available today. Functionally, the Model 2020 provides in a double width NIM module an exceptional spectroscopy amplifier, a gated active baseline restorer, a pulse pileup rejector and a live time corrector.

Canberra's near-Gaussian filter shaping, well known and now emulated by others in the industry, has been refined in the Model 2020 for improved pulse symmetry, minimum sensitivity of output amplitude to variations in detector rise time, and maximum signal to noise ratio. For a given shaping time constant, the improved pulse symmetry minimizes the pulse dwell time by tucking in the trailing skirt of the unipolar pulse shape. This allows a faster return to the baseline. The result is superior energy resolution, count rate, and throughput performance. Unipolar shaping is achieved with one differentiator and two active filter integrators. The differentiator is placed early in the amplifier to insure good overload recovery. The integrators are placed late to minimize noise contribution from the gain stages. The amplifier offers 12 front panel switch selectable pulse SHAPING time constants of 0.25, 0.5, 1, 1.5, 2, 3, 4, 5, 6, 8, 10 and 12 μs.

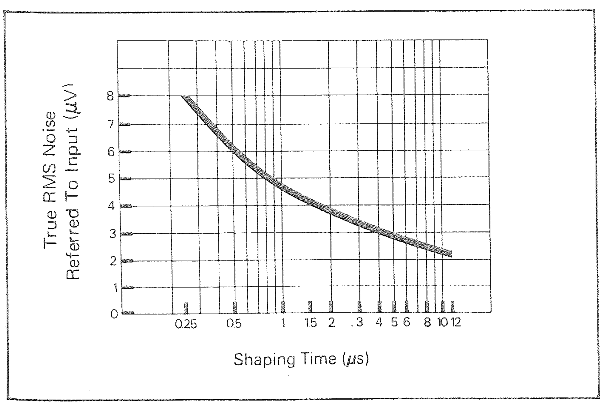


Figure 1.
Typical Model 2020 Unipolar Output True rms Noise (referred to input for gain of 100) vs. Shaping Time constant.

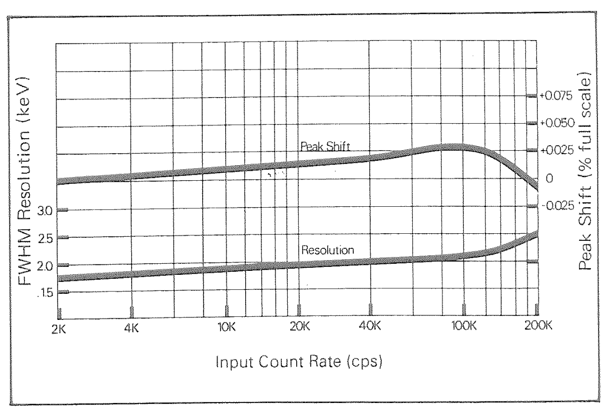


Figure 2.
Typical Model 2020 Resolution and Peak Shift Stability vs. Counting Rate for 2 μs shaping, AUTO Restorer Rate, AUTO Restorer Threshold, ASYM Restorer Mode and a 1.33 MeV ^{60}Co Gamma Peak.

The gated dc restorer offers automatic features on both the restorer threshold and restorer rate, assuring the best possible low and high count rate performance. Amplifier performance is very much dependent on the restorer rate and threshold settings, so the 2020 includes circuitry which continuously samples the amplifier output noise and count rate, and automatically sets the respective restorer threshold and rate with precision for optimum performance. The restorer is also flexible: the discriminating researcher can overide the automatic restorer features. Setting the RESTORER RATE and THRESHOLD switches to their manual positions High and VARiable respectively, allows manual optimization. A front panel LED is provided as a user aid when setting the restorer threshold manually.

The flexibility of the restorer is further enhanced by providing SYMmetrical or ASYMmetrical restorer modes. The symmetrical restorer mode is used for detector systems which exhibit baseline discontinuities resulting from excessive noise and/or high voltage effects, preamp reset pulses and preamp secondary time constants. The asymmetrical restorer mode virtually eliminates charge accumulation and correlated noise on the restorer holding capacitor. This restorer mode is especially suited for use with high resolution detector systems that exhibit minimal baseline discontinuities and whose signals have a clean monotonic return to the baseline. The result is superior resolution/count rate performance when compared to more conventional methods.

Simultaneous UNIPOLAR and BIPOLAR outputs are available at both front and rear panel BNC connectors. The unipolar signal can be delayed 2 μs, or with the 2020-4 option by 4 μs. The bipolar output can be used for counting, timing, or gating.

The internal live time corrector and pileup rejector allows quantitative gamma spectrum analysis nearly independent of system count rate. By connecting the ADC's Linear Gate (LG) signal to the Model 2020 and connecting the Model 2020's REJECT and Dead Time (DT) signals to the ADC and live timer, the Model 2020 and associated ADC together perform pileup rejection and live time correction. During the amplifier and ADC processing time, the Model 2020 inspects for pileup and permits the ADC to convert only those detector signals resulting from a single energy event. To compensate for rejected pulses and amplifier and ADC dead times, a system dead is generated by the live time correction function. The system dead time is the composite dead time of the ADC and Model 2020, extending the collection time by the appropriate amount. A front panel LED is provided as a user aid when setting the PUR DISCriminator.

The Model 2020's exceptional dc stability and ultra low noise ensure that optimum performance is realized. Together with its broad gain range (X3 to X3900), 12 shaping time constants, pileup rejection and live time correction, the Model 2020 offers uncompromising performance when used with Germanium, Silicon, Scintillation, Gas Proportional and Surface Barrier detectors.

Specifications

INPUTS

INPUT - Accepts positive or negative pulses from an associated preamplifier; amplitude: ±10 V divided by the selected gain, ±12 v maximum; rise time: less than SHAPING time constant; decay time constant: 40 μs to ∞ for 0.25, 0.5, 1, 1.5, 2, 3, and 4 μs shaping time constants, 100 μs to ∞ for 5, 6, 8, 10 and 12 μs shaping time constants; input impedance: ≈ 1 kilohm; front and rear panel BNC connectors.

LG (LINEAR GATE) - Receives a standard TTL logic signal from the ADC. Indicates to the Model 2020 that the ADC has accepted and is processing an event; input is TTL compatible, logic low when ADC accepts input, returning to a logic high at the conclusion of the ADC acquisition cycle; accessible through rear panel PUR Connector.

PUR INHIBIT - Receives a standard TTL logic signal from associated pulsed optical feedback preamplifier used to extend the Model 2020 DT signal, inhibit and reset the pileup rejector during the preamplifier's reset cycle; internal jumper selects the option of either positive true or negative true logic pulses; rear panel BNC connector.

OUTPUTS

UNIPOLAR OUTPUT - Provides positive, linear actively filtered near-Gaussian shaped pulses; amplitude linear to +10 V, 12 V max.; dc restored; output dc level factory calibrated to 0 ± 5 mV, front panel output impedance less than 1 ohm or ≈ 93 ohms, internally selectable; rear panel output impedance ≈ 93 ohms; short circuit protected; prompt or delayed 2 μs (4 μs with 2020-4 option); front and rear panel BNCs.

BIPOLAR OUTPUT - Provides prompt positive lobe leading linear active filter bipolar shaped pulses; amplitude linear to +10 V, 12 V max., negative lobe is approximately 70% of positive lobe; dc coupled; output dc level ± 25 mV; front panel output impedance <1 ohm or ≈ 93 ohms; internally selectable; rear panel output impedance ≈ 93 ohms; short circuit protected; front and rear panel BNCs.

DT (DEAD TIME) - Provides a negative logic signal and when "OR"ed together with the ADC dead time, at the ADC's live timer, provides live time correction for the amplifier and pileup rejector. Open collector with 1 kilohm pull up resistor through 47 ohm output resistor. Logic low when system is busy, logic high otherwise. BNC connector located on rear panel.

REJECT - Provides a standard TTL logic signal used to initiate an ADC reject sequence for corresponding piled up events; internal jumper selects positive true or negative true logic pulse; 50 ohm output impedence. Accessible through rear panel PUR Connector.

ICR (INCOMING COUNT RATE) - Provides a standard TTL logic signal corresponding to input count rate, positive true, width nominally 150 ns, 50 ohm output impedance; rear panel BNC connector. PUR must be selected.

FRONT PANEL CONTROLS

COARSE GAIN - 6-position rotary switch selects gain factors of X10, X30, X100, X300, X1000 and X3000.

FINE GAIN - Ten-turn locking dial precision potentiometer selects variable gain factor of X0.3 to X1.3; resetability ≤ 0.03%.

SUPER FINE GAIN - 22-turn screwdriver potentiometer to select gain with an adjustment resolution of better than 1 in 16 000 or 0.0063%.

INPUT POLARITY - 2-position toggle switch to set the Model 2020 for the polarity of the incoming preamplifier signal.

P/Z - 22-turn screwdriver pole zero potentiometer to optimize amplifier baseline recovery and overload performance for the preamplifier fall time constant and the Model 2020's pulse shaping chosen; 40 μs to ∞ for 0.25, 0.5, 1, 1.5, 2, 3 and 4 μs SHAPING time constants, 100 μs to ∞ for 5, 6, 8, 10 and 12 μs SHAPING time constants.

SHAPING TIME - 6-position rotary switch; provides 0.25, 1, 1.5, 4, 5 and 6 μs basic shaping time constants.

MULTIPLIER - Multiplies SHAPING TIME setting by X1 or X2 giving additional shaping time constants of 0.5, 2, 3, 8, 10 and 12 μs, a total of 12 shaping time constants.

RESTORER RATE - 2-position toggle switch to set the baseline restorer rate (slew rate); AUTO: the baseline restorer rate is automatically optimized by internal circuitry as a function of unipolar output signal duty cycle and count rate; High: when selected sets the baseline restorer to a fixed high rate.

RESTORER MODE - 2-position toggle switch to select SYMmetrical or ASYMmetrical baseline restorer modes.

THRESHOLD AUTO/VAR - 2-position toggle switch to set the baseline restorer threshold; AUTO: the baseline restorer threshold is automatically optimized by internal circuitry as a function of the unipolar output signal noise level; VARiable: provides a manual variable baseline threshold adjustment range of 0 V to 200 mV dc. The negative (referenced to the UNIPOLAR OUTPUT) threshold is set at -500 mV dc. An LED indicator is provided as a user-aid for set up convenience.

PUR ON/OFF - 2-position toggle switch to enable (ON) or disable (OFF) the pileup rejector and live time corrector.

PUR DISC - 22-turn screwdriver adjustment potentiometer for optimizing the pileup rejector discriminator threshold level. Provides a variable range of 0 to 550 mV. An LED indicator is provided to aid the user when setting the PUR DISC just above the system noise.

INTERNAL CONTROLS

UNIPOLAR DELAY - 2 jumper plugs provided to select UNIPOLAR output to prompt (OUT) or delayed 2 μs (IN), or 4 μs on option 2020-4. Shipped in the prompt (OUT) position.
UNIPOLAR Z_{out} - Jumper plug provides $Z_{out} \leq 1$ ohm or ≈ 93 ohms for the front panel BIPOLAR output. Shipped in the ≤ 1 ohm position.
BIPOLAR Z_{out} - Jumper plug provides $Z_{out} \leq 1$ ohm or ≈ 93 ohms for the front panel BIPOLAR output. Shipped in the ≤ 1 ohm position.
INB-INB/ - Jumper plug J5 allows the PUR INHIBIT input to accept either positive true or negative true logic signals. Shipped in the INB (positive true) position.
REJ-REJ/ - Jumper plug J6 allows the reject output to be a positive true or negative true logic signal. Shipped in the REJ (positive true) position.
L/E - Jumper plug J7 selects a linear or exponential restorer response. Shipped in the L (linear) position.

PERFORMANCE

Amplifier

GAIN RANGE - Continuously variable from X3 to X3900.
OPERATING TEMPERATURE RANGE - 0 to 50°C.
GAIN DRIFT - $\leq \pm 0.0075\%/°C$.
DC LEVEL DRIFT - UNIPOLAR output: $\leq \pm 10$ μV/°C; BIPOLAR OUTPUT: $\leq \pm 50$ μV/°C.
INTEGRAL NON-LINEARITY - $\leq \pm 0.05\%$, over total output range for 2 μsec shaping.
CROSSOVER WALK - BIPOLAR output: $\leq \pm 3$ ns for 50:1 dynamic range and 2 μs shaping when used with Canberra Model 2037A Edge/Crossover Timing Single Channel Analyzer.
OVERLOAD RECOVERY - UNIPOLAR (BIPOLAR) output recovery to within $\pm$ 2% (1%) of full scale output from X1000 overload in 2.5 (2.0) non-overloaded pulse widths, at full gain, any shaping time constant and pole-zero cancellation properly set.
NOISE CONTRIBUTION - ≤ 3.2 μV true rms UNIPOLAR (7.1 μV BIPOLAR) output referred to input, 3 μs shaping and amplifier gain ≥ 100.
PULSE SHAPING - Near-Gaussian shape; one differentiator (two for bipolar), two active filter integrators; UNIPOLAR time to peak: 2.35X shaping time; pulse width: 7.3X shaping time; BIPOLAR time to crossover: 2.8X shaping time, time to peak, pulse width and crossover times measured at 0.1% of full scale output.
RESTORER - Active gated.
*SPECTRUM BROADENING - The FWHM of a ^{60}Co 133 MeV gamma peak for an incoming rate of 2 kcps to 100 kcps and a 9 V pulse height will typically change less than 14% for 2 μs shaping, AUTO Restorer Rate, AUTO Restorer Threshold and ASYM Restorer Mode.
COUNT RATE STABILITY - The peak position of a ^{60}Co 1.33 MeV gamma peak for an incoming count rate of 2 kcps to 100 kcps and 9 V pulse height will typically shift less than 0.024% for 2 μs shaping, AUTO Restorer Rate, AUTO Restorer Threshold and ASYM Restorer Mode.

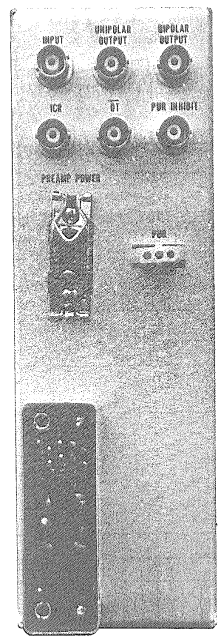
*Note: These results may not be reproducible if associated detector exhibits an inordinate amount of long rise time signals.

Pileup Rejector/Live Time Corrector

PULSE PAIR RESOLUTION - ≤ 500 ns.
MINIMUM DETECTABLE SIGNAL - Limited by detector/preamp noise characteristics.
ADC INTERFACE - Compatible Canberra ADCs are available and can be ordered using the following designations:
Model 8075
Model 8076
Model 8077
Series 35 PLUS MCA
For use with older Canberra systems, detailed instructions are provided in the 2020 manual to allow the user to adapt his ADC to interface with the Model 2020 for pileup rejection and live time correction.

CONNECTORS

With the exception of the PUR and PREAMP POWER connectors, all signal connectors are BNC type.



PUR - Molex plug 03-06-1031.
PREAMP POWER - Rear panel, Amphenol, type 17-10070.
ACCESSORIES - C1514 PUR/LTC and DT cables.

POWER REQUIREMENTS

+24 V dc — 130 mA +12 V dc — 150 mA
-24 V dc — 165 mA -12 V dc — 80 mA

PHYSICAL

SIZE - Standard double-width NIM module 6.86 X 22.12 cm (2.70 X 8.71 inches) per TID-20893 (rev.)
NET WEIGHT - 1.3 kg (2.9 lbs.)
SHIPPING WEIGHT - 2.3 kg (5.0 lbs.)

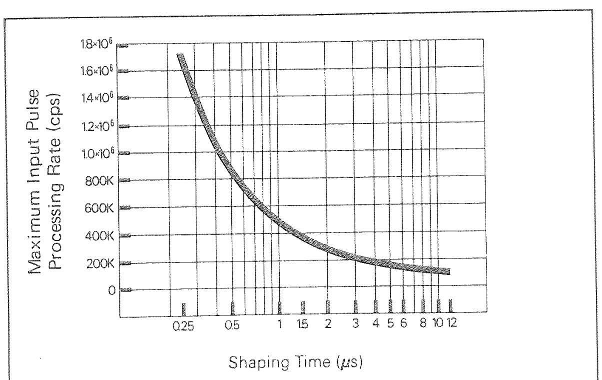


Figure 3.
Typical Model 2020 Maximum Input Pulse Processing Rate versus shaping time constant.

*Maximum Input Pulse Processing Rate: Maximum amplifier input count rate (pulses per second) for which the amplifier's dc restorer maintains the baseline at ground reference.

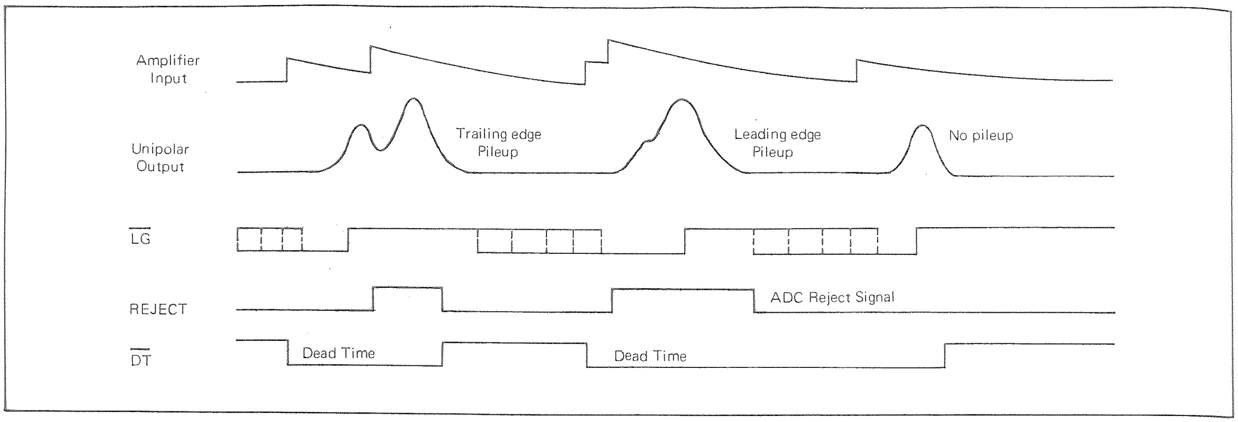


Figure 4.
Relationship of Amplifier and Pileup Rejector Signals.

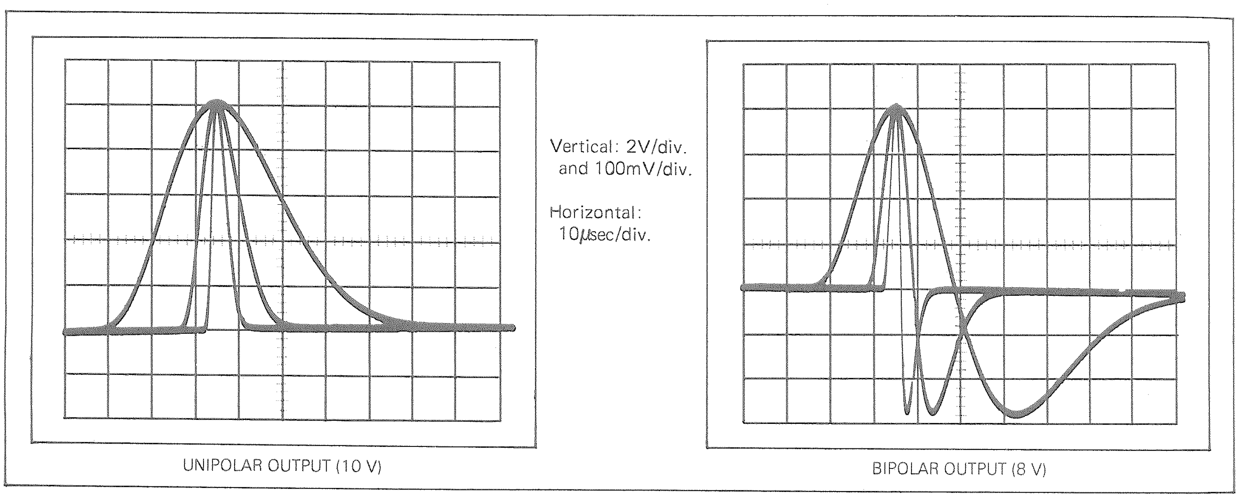


Figure 5.
Model 2020 SHAPING selected for 12, 4 and 1.5 μs.

During the amplifier and ADC processing time, the Model 2020 inspects for pileup and permits the ADC to convert only those detector signals resulting from a single energy event, see Figure 6.

Note the reduction in amplitude of both sum peaks and background. Also note the improved resolution of the sum peaks. The background reduction and improved resolution are directly indicative of the Pileup Rejector's capabilities, since only sum peak pulses which are indeed 100% in coincidence should be processed.

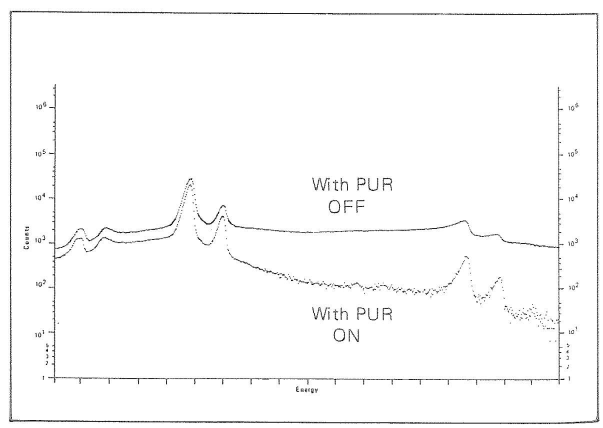


Figure 6.
^{57}Co spectrum at 80 kcps and 4 μs shaping.

Detector: Canberra Model GC2020
MCA: Canberra Model 9102
Amplifier: Canberra Model 2020
Spectrum: ^{57}Co at 60 kcps

Timing Single-Channel Analyzer

The EG&G ORTEC Model 551 Timing Single-Channel Analyzer performs the dual functions of single-channel pulse-height analysis and timing signal derivation.

The patented* trailing-edge constant-fraction timing technique provides unexcelled timing on either unipolar or bipolar signals and shows better results than are possible with conventional leading-edge discriminators.

With SCAs that utilize leading-edge timing, the rise time of the input pulses causes degradation of time resolution because the pulses have varying amplitudes.

Constant-fraction timing compensates for varying amplitudes and essentially eliminates this timing shift, giving consistently better timing results.

For the internally set 50% fraction, the output occurs soon after the midpoint on the linear input trailing edge to facilitate gating and accumulation of data at very high input rates. This technique also minimizes timing shift and dead time when used with sodium iodide, silicon, and germanium detectors, thereby allowing better system time resolution and higher counting rates.

The constant-fraction technique makes it possible to realize significant improvements in time resolution in most timing applications. Notice that analysis is made of the main amplifier output. This technique allows optimization of time resolution and extension of dynamic range for neutron-gamma discrimination and other timing applications. Walk of <3 ns for 100:1 dynamic range using input pulses from a pulser is possible.

The Model 551 is versatile, with three basic operating modes provided. In the Window mode, the unit operates as a high-resolution, narrow (0 to 10%) window, single-channel analyzer. For wide-window applications, the Normal mode is used. In this mode the upper-level and lower-level controls are independently variable from 0 to 10 V, and an output is generated for pulses analyzed between the levels. Through use of the separate rear-panel LL Out and UL Out outputs, the unit can operate as a dual wide-dynamic-range integral discriminator for leading-edge timing or for pulse routing.

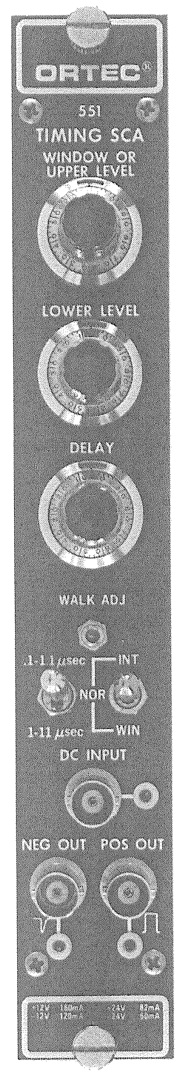
The dc-coupled input of the Model 551 makes it possible to take full advantage of the baseline restoration of the main amplifier for maximum performance at widely varying counting rates.

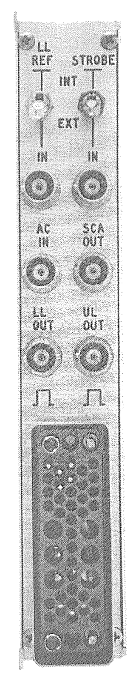
The continuously adjustable output delay (two ranges covering 0.1 to 11 μs) makes it possible to align output signals that have actual time differences without a need for additional delay devices or modules. Alternatively an External strobe input can be used to cause an SCA output at the desired time.

For an application where it is desirable to scan an entire spectrum, an external base-line sweep input is provided via the rear-panel LL Ref Ext BNC connector. In this mode of operation, the baseline (lower-level threshold) on which a window is riding is swept through an energy range and the count rate is recorded as a function of energy.

*U.S. Patent No. 3,714,464.

- **Single-channel analyzer and timing signal derivation**
- **Trailing-edge constant-fraction timing provides walk <±3 ns for 100:1 dynamic range**
- **Integral, normal, and window modes**
- **Separate lower-level and upper-level discriminator outputs**
- **DC-coupled**
- **Adjustable delay 0.1 to 11 μs**
- **Provision for external baseline sweep**





551
Timing Single-Channel Analyzer (continued)

Specifications

PERFORMANCE

DYNAMIC RANGE 200:1.

PULSE-PAIR RESOLVING TIME Output pulse width plus Delay (as selected by the front-panel Delay controls), plus 100 ns for fast NIM output or plus 200 ns for positive NIM output. Minimum resolving time for negative output 220 ns; for positive output 800 ns.

THRESHOLD TEMPERATURE INSTABILITY ≤±0.01%/°C of full scale, 0 to 50°C using a NIM Class A power supply (referenced to −12 V).

DISCRIMINATOR NONLINEARITY ≤±0.25% of full scale (integral) for both discriminators.

DELAY TEMPERATURE INSTABILITY ≤±0.03%/°C of full scale, 0 to 50°C.

DELAY NONLINEARITY <±2% of delay range.

WINDOW WIDTH CONSTANCY ≤±0.1% variation of full-scale window width over the linear range 0 to 10 V.

MINIMUM INPUT THRESHOLD 50 mV for lower-level discriminator.

TIME SHIFT vs PULSE HEIGHT (WALK)

Walk (ns) System A	Walk (ns) System B	Dynamic Range
±1.0	±2.0	10:1
±2.5	±4.0	50:1
±3.0	±8.0	100:1

System A: Using an EG&G ORTEC Model 460 Amplifier, single delay-line mode, integrate ≤0.1 µs with 1-µs delay line.

System B: Using an EG&G ORTEC Model 570, 571, or 572 Amplifier, unipolar output with 0.5-µs shaping time. Input from EG&G ORTEC Model 419 Pulser.

CONTROLS

LOWER LEVEL Front-panel 10-turn potentiometer adjustable from 0 to 10 V; when the rear-panel LL Ref mode switch is set on Int, determines the threshold setting for the lower-level discriminator. When the LL REF mode switch on the rear panel is in the EXT position, this control is ineffective.

WINDOW OR UPPER LEVEL Front-panel 10-turn potentiometer determines the window width (0 to +1 V) in the Window mode or the upper-level (0 to +10 V) threshold in the Normal mode. This control is disabled in the Integral mode.

INT/NOR/WIN Front-panel 3-position locking toggle switch selects one of three operating modes:

Integral LL sets a single-discriminator threshold (0 to +10 V) and UL is disabled.
Normal UL and LL are independently adjustable levels (0 to +10 V).
Window LL sets the baseline level (0 to +10 V) and UL sets the window width (0 to +1 V).

DELAY RANGE Front-panel locking toggle switch selects delay ranges of 0.1 to 1.1 µs or 1.0 to 11 µs.

DELAY Front-panel 10-turn potentiometer for continuous adjustment of output delay over selected range. In the external strobe mode the delay control adjusts the automatic reset time from ≈5 µs to 50 µs.

WALK ADJUST Front-panel screwdriver adjustment for precise setting of walk compensation.

LL REF MODE Rear-panel 2-position locking toggle switch selects either the front-panel LL potentiometer or the voltage signal applied to the rear-panel LL REF EXT connector as the LL discriminator reference threshold.

STROBE Rear-panel 2-position locking toggle switch selects either Internal or External source for the SCA output signal strobe function.

INPUTS

SIGNAL INPUT Front-panel dc-coupled BNC connector accepts positive unipolar or bipolar signal, 0 to +10 V linear range, ±12 V maximum; width 100 ns; 1000-Ω input impedance. Rear-panel ac-coupled BNC connector accepts positive unipolar or bipolar signal, 0 to +10 V linear range, ±100 V maximum; width 0.2 to 10 µs; 1000-Ω input impedance.

LL REF EXT When the rear-panel LL REF mode switch is on EXT, the rear-panel LL REF EXT BNC connector accepts the lower-level biasing (an input of 0 to −10 V on this connector corresponds to a range of 0 to 10 V for the lower-level discriminator setting). Input protected to ±24 V.

EXT STROBE INT When the rear-panel EXT/INT STROBE locking toggle switch is in EXT, the rear-panel EXT STROBE IN BNC connector accepts a positive NIM-standard input, nominally +5 V, 500 ns wide, to cause an output to occur from the SCA. The external strobe should be given within 5 µs (or 50 µs as determined by the front-panel Delay control) of the linear input. At the end of this period, the Model 551 resets its internal logic without producing an output signal.

OUTPUTS

SCA POS OUT Front- and rear-panel BNC connectors provide positive NIM-standard output, nominally +5 V; 500 ns wide; 10-Ω output impedance. For internal strobe the output occurs at the midpoint of the linear input trailing edge plus the output Delay as selected by the front-panel controls. For external strobe the output occurs at the time of strobe signal.

SCA NEG OUT Front-panel BNC connector provides fast NIM-standard output, nominally −16 mA (−800 mV on 50-Ω load); width ≤20 ns; rise time ≤5 ns; ≤10-Ω output impedance. Output occurs at the mid-point of the linear trailing edge plus the output Delay as selected by the front-panel controls.

LL OUT Rear-panel BNC connector provides positive NIM-standard output, nominally +5 V, 500 ns wide; ≤10-Ω output impedance. Output occurs as leading edge of linear input crosses the LL threshold.

UL OUT Rear-panel BNC connector provides NIM-standard output, nominally +5 V, 500 ns wide; ≤10-Ω output impedance. Output occurs as leading edge of linear input crosses the UL threshold.

ELECTRICAL AND MECHANICAL

POWER REQUIRED +12 V, 160 mA; −12 V, 110 mA; +24 V, 90 mA; −24 V, 50 mA.

WEIGHT
Net 1.1 kg (2.5 lb).
Shipping 2.25 kg (5.0 lb).

DIMENSIONS NIM-standard single-width module 3.43 X 22.13 cm (1.35 X 8.714 in.) per DOE/ER-0457T.

Related Equipment

The Model 551 is compatible with all EG&G ORTEC amplifiers and other amplifiers having a 0 to 10 V positive, linear output range.

Ordering Information

To order, specify:

Model	Description
551	Timing Single-Channel Analyzer

Contents

Introduction

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.

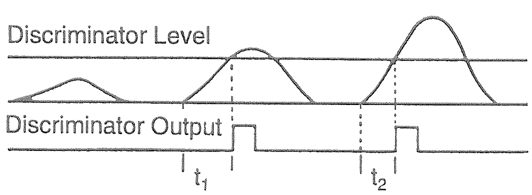


Fig. 1. Integral Discriminator Output Triggering.

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.

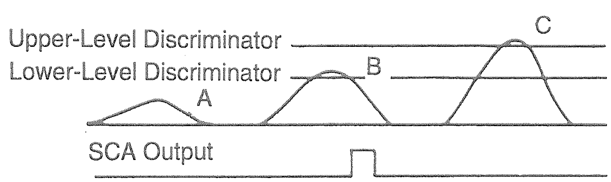


Fig. 2. Single-Channel Analyzer Function.

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 EG&G 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 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 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.

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

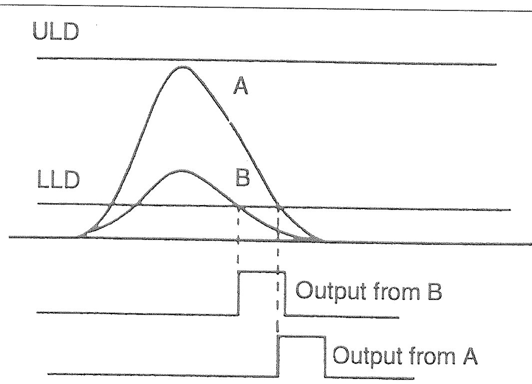


Fig. 3. Non-Timing SCA Output Triggering.

Timing SCAs, such as the EG&G ORTEC Models 551, 552, 553, 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.

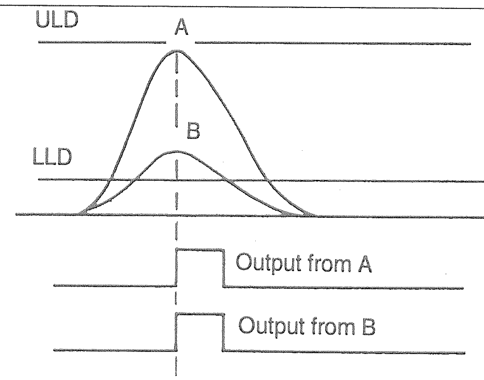


Fig. 4. Peak-Sensing SCA Output Triggering.

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 EG&G ORTEC Model 552, because the input signal crosses the baseline with a large slope even when the pulse amplitude is low.

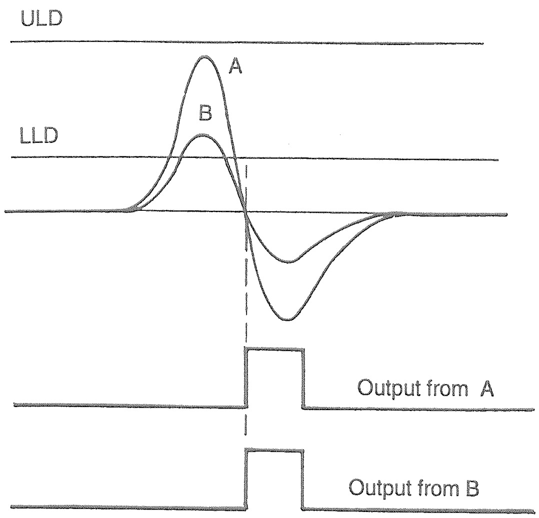


Fig. 5. Zero-Crossover SCA Output Triggering.

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 trailing-edge constant-fraction timing technique is available with three EG&G ORTEC SCAs: Models 551, 552, and 553.

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 EG&G 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

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

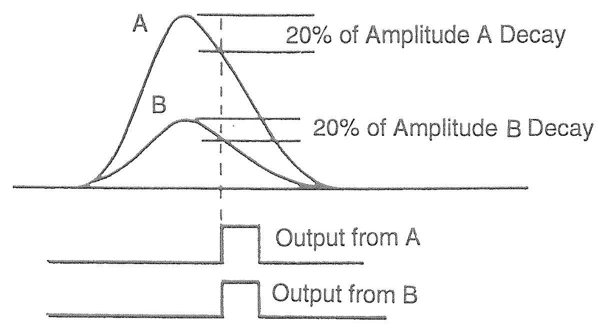


Fig. 6. Constant-Fraction SCA Output Triggering.

shape measurement of the input signals by evaluating the timing at two different fractions.

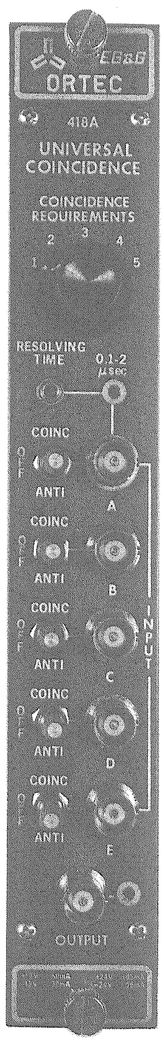
The following Selection Guide provides comparative data for all EG&G ORTEC Single-Channel Analyzers.

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.
553	Economical constant-fraction timing and SCA.
590A	Cost efficient, includes built-in amplifier.
850	Economical, four SCAs in a single-width module for general-purpose counting.

418A
Universal Coincidence

- **Provides coincidence determinations using majority logic**
- **Five, positive-polarity, dc-coupled inputs**
- **Coincidence, Anticoincidence, or Off selectable for each input**



The EG&G ORTEC Model 418A is a Universal Coincidence unit with five dc-coupled inputs. Each input is accepted through a convenient front-panel connector.

Input A accepts an input signal with a width of 50 ns or more and regenerates an internal signal that will be used for coincidence comparisons. The Input A signal width is adjustable for a resolving time of 100 ns to 2 µs, and this range is available with a front-panel control.

The function of each input is selectable, and its signal can be used for coincidence or anticoincidence or can be disabled. This permits various combinations of input signal relations to be selected without adding or removing cables in the system.

Another feature that simplifies operating flexibility without changing any cables is a selectable number of inputs that are required to satisfy a coincidence. For example, if the selector shown is set at 2, an overlap between any two inputs that are selected for the coincidence function will cause an output to be generated. If any one or more inputs are selected for anticoincidence, all outputs are inhibited while such signals are present. Because any combination of input signal effects can be selected easily at the front panel, the Model 418A is a Universal Coincidence unit that can be adapted to any coincidence system arrangement.

Specifications

PERFORMANCE

INPUT A RESOLVING TIME 100 ns to 2 µs; controlled by a front-panel, 20-turn, screwdriver adjustable potentiometer; inputs B, C, D, and E controlled by input pulse width.

TEMPERATURE INSTABILITY
Input A Change in resolving time, τ, $<\pm 0.1\%/°C$.

Inputs B, C, D, E Change in resolving time, τ, $<\pm 0.05\%/°C$ for $\tau = 500$ ns.

OPERATING TEMPERATURE 0 to 50°C.

CONTROLS

COINCIDENCE REQUIREMENTS Selects number of inputs necessary to satisfy a coincidence requirement (majority logic).

INPUT CONTROLS Five 3-position toggle switches select Coincidence, Anticoincidence, or Off (disabled).

INPUTS

POLARITY +2 V minimum, 30 V maximum.

PULSE WIDTH 50 ns to dc.

CONNECTORS BNC (UG-1094/U) on front panel.

INPUT IMPEDANCE >1.5 kΩ, dc-coupled.

OUTPUTS

AMPLITUDE +5 V.

PULSE WIDTH 500 ns.

CONNECTORS BNC (UG-1094/U) on front and rear panels.

OUTPUT IMPEDANCE <10 Ω, dc-coupled.

ELECTRICAL AND MECHANICAL

POWER REQUIREMENTS The Model 418A derives its power from a standard NIM bin/power supply. The power required is +24 V, 105 mA; –24 V, 95 mA; +12 V, 50 mA; and –12 V, 30 mA.

WEIGHT
Net 0.9 kg (2.0 lb).
Shipping 2.25 kg (5.0 lb).

DIMENSIONS Standard single-width NIM module 3.43 X 22.13 cm (1.35 X 8.714 in.) per DOE/ER-0457T.

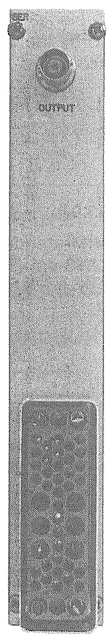
Related Equipment

Input signals to the Model 418A can be from any timing instrument providing a positive output signal from 2 to 30 V. The output of the Model 418A provides a logic signal suitable for driving any of the medium-speed logic modules in the EG&G ORTEC product line, but it is more typically used as a gating signal such as a gate-enable signal to a multichannel analyzer.

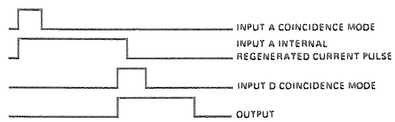
Ordering Information

To order, specify:

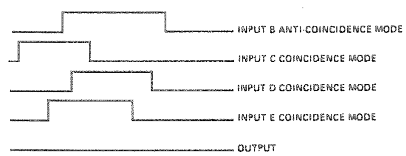
Model	Description
418A	Universal Coincidence



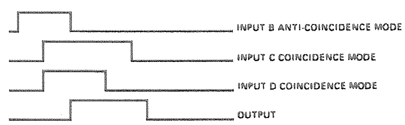
Coincidence Requirements When Switch Setting is 2.



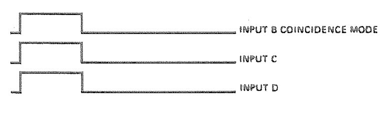
Coincidence Requirements When Switch Setting is 2.



Coincidence Requirements When Switch Setting is 3.



Coincidence Requirements When Switch Setting is 2.



Coincidence Requirements When Switch Setting is 4.