Acquisitions Systems

Acquisitions Systems

- **Electronic modules and functions**
- **Fast Linear Signals for Timing**
- **Examples of Systems Assembled Using Modular Electronics**

Electronic modules and functions

Origin of the signal source

- Optical photons
- X rays
- Gamma rays
- Alpha particles
- Beta particles
- Ions or ionized molecules
- Neutral atoms or molecule

Modular Electronic Instruments

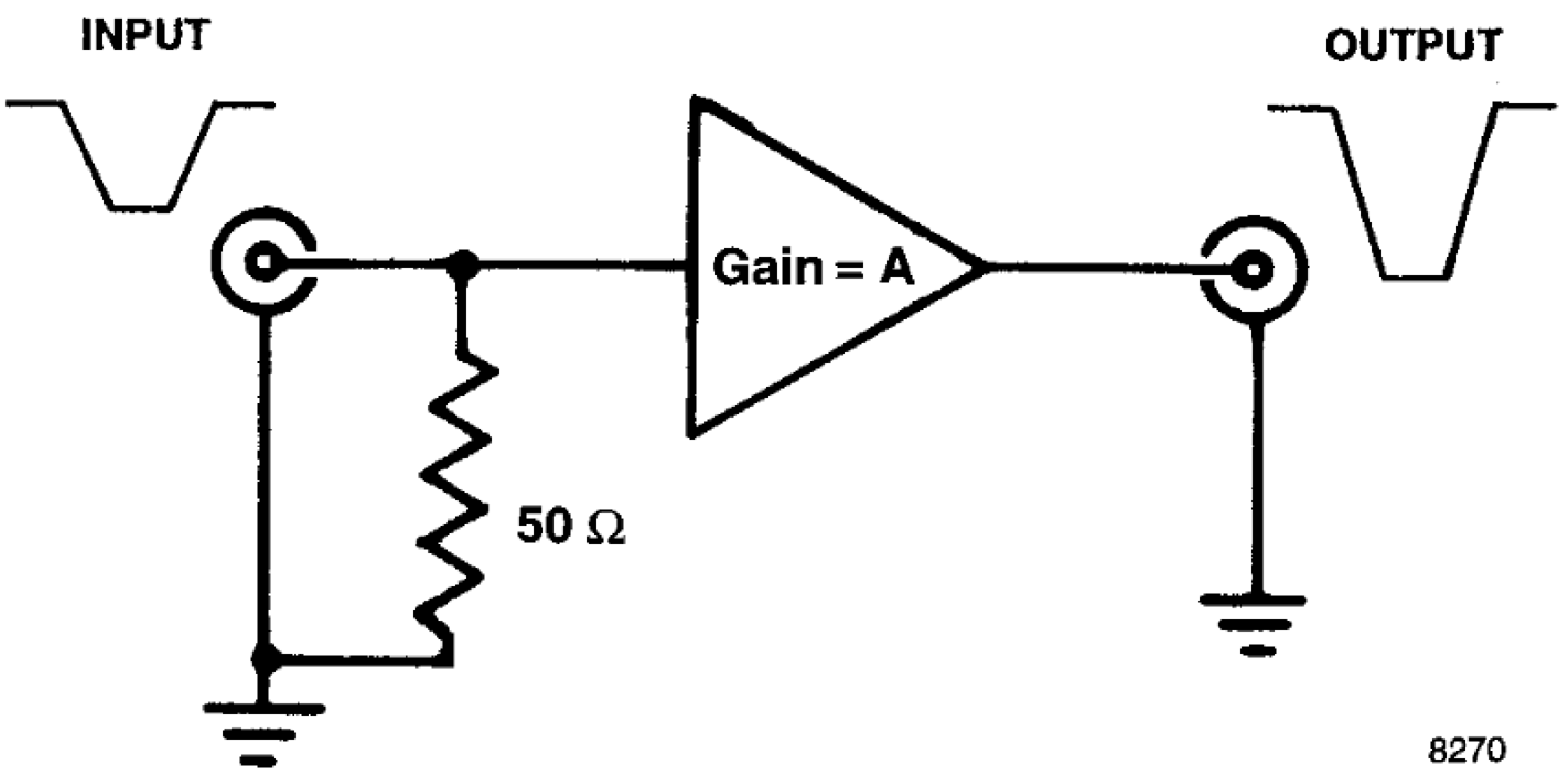
- Preamplifiers
- Amplifiers
- Single-Channel Pulse-Height Analyzers
- Counters/Timers/Ratemeters
- Fast-Timing Discriminators
- Time-to-Amplitude Converters
- Multichannel Analyzers (MCA), Multichannel Buffers (MCB)
- Delays/Gate and Delay Generators/Logic Modules/Linear Gates
- Pulse Generators and Special Instruments
- HV Bias/NIM Power Supplies and Bins

Preamplifiers

- The primary function of a preamplifier is to extract the signal from the detector without significantly degrading the intrinsic signal-to-noise ratio. Therefore, the preamplifier is located as close as possible to the detector, and the input circuits are designed to match the characteristics of the detector.
- Matching the Preamplifier to the Detector and the Application

Preamplifiers

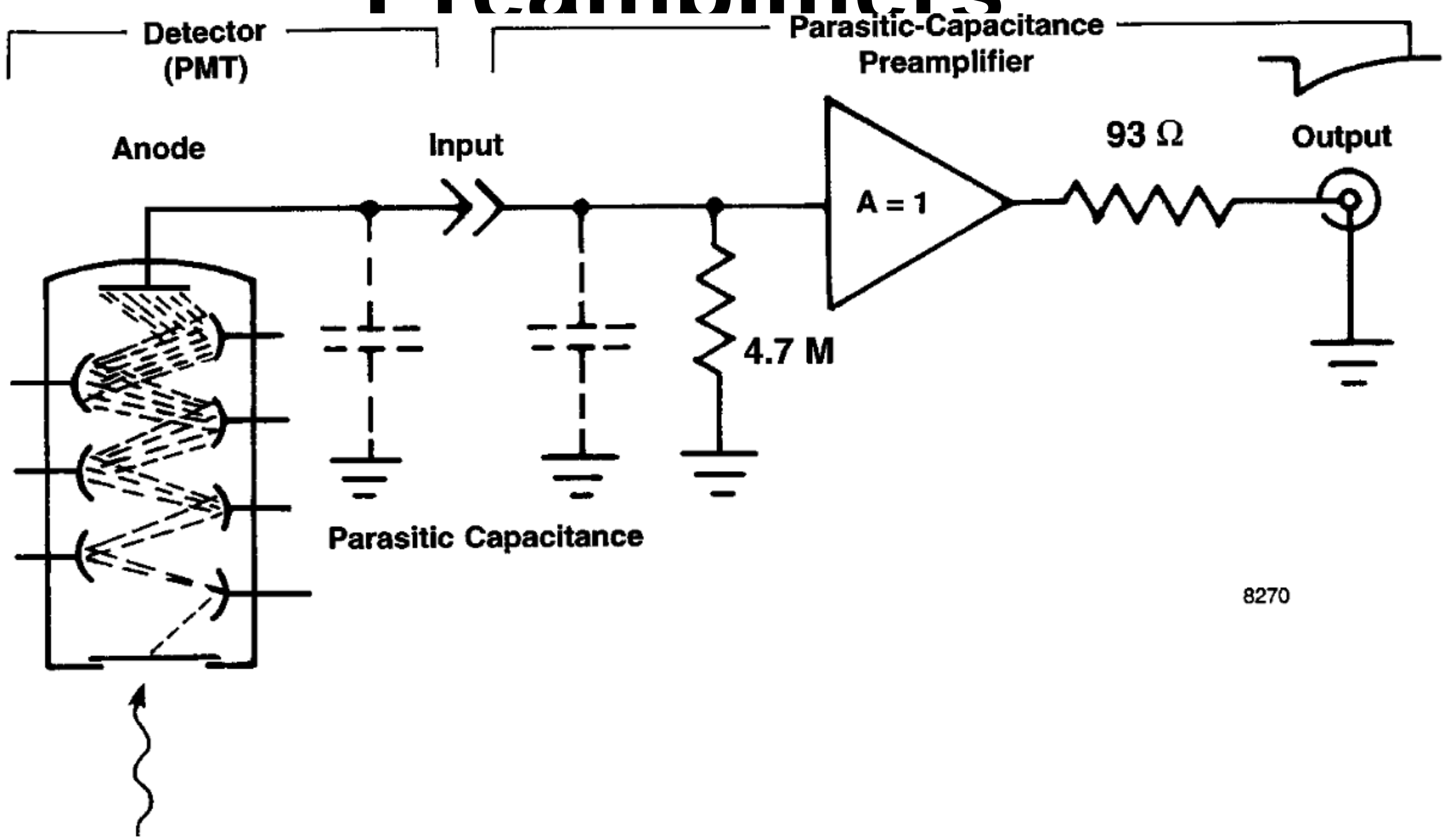
Current-Sensitive Preamplifiers



A Simplified Schematic of the Current-Sensitive Preamplifier.

Preamplifiers

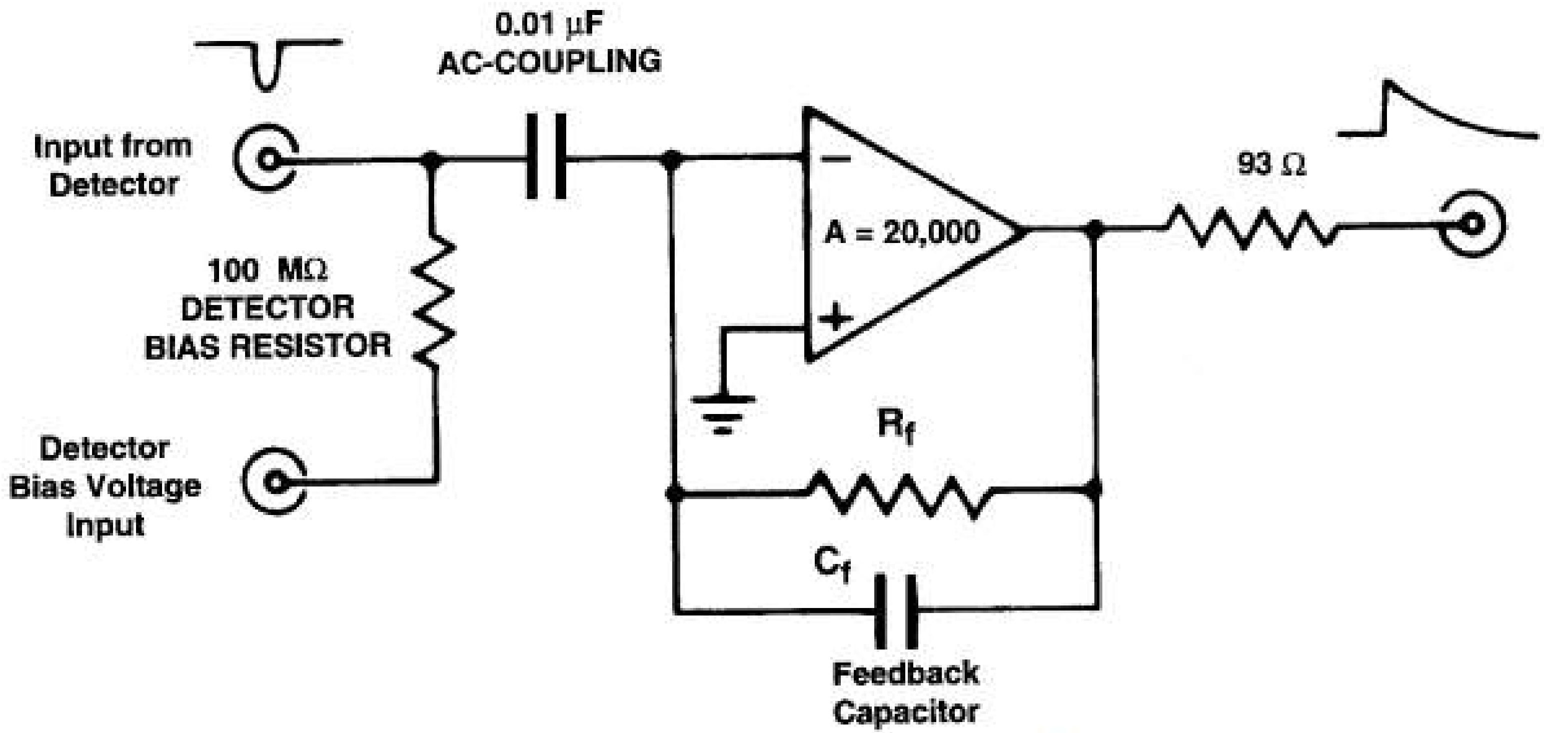
Parasitic-Capacitance Preamplifiers



A Simplified Diagram of the Parasitic-Capacitance Preamplifier.

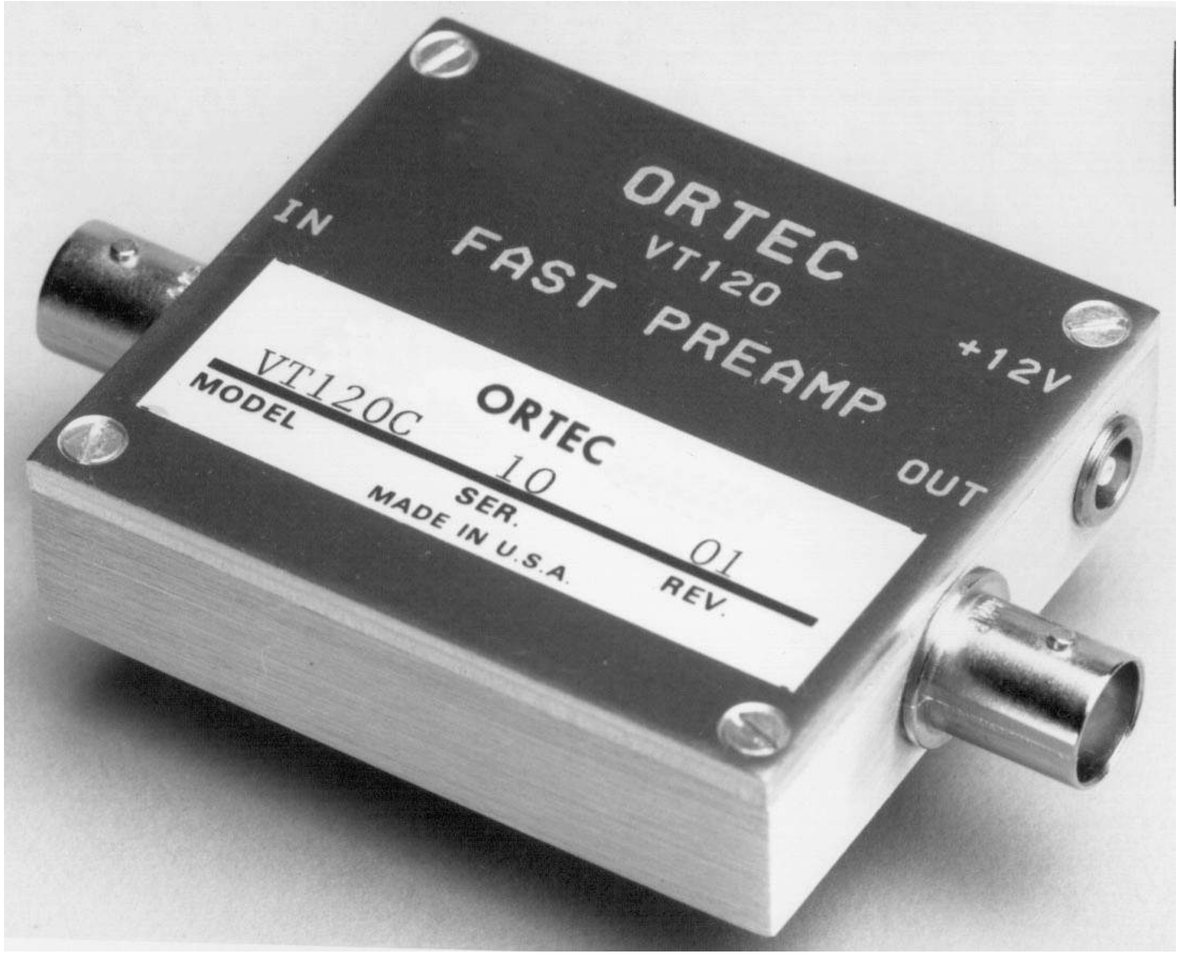
Preamplifiers

Charge-Sensitive Preamplifiers



Simplified Schematic of the AC-Coupled Charge-Sensitive Preamplifier. (For a dc-coupled preamplifier, the detector bias resistor is removed, and the 0.01µF capacitor is replaced by a wire.)

Fast-Timing Preamplifier



Scintillation Preamplifier

GHz Preamplifier

Amplifiers

Choosing the Right Amplifier for the Application

The amplifier is one of the most important components in a pulse processing system for applications in counting, timing, or pulse-amplitude (energy) spectroscopy. Normally, it is the amplifier that provides the pulse-shaping controls needed to optimize the performance of the analog electronics

Fast-Timing Amplifiers

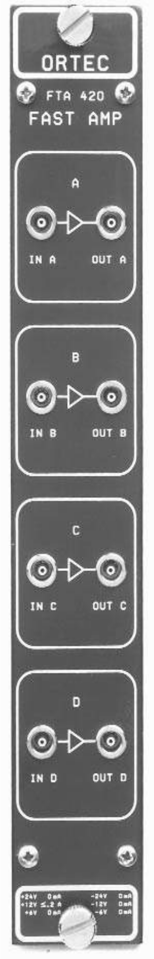
Timing amplifiers are designed to have output rise times in the low nanosecond or sub-nanosecond range. Achieving such fast rise times usually compromises linearity and temperature stability.

Two types of fast amplifiers are available: wideband amplifiers (photomultipliers) and timing filter amplifiers (germanium detectors).

Fast Timing Amplifier

For amplifying fast analog signals from photomultipliers, electron multipliers, photodiodes, microchannel plates, and silicon charged-particle detectors

• ≤1 ns rise time



Timing Filter Amplifier

Timing with germanium detectors
• Energy spectroscopy at ultrahigh count rates
• Selectable filter for pulse shaping
• Signal-to-noise ratio optimization
• Continuously adjustable gain, X2 to X250
• Pole-zero cancellation
• DC-coupling

Linear, Pulse-Shaping Amplifiers for Pulse-Height (Energy) Spectroscopy

For pulse-height or energy spectroscopy, the linear, pulse shaping amplifier performs several key functions. Its primary purpose is to magnify the amplitude of the preamplifier output pulse from the millivolt range into the 0.1- to 10-V range.

In addition, the amplifier shapes the pulses to optimize the energy resolution, and to minimize the risk of overlap between successive pulses. Most amplifiers also incorporate a baseline restorer to ensure that the baseline between pulses is held rigidly at ground potential in spite of changes in counting rate or temperature.

Amplifier

General-purpose amplifier for energy spectroscopy with all types of detectors

- **Unipolar and bipolar outputs**
- **Selectable unipolar output delay**
- **Active filter networks with wide range of time constants**
- **Wide gain range**
- **Gated baseline restorer with automatic BLR threshold control for excellent counting rate performance**

Delay Amplifiers

Frequently, it is necessary to delay an analog signal to align its arrival with the arrival time of a gating logic signal. This is the function of a delay amplifier. It provides an adjustable delay of the analog signal while preserving the shape and amplitude of the analog pulse.

Delay Amplifier

Delay-line shaping for energy and time spectroscopy with scintillation detectors

• Ideal for n–γ discrimination by pulse-shape analysis

• Excellent high-counting rate performance

• Optimum timing capabilities

• Selectable integration time constants

Single-Channel Pulse-Height Analyzers

Three primary modes of discriminator operation are available Integral, Normal, and Window.

- In the Integral mode of operation, the SCA can function as an integral discriminator.
- 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.

Single-Channel Analyzer

Ideal for selecting a range of pulse amplitudes from a spectroscopy amplifier for counting on a ratemeter or counter/timer

• Provides the excellent stability, resolution, and dynamic range demanded by high-resolution detectors

• Four operating modes:

Integral

Normal (independent upper and lower levels)

Asymmetric window

Symmetric window

• DC-coupled for high counting rates

• SCA output generated when the input signal falls below the lower level

Timing Single-Channel Analyzer

- **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**

Pulse-Shape Analyzer/Timing SCA

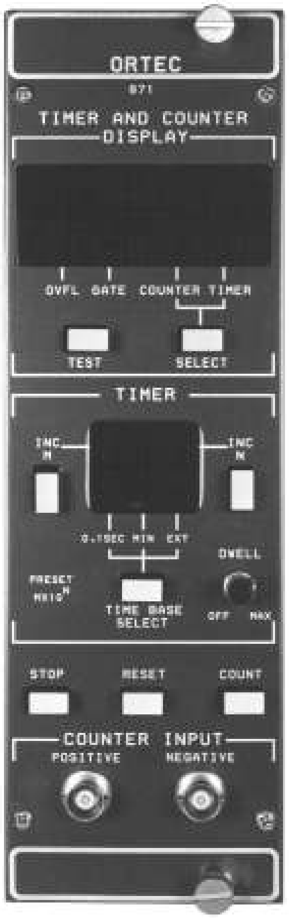
- **Pulse-height analysis, timing signal derivation, and pulse-shape analysis**
- **Trailing-edge constant-fraction timing with two independent timing channels**
- **Walk <±250 ps for a 10:1 dynamic range**
- **DC-coupled**
- **Resolves shape variations over a 200:1 dynamic range**
- **Adjustable delay 0.1 to 1.1 μs**
- **Provision for external baseline sweep**

Counters/Timers/Ratemeters

- Counters simply count the number of input pulses received during the counting period.
- Timers count pulses generated by an internal clock and are used to measure elapsed time or to establish the length of the counting period.
- Ratemeters provide a meter reading and an analog voltage output that are proportional to the average count rate per unit of time, which is usually expressed in counts per second (counts/s).

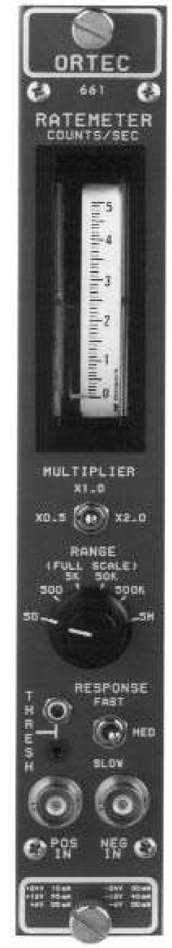
Timer and Counter

- **8-decade presettable timer and counter**
- **25-MHz positive or negative input count rate**
- **Crystal-controlled time base**
- **Auto recycle dwell time control**



Ratemeter

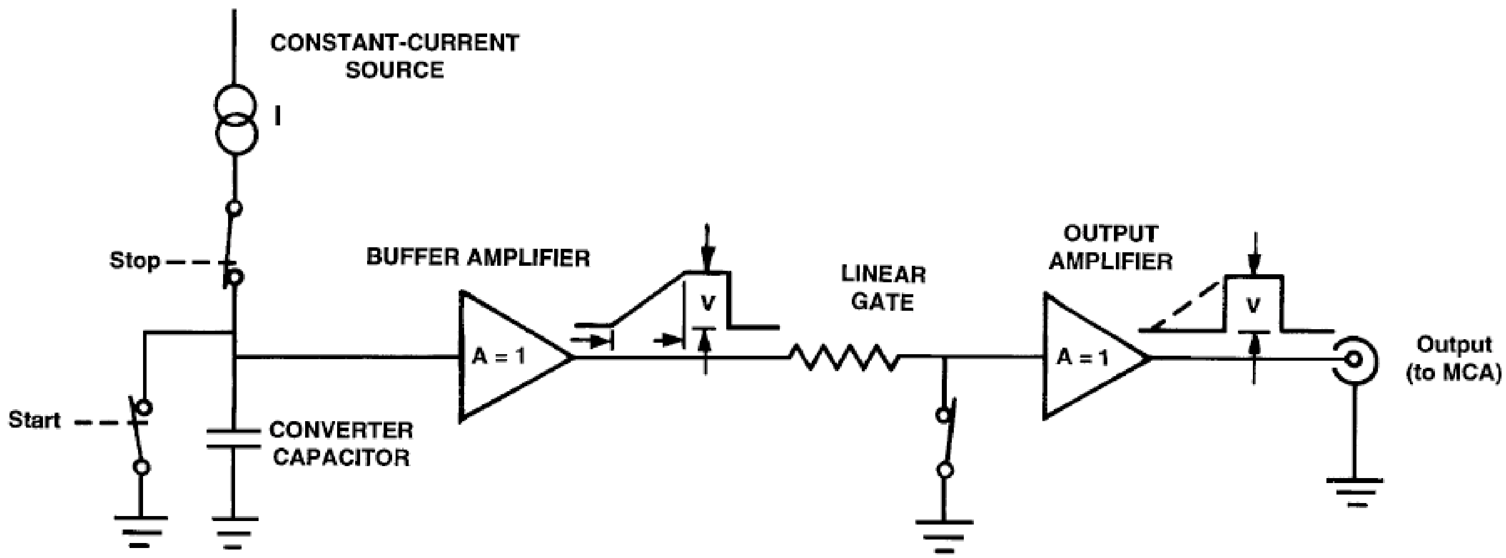
- Measures counting rates up to 107 counts/s
- 18 full-scale meter ranges from 25 counts/s to 107 counts/s
- Fast, medium, and slow response selections offer <1%, <3%, or <10% standard deviation in the measurement
- Fast response circuit permits settling to 1% precision in a fraction of the normal time
- Positive and negative inputs
- Adjustable positive input discriminator
- Flexible analog output for strip chart recorders



Time-to-Amplitude Converters

When a timing application demands picosecond precision, a time-to-amplitude converter is a prime candidate. A TAC can achieve such exceptional precision because it uses an analog technique to convert small time intervals to pulse amplitudes.

Time-to-Amplitude Converters



Time-to-Amplitude Converters

- **For time spectroscopy in the range from 50 ns to 80 μs**
- **Coincidence or anticoincidence gating**
- **Simple start/stop operation**
- **Selectable output delay and width**
- **Output synchronized with a stop Or external strobe signal**

Time-to-Amplitude Converter/SCA

- For time spectroscopy in the range from 10 ns to 2 ms
- Includes SCA to set a time window for coincidence experiments
- Valid Start and Valid Conversion outputs
- Selectable output delay and width
- Output synchronized with a stop or external strobe signal
- Positive or negative input signals

Multichannel Analyzers

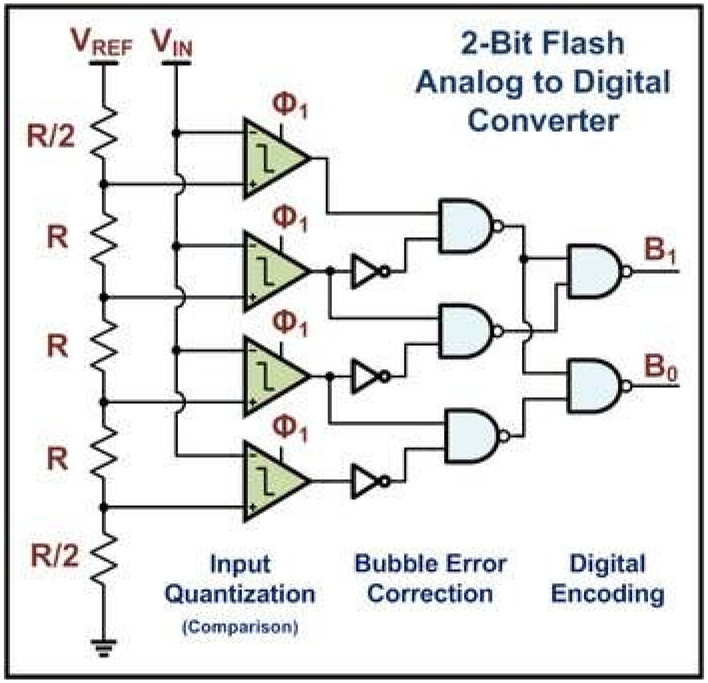
- A multichannel pulse-height analyzer (MCA) consists of an ADC, a histogramming memory, and a visual display of the histogram recorded in the memory. The purpose of the analog-to-
- digital converter (ADC) is to measure the maximum amplitude of an analog pulse and convert that value to a digital number. This digital output is a proportional representation of the analog amplitude at the ADC input

Multichannel Analyzers
Flash ADC

A direct-conversion ADC or flash ADC has a bank of comparators sampling the input signal in parallel, each firing for their decoded voltage range. The comparator bank feeds a logic circuit that generates a code for each voltage range.

Direct conversion is very fast, capable of gigahertz sampling rates, but usually has only 8 bits of resolution or fewer, since the number of comparators needed, $2^N - 1$, doubles with each additional bit, requiring a large, expensive circuit

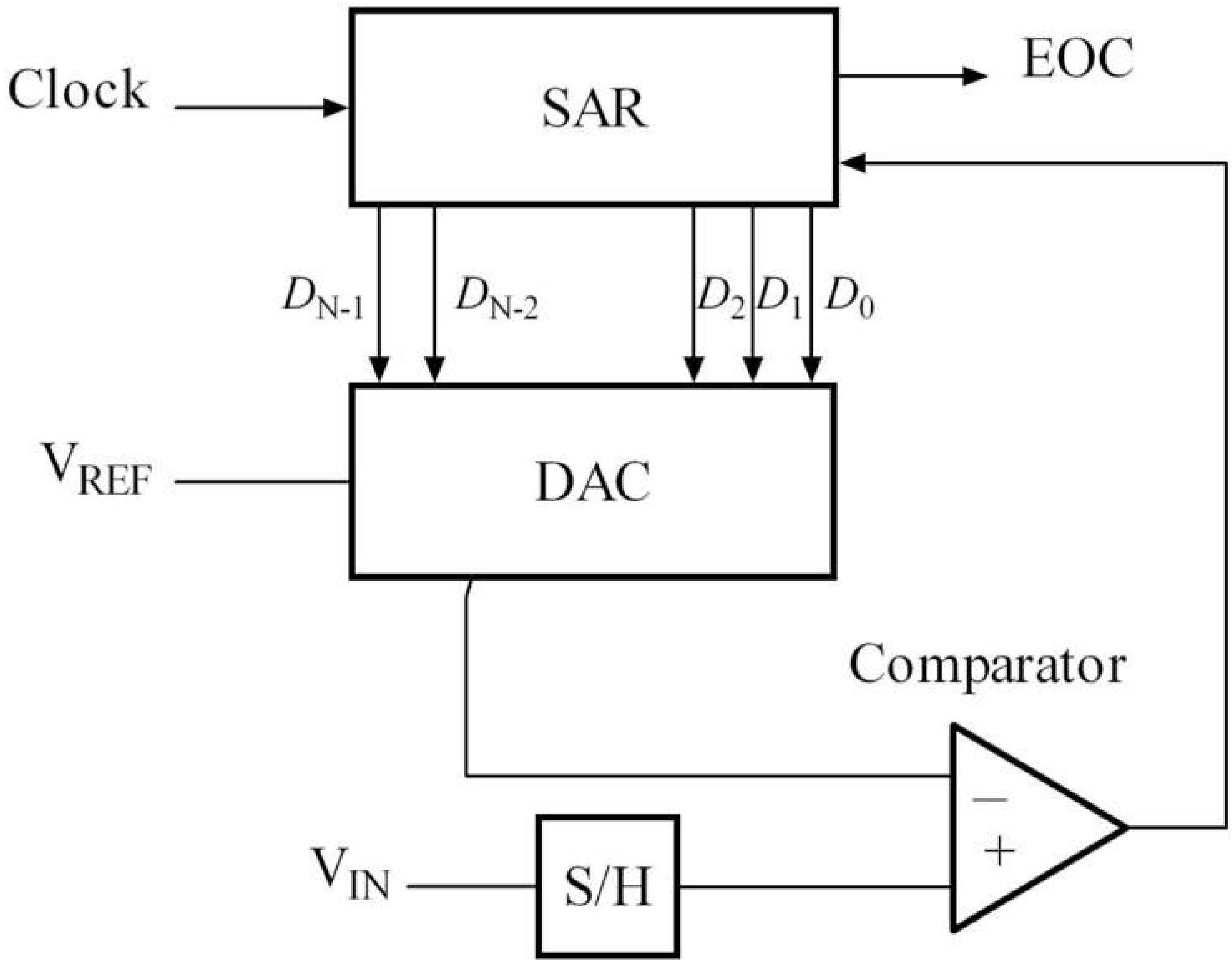
Multichannel Analyzers
Flash ADC



Multichannel Analyzers Successive-approximation ADC

A successive-approximation ADC uses a comparator to successively narrow a range that contains the input voltage. At each successive step, the converter compares the input voltage to the output of an internal digital to analog converter which might represent the midpoint of a selected voltage range. At each step in this process, the approximation is stored in a successive approximation register (SAR).

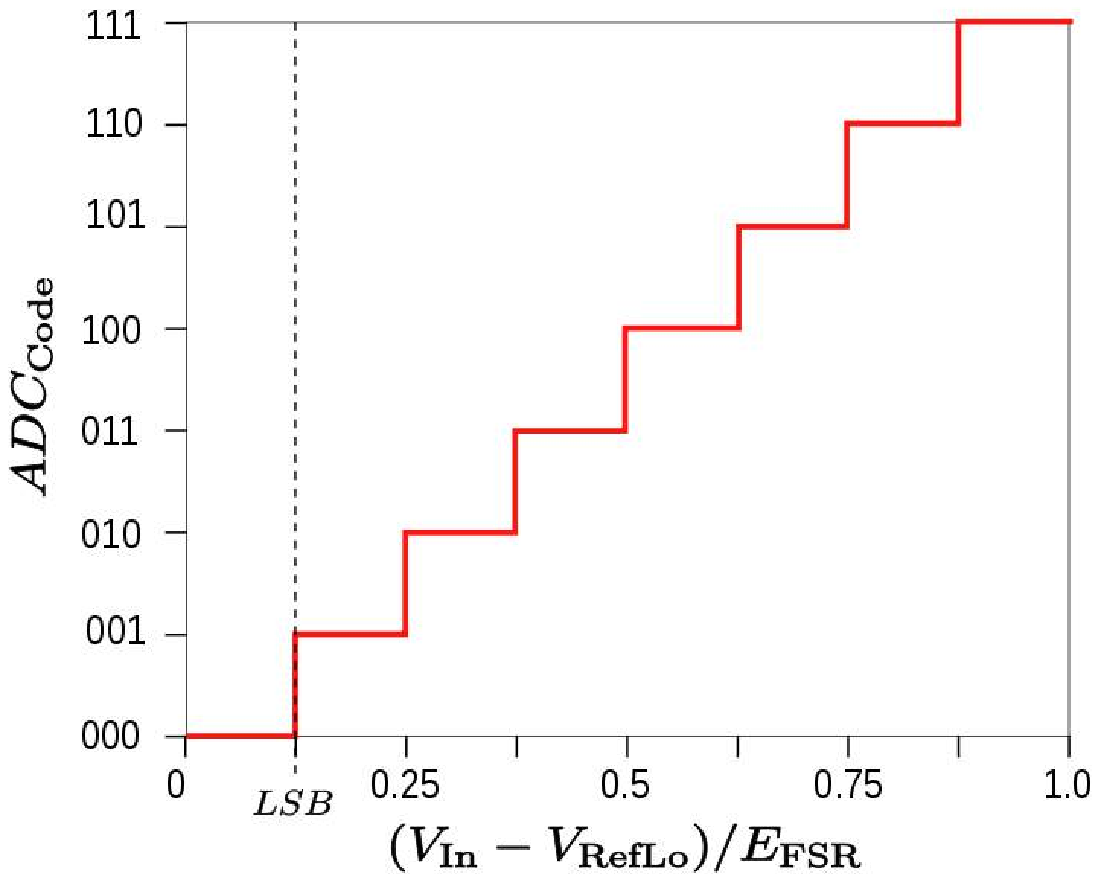
Multichannel Analyzers
Successive-approximation ADC



Multichannel Analyzers
Wilkinson ADC

The Wilkinson ADC is based on the comparison of an input voltage with that produced by a charging capacitor. The capacitor is allowed to charge until its voltage is equal to the amplitude of the input pulse (a comparator determines when this condition has been reached). Then, the capacitor is allowed to discharge linearly, which produces a ramp voltage. At the point when the capacitor begins to discharge, a gate pulse is initiated. The gate pulse remains on until the capacitor is completely discharged. This gate pulse operates a linear gate which receives pulses from a high-frequency oscillator clock.

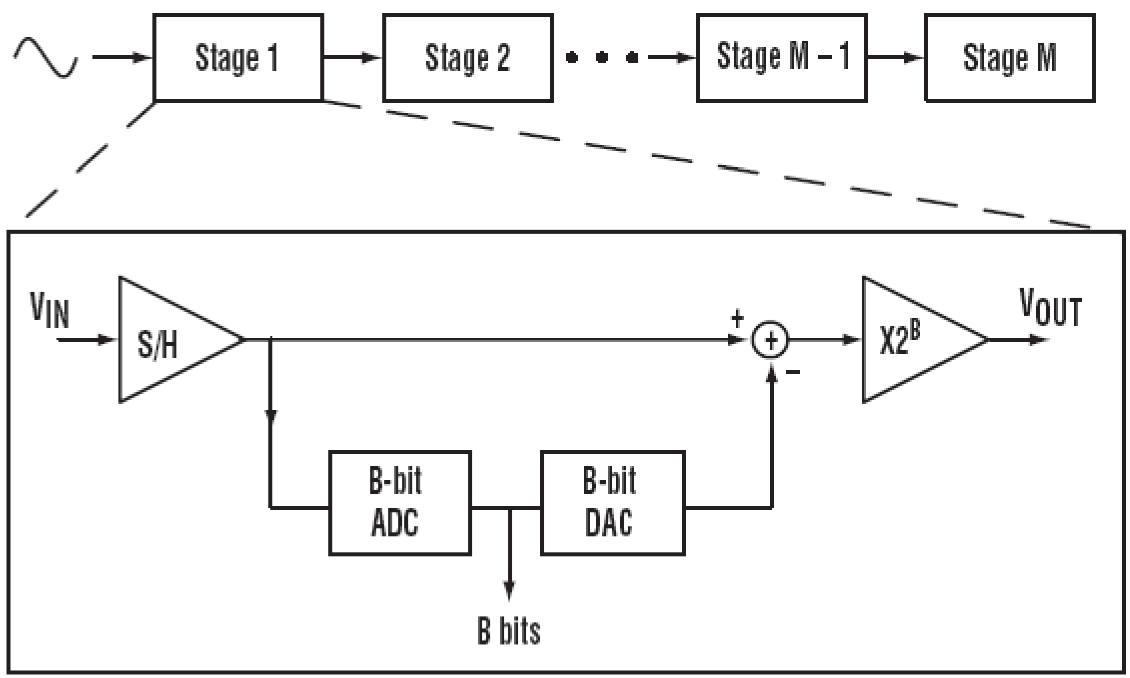
Multichannel Analyzers
Wilkinson ADC



Multichannel Analyzers
Pipeline ADC

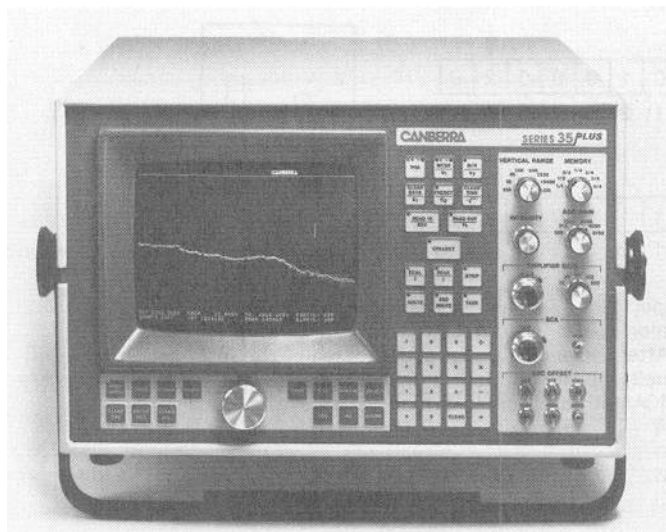
A pipeline ADC (also called subranging quantizer) uses two or more steps of subranging. First, a coarse conversion is done. In a second step, the difference to the input signal is determined with a digital to analog converter (DAC). This difference is then converted finer, and the results are combined in a last step. This can be considered a refinement of the successive-approximation ADC

Multichannel Analyzers
Pipeline ADC

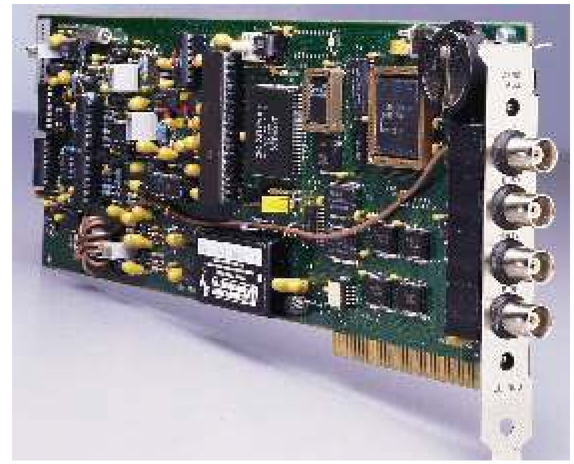


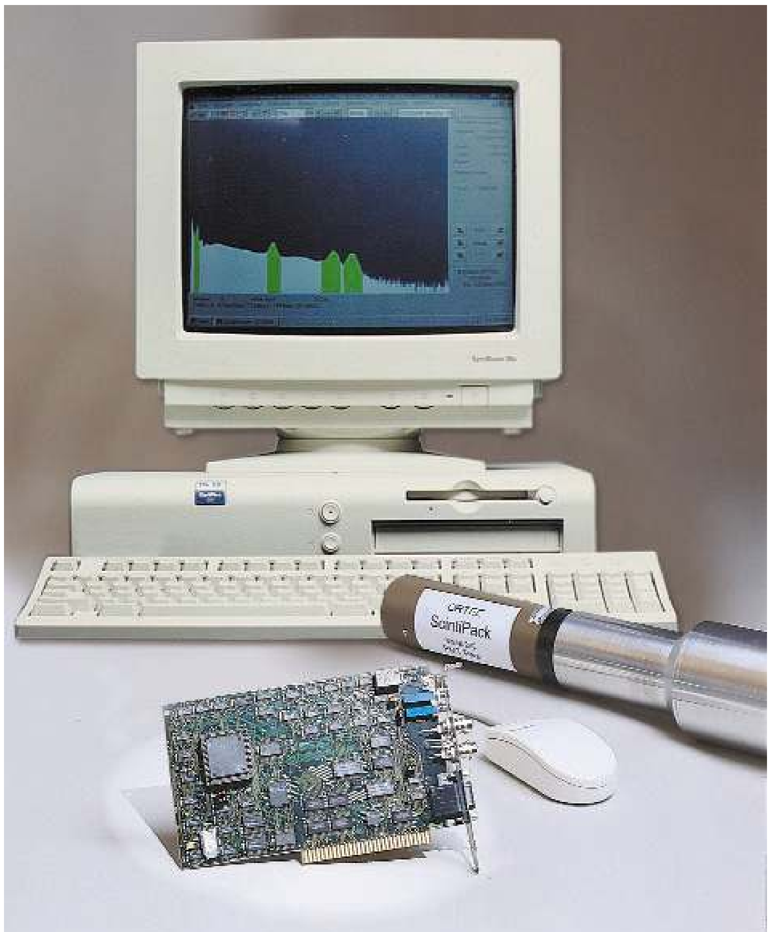
1. A general stage in a pipeline ADC has a S/H, a low-resolution ADC, a low-resolution DAC, a subtracter, and a controlled-gain amplifier.

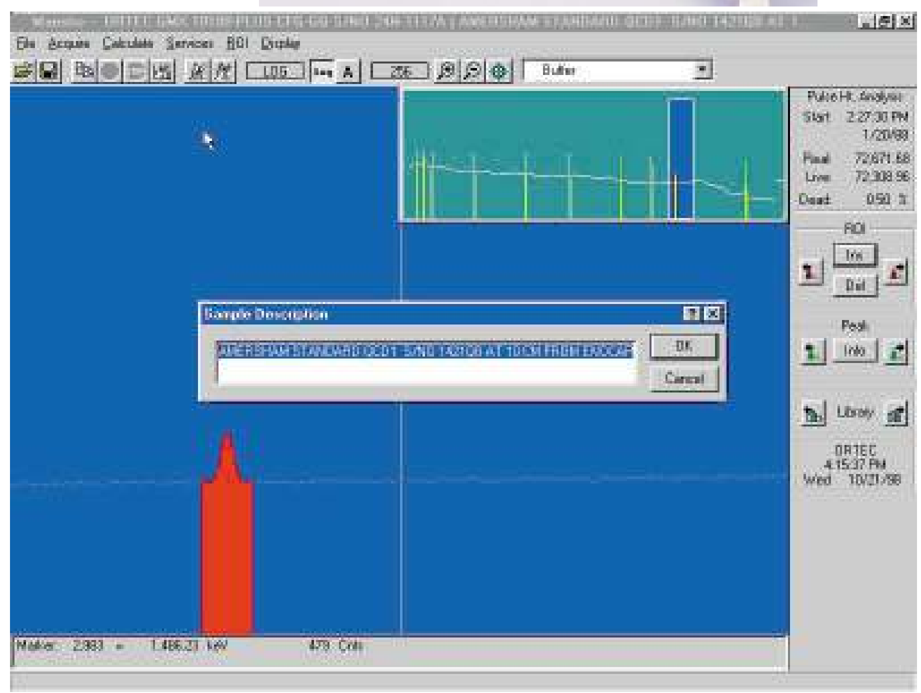
Multichannel Analyzers



Multichannel Analyzers

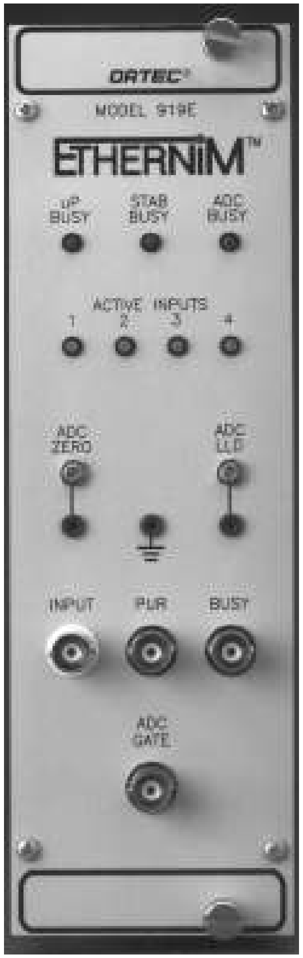






Multichannel Buffer

• High-performance MCA in a two-wide NIM
• Integral Ethernet connection for instant integration into
CONNECTIONS
spectroscopy networks
• FOUR independently-controlled inputs, with
independent conversion gains
• 64k-channel data memory, 231–1 (2 billion) counts per
channel
• 16k-channel, <7 µs conversion time ADC
• Digital spectrum stabilizer
• Sample changer control port

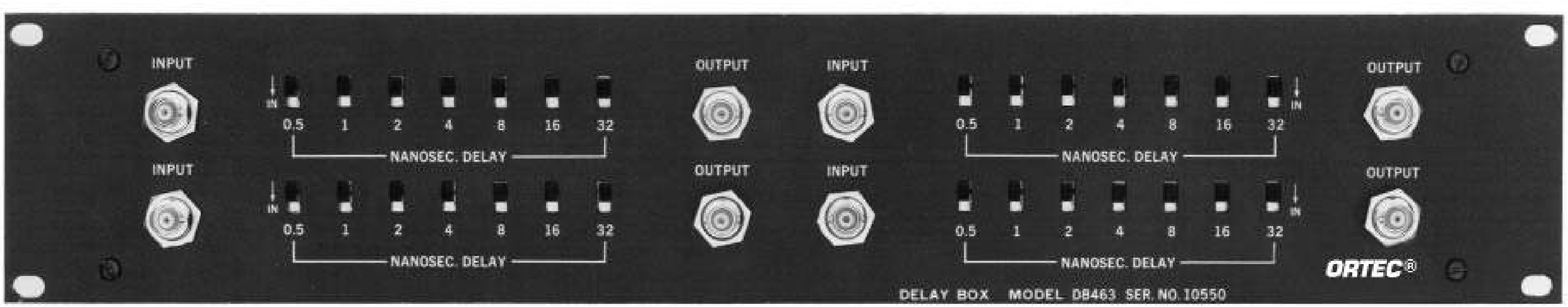


Delays

In experiments involving several sources of analog and logic signals, the signals from different paths usually must be aligned to arrive simultaneously at the decision points. This is the function of delay modules. For analog signals the pulse amplitude information must be preserved. Consequently, coaxial cables or lumped-parameter delay lines are used to generate the delay.

Delay Box

- Aligns fast-timing channels that incorporate coincidence circuits or TACs
- Four independent sections
- 50-Ω calibrated cable delay for linear or logic signals
- 0 to 63.5-ns delay in 0.5-ns steps



Logic Modules

In coincidence measurements, logic signals from various parts of the experiment must often be combined to determine which events are to be accepted for analysis. Logic modules provide a flexible means of making these decisions.

Fast Linear Signals for Timing

NIM-Standard Positive Logic Signals

The NIM-standard, positive logic signal is used for slow-to-medium-speed logic signals with repetition rates from dc to 1 MHz. The NIM-standard Preferred Practice provisions define this signal by the following amplitude limits:

•Output / Input

•Logic 1 +4 to +12 V +3 to +12 V

•Logic 0 +1 to –2 V +1.5 to –2 V

Fast Linear Signals for Timing

NIM-Standard Fast Negative Logic Signals

The NIM-standard, fast negative logic signal is normally used when rise time or repetition rate requirements exceed the capability of the positive logic pulse standard. The NIM Preferred Practice provisions define this signal as one that is furnished into a 50-Ω impedance with the following characteristics:

Output / Input

•Logic 1 –14 to –18 mA –12 to –36 mA

Fast Linear Signals for Timing

ECL Logic Signals

A convenient method of interconnecting channels from module to module incorporates a 34-pin (in two 17-pin rows) connector, and either a ribbon cable or a cable containing 100-Ω twisted pairs. The standard used for fast logic signals with this system is the ECL standard. The signal standard for ECL logic at 25℃ is:

Output / Input

- High state –0.81 to –0.98 V –0.81 to –1.13 V
- Low state –1.63 to –1.95 V –1.48 to –1.95 V

Fast Linear Signals for Timing

TTL Logic Signals

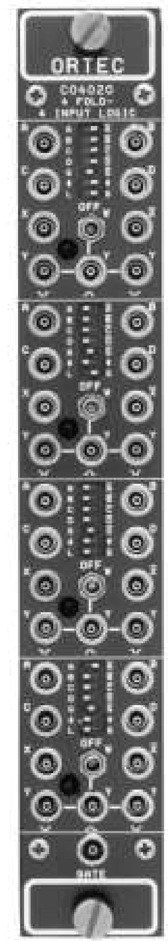
The slow logic functions inside the instruments are usually designed with integrated circuits employing the TTL logic standard. The standard signal levels for TTL logic are:

Output / Input

- Logic 1 +2.4 to +5 V +2 to +5 V
- Logic 0 0 to +0.4 V 0 to +0.8 V

Quad 4-Input Logic Unit

• General-purpose logic module for AND, OR, Veto, Fan-Out, and Gating functions
• Four independent channels
• Overlap outputs and adjustablewidth outputs
• 3-ns overlap resolution
• TTL and fast negative NIM outputs



Linear Gates

When some analog signals must be blocked, and some must be selected to pass on to a subsequent instrument, a linear gate is required. Linear gates usually provide a variety of ways to use a logic pulse in blocking or passing the analog signal.

Octal Gate and Delay Generator

• For adjusting the delay and width of coincidence and gating pulses
• Eight, independent, duplicate channels in a compact package
• TTL outputs and NIM-standard fastnegative outputs
• Output delay adjustable from 70 ns to 10 μs
• Output width adjustable from 50 ns to 10 μs

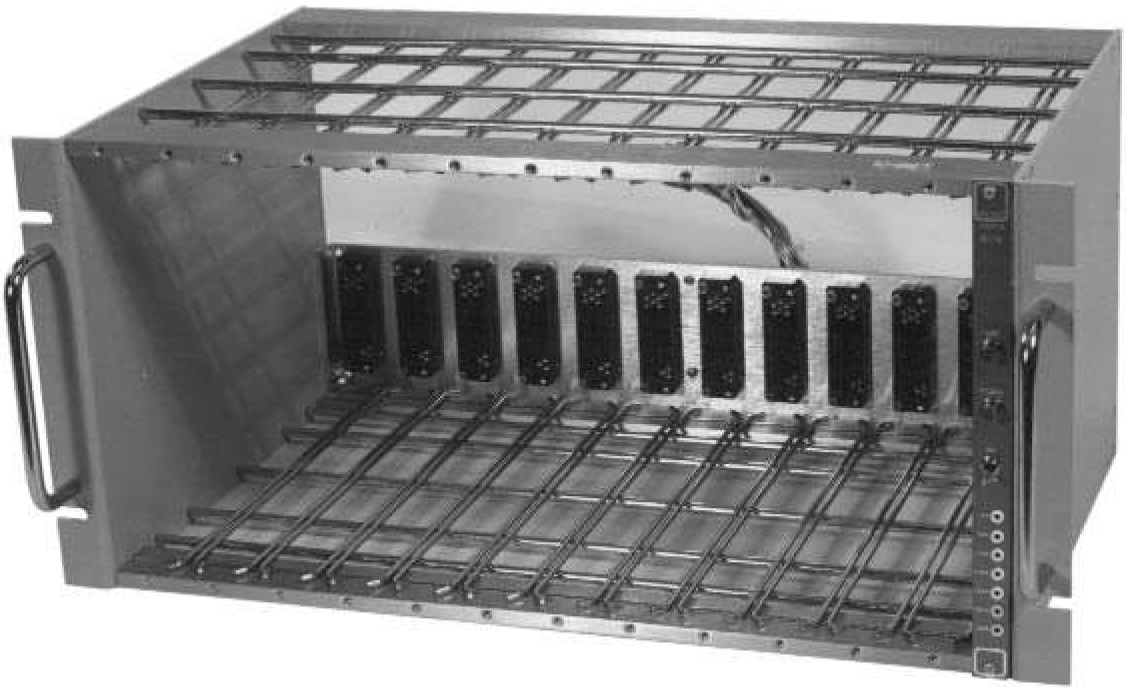
Precision Pulse Generator

- Simulates detector output signals
- Precision dial may be calibrated to read directly in terms of equivalent energy deposition in semiconductor detectors
- Exponential pulse shape with 5- to 250-ns rise time and 200- or 400-μs decay time constant
- Line frequency or 70-Hz pulse rate
- Positive or negative polarity
- Direct 0 to 1-V output (0 to 10 V with external reference voltage)
- Attenuated output with 2000:1 attenuation range
- Internal or external reference voltage

HV Bias/ NIM Power Supplies and Bins

- Power supplies that provide operating voltages for a detector (more properly called detector bias supplies)
- Power supplies that provide the necessary operating voltages for electronic instruments.

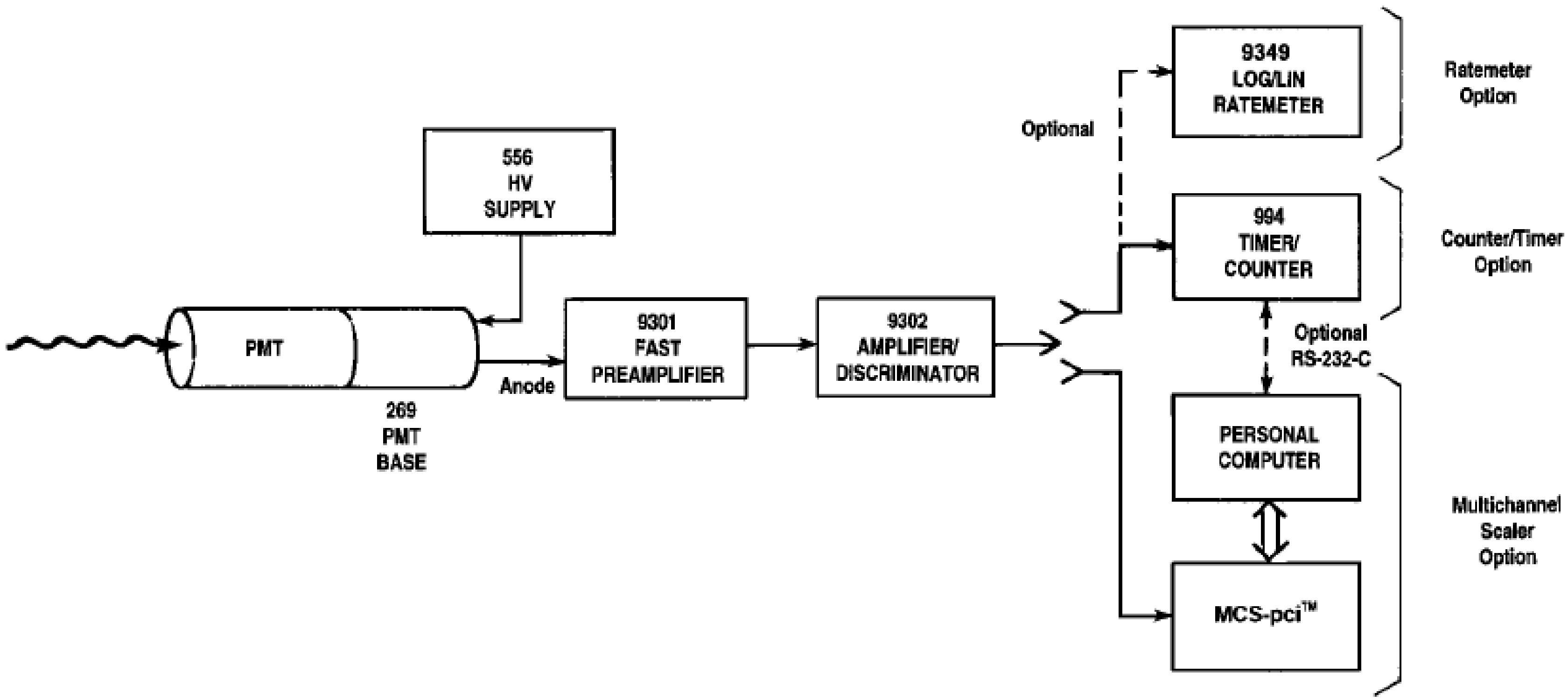
HV Bias/
NIM Power Supplies and Bins



Examples of Systems Assembled Using Modular Electronics

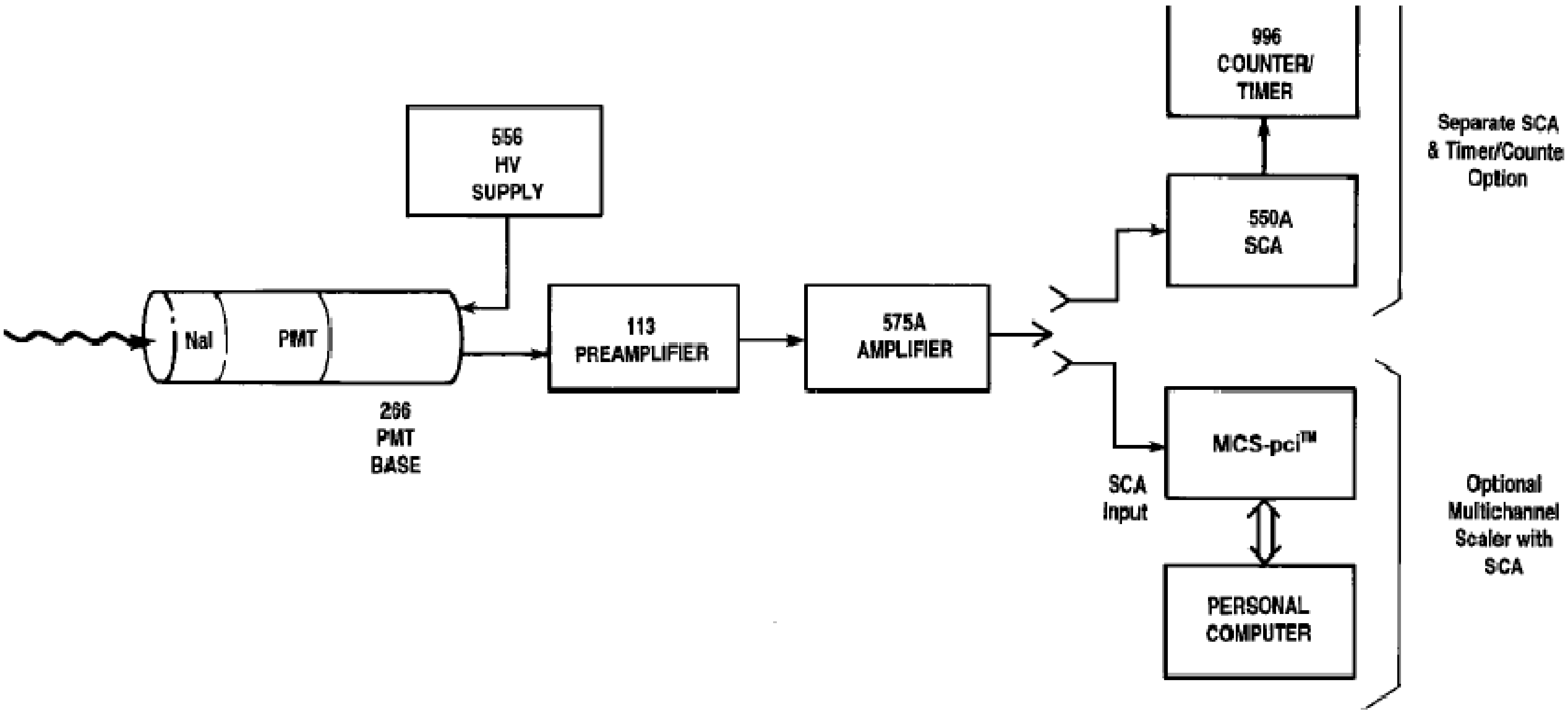
- Time Spectrometry/ Counting
- Pulse-Height, Charge, or Energy Spectroscopy
- Coincidence Measurements

Time Spectrometry/Counting



Counting Fast Single-Photon Pulses from a Photomultiplier Tube Anode.

Time Spectrometry/Counting



Counting Selected Amplitudes of Slow Linear Signals from a NaI(Tl) Scintillation Detector.

Pulse-Height, Charge, or Energy Spectroscopy

- Microchannel plate detector
- NaI(Tl) scintillation detector.
- Silicon charged-particle detector .
- Ge or Si(Li) detector .

Micro channel plate detector

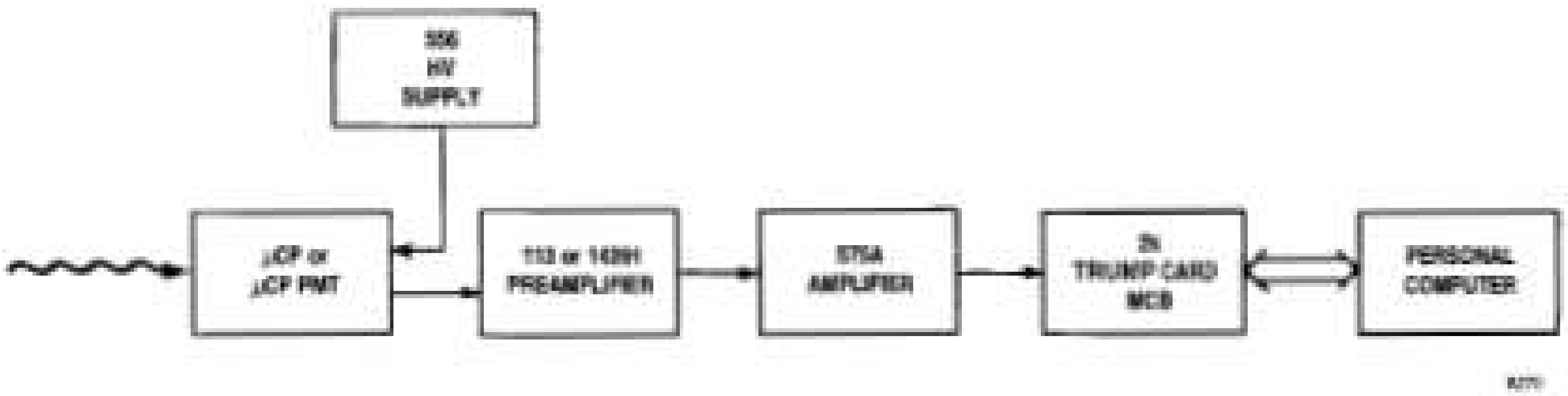


Fig. 3. Pulse-Height (Charge) Spectroscopy with a Microchannel Plate (μCP) Detector, or a Microchannel Plate Photomultiplier Tube (μCP PMT).

NaI(Tl) scintillation detector

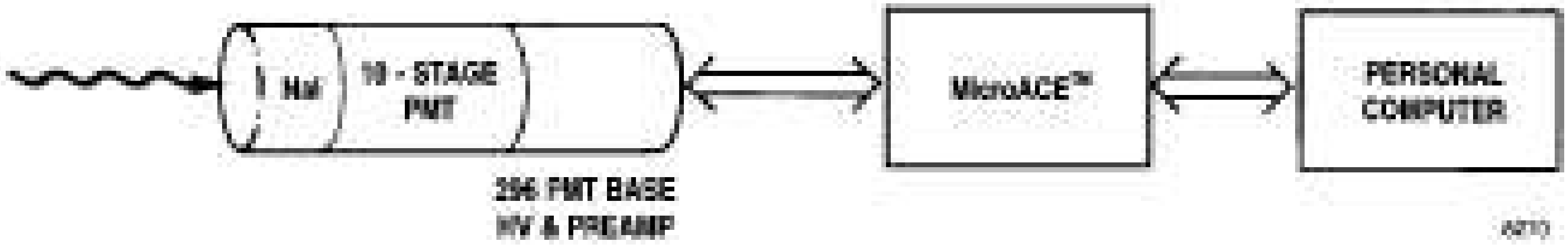


Fig. 4. Pulse-Height (Energy) Spectroscopy with a NaI(Tl) Scintillation Detector

Silicon charged-particle detector

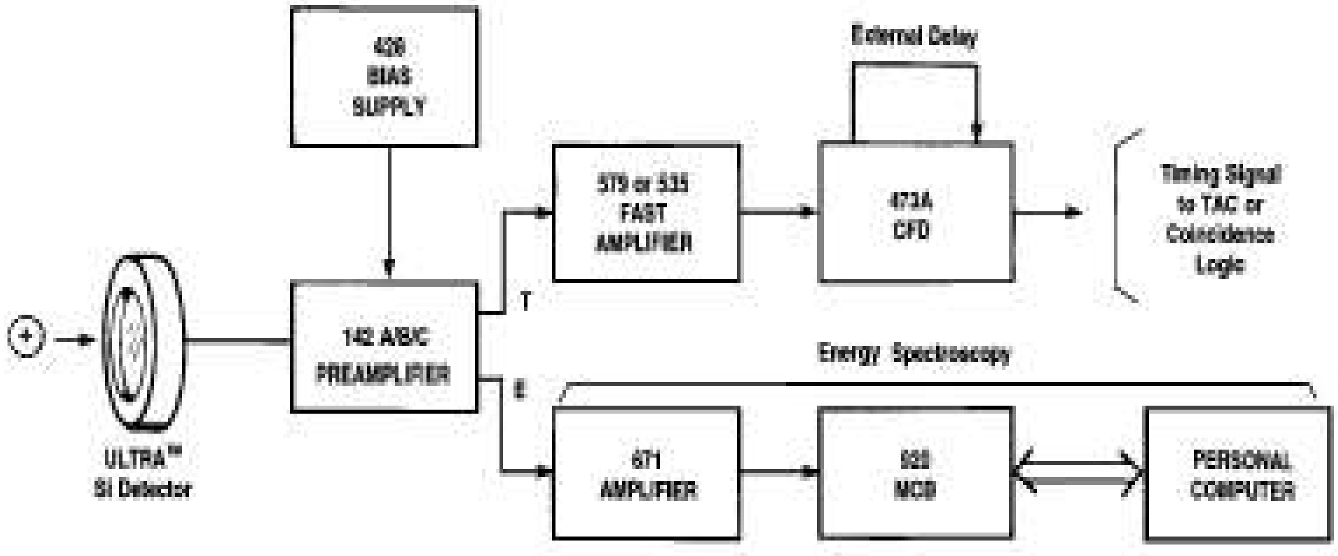


Fig. 7. Pulse-Height (Energy) Spectrometry with a Si Charged-Particle Detector, Including Derivation of an Optional Timing Signal.

Ge or Si(Li) detector

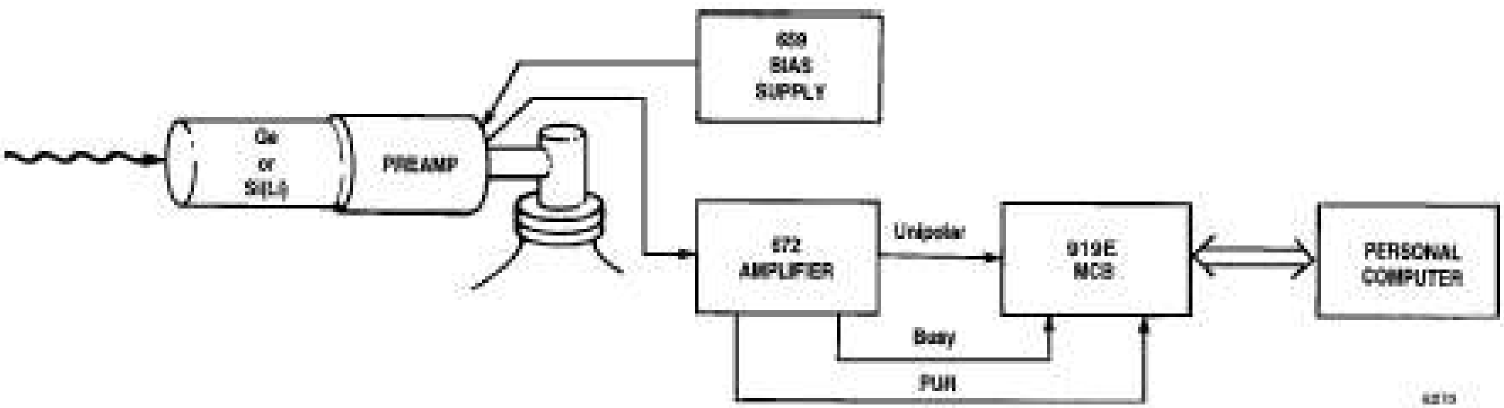
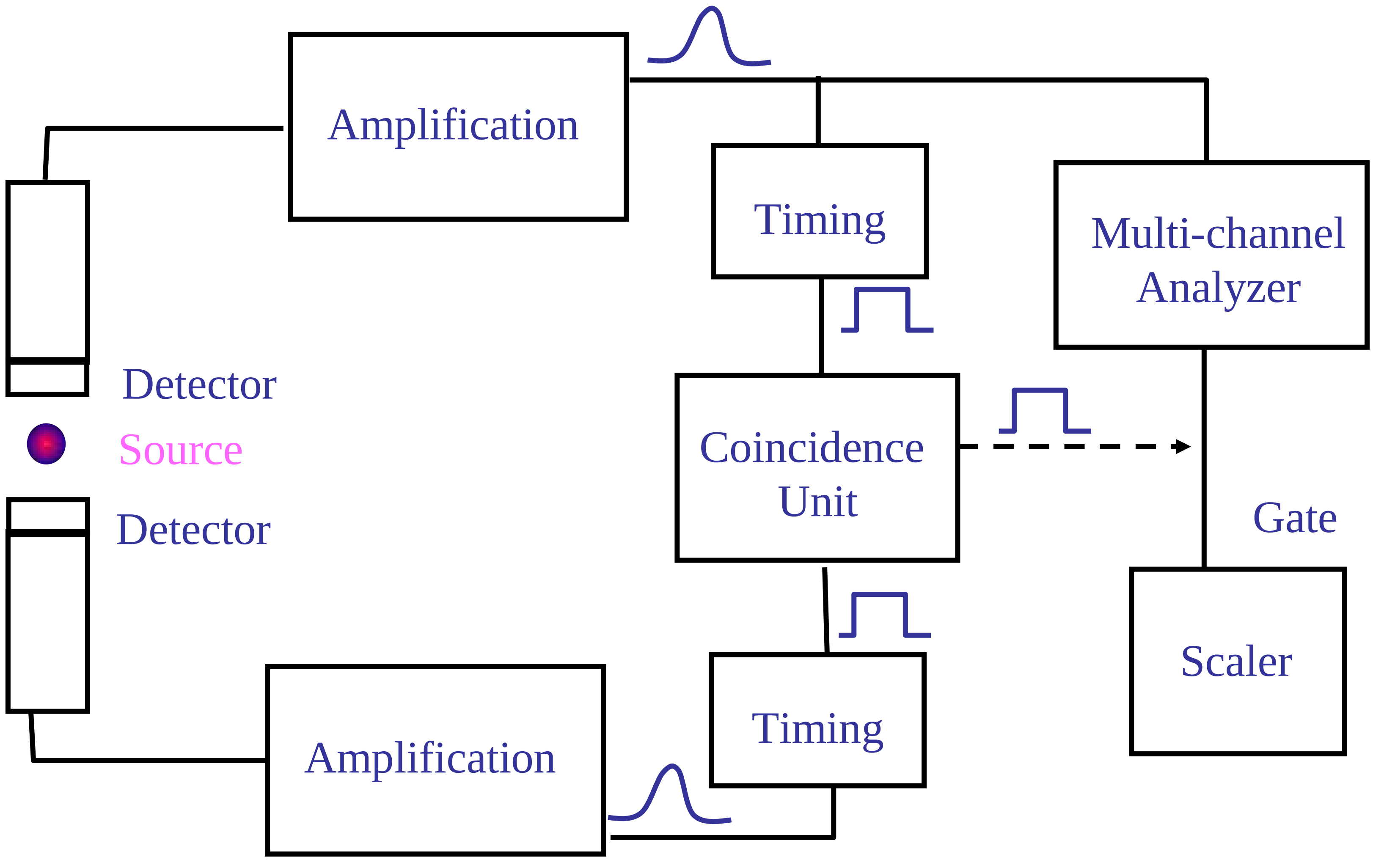


Fig. 8. Pulse-Height (Energy) Spectroscopy with a Ge Detector for Gamma Rays, or a Si(Li) Detector for X Rays.

Coincidence Measurements



Coincidence Measurements

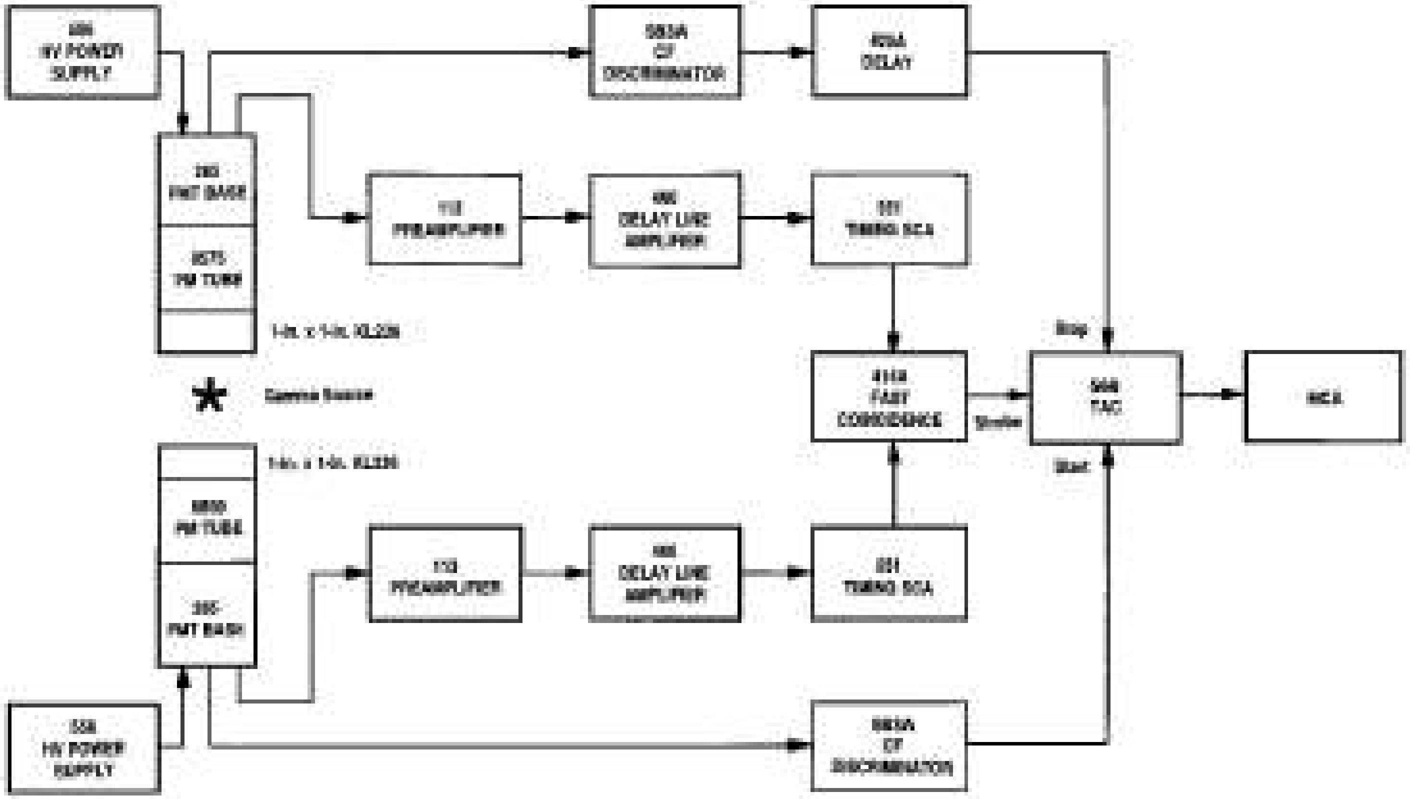


Fig. 17. Typical Fast/Slow Timing System for Gamma-Gamma Coincidence Measurements with Scintillators and Photomultiplier Tubes.

Întrebări

- De unde provin semnalele analogice prelucrate de modulele electronice ?
- Enumerati 5 tipuri de module electronice folosite in achiziţia datelor
- Care este rolul liniilor de întârziere
- Enumerati cateva tipuri de convertoare analog digitale.
- Ce tipuri de semnale logice se folosesc in electronica de achizitie ?