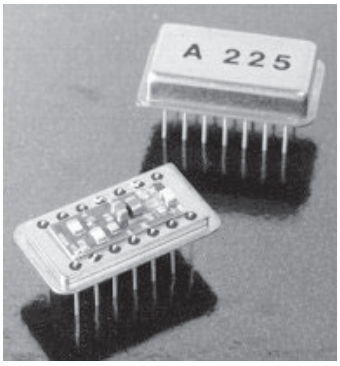
CHARGE SENSITIVE PREAMPLIFIER AND SHAPING AMPLIFIER

A225

ULTRA LOW NOISE: <280 electrons RMS



Model A225 is a high performance thin film hybrid charge sensitive preamplifier and shaping amplifier developed especially for high resolution systems employing solid state detectors, proportional counters, photomultiplier tubes and other charge producing detectors in the pulse height analysis or A/D mode of operation.

While these units were specifically designed for satellite instrumentation, the following unique characteristics make them equally useful for space, laboratory and commercial applications:

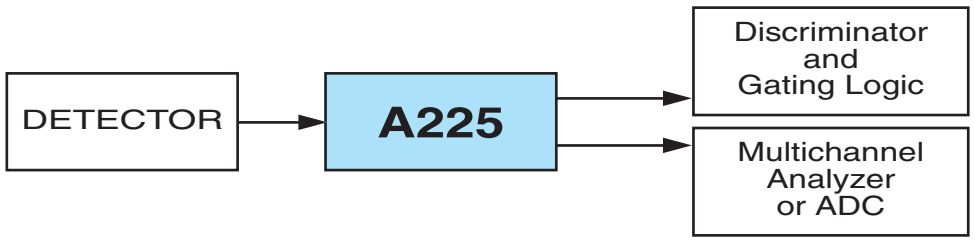
Features

- Operates from -55 to +125 ºC.
- Small size (14 pin hybrid DIP) allows mounting close to the detector.
- Ultra low power (as low as 10 mW)
- Wide range single supply voltage (+4 to +25 VDC)
- Pole-zero cancellation (internal)
- Two outputs available (timing pulse and shaped unipolar)
- High reliability screening
- One year warranty

Applications

-
- Portable instrumentation
- Nuclear monitoring
- Particle, x-ray, and gamma detection
- Imaging
- Research experiments
- Medical and nuclear electronics
- Electro-optical systems

TYPICAL APPLICATION



Amptek High Reliability Screening

- Precap Visual: MIL-STD-883, Method 2017, low magnification, high magnification
- Sealing: Welded, Hermetic Seal
- Stamping: Date Code and Serial Number
- Stabilization Bake: MIL-STD-883, Method 1008, Condition C. +150 °C, 24 hours minimum
- Temperature Cycle: MIL-STD-883, Method 1010, Condition C. Min. T=-65 °C to +150 °C, 10 minutes each extreme, 5 minutes maximum transfer time
- Centrifuge: MIL-STD-883, Method 2001, condition B. YI axis; 10,000 G's
- Electrical Test: As per Specifications
- Burn-In Test: MIL-STD-883, Method 1015, 160 hours at +125 °C
- Fine Leak Test: MIL-STD-883, Method 1014, Condition A. Rejection if leak rate in excess of 5×10^{-7} cc/sec.
- Gross Leak Test: MIL-STD-883, Method 1014, Condition C. Perflourocarbon
- Electrical Test: As per Specification
- External Visual: MIL-STD-883, Method 2009

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SPECIFICATIONS

(Vs = +5 V, T = 25 °C, R_{LOAD} = 10 K)

Input Characteristics

Sensitivity:	240 mV/Mev (Si) 300 mV/Mev (Ge) 195 mV/Mev (CdTe) 206 mV/Mev (HgI2) 5.2 V/pC 0.83 µV/electron
Noise:	2.5 keV FWHM (Si) 2.0 keV FWHM (Ge) 3.1 keV FWHM (CdTe) 2.9 keV FWHM (HgI2) 4.5 x 10^{-17} C rms 280 electrons rms
Noise Slope:	50 eV/pF (Si) 40 eV/pF (Ge) 62 eV/pF (CdTe) 58 eV/pF (HgI2) 9 x 10^{-19} C/pF 5.6 electrons/pF
Dynamic Input Capacitance:	> 7,000 pF
Polarity:	Negative
Detector Capacitance:	Up to 1,000 pF

Output Characteristics

1) Shaping Amplifier (Pin 8)

Polarity:	Positive
Peaking Time:	2.4 µs
Integral Nonlinearity:	< 0.04% for 0 to 10V output pulse
Pole-Zero Compensation:	Internal
Dynamic Range:	(Vs - 1.25) Volt
DC Level:	0.8 V nominal

2) Timing Pulse (Pin 12)

Polarity:	Positive
Sensitivity:	44 mV/Mev (Si) 55 mV/Mev (Ge) 1.0 V/pC
Risetime:	18 ns (unloaded)

General

Weight:	.14 oz, 4 g
Operating Voltage:	Vs = +4 to +25 VDC
Operating Current:	2.3 mA independent of Vs
Variation of Sensitivity with Supply Voltage:	< 0.07% /Volt, 4 to 10 Volts < 0.005% /Volt, 10 to 25 Volts
Temperature:	-55 to +125 °C Operational
Temperature Stability:	0.02% / °C at 25 °C typical ±2% from -25 to +75 °C
Screening:	Amptek High Reliability
Package:	14 pin hybrid DIP (metal)
Radiation Resistance:	100k rad(Si)
Warranty:	One year
Test Board:	PC-25

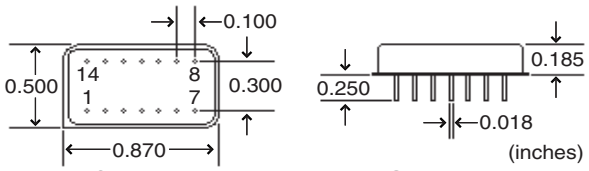
OPERATING NOTES

General

Due to its hermetic seal and small size, the A225 is well suited for use in space or within a vacuum chamber. In such applications care should be taken to avoid electrical discharge near the input which can damage the unit and VOID WARRANTY. Use care in soldering leads - avoid overheating.

For laboratory usage, the A225 can be mounted on its PC-25 test board (see below) and enclosed in a small metal box with appropriate cable connectors. A high voltage coupling capacitor should be added at the input as well as a small hole in the metal box in order to provide screwdriver adjustment to the gain control potentiometer.

Package and Pin Configuration



Pin 1	Input
Pin 2, 9	Case
Pin 3, 6, 7, 10, 13	NC
Pin 4	Input GND and Case
Pin 5	Output GND
Pin 8	Output
Pin 11	Vs = +4 to +25 VDC
Pin 12	Timing Pulse
Pin 14	Compensation (see notes)

Circuit Layout

Due to the high sensitivity and ultra low noise of the A225, care should be taken in circuit layout. The PC-25 Test Board may be used as an example of appropriate layout technique. In general, ground plane construction is recommended. Input and output lines should be kept well separated and in most cases shielding will be necessary.

Particular attention should be paid to the detector ground connection to avoid oscillation due to feedback. The supply voltage is internally decoupled. While this is normally adequate, in some applications external bypassing may be helpful.

To facilitate noise minimization in certain applications, two separate ground connections are provided. Pin 4 is the ground connection for the input stage and is also connected to the case. Pin 5 is ground for the remainder of the circuit. In most applications Pin 4 and 5 may be connected to the same ground (preferably a ground plane under the unit) along with Pins 2,3,6,7,9,10 and 13.

The A225 may also be used in applications where the input from the detector is positive by connecting Pin 5 (output ground) to a negative supply voltage instead of ground. This voltage can range from 0 to -10 V. A negative output pulse at Pin 8 will result from a positive input. The dynamic range in this case will be approximately 0.5 Volts greater than Pin 5. For example, with Pin 5 operated at -5 Volts, negative pulses of up to 5.5 Volts amplitude can be obtained. This mode of operation will result in increased operating current. The A225 is not specified in this mode and critical parameters should be verified by the user.

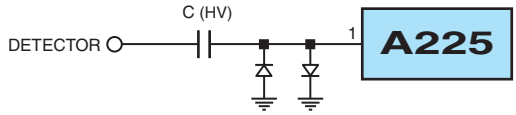
Power Supply

While specifications are given for operation at +5 V, the characteristics of the A225 are relatively unaffected by changes in supply voltage from +4 to +25 VDC. Parameters critical to a particular application should be checked at the actual operating voltage.

Input

In order to minimize noise, the A225 input (Pin 1) has no internal protection. External protection may be added to Pin 1 by connecting two back-to-back diodes to ground.

Typical Protective Circuit



NOTE: The input protection circuit provides a limited amount of protection against transients generated in the detector and bias network. Any circuit capable of providing absolute protection would cause intolerable degradation of noise performance. For this reason, care must be exercised in the use of any preamp with high voltage detectors. Specifically, damage may result from detector breakdown, breakdown of the high voltage coupling capacitor or other component, excessively rapid rise or fall of detector bias voltage, or the addition of uncharged capacitance across the input with bias voltage applied.

In some applications, increased protection will justify an increased noise level. In this case, a resistor may be added in series with the input - normally a few hundred ohm will suffice.

Outputs

Pin 8

The shaping amplifier of the A225 produces a unipolar pulse at Pin 8 suitable for high resolution, high rate pulse height analysis. This output has an AC impedance of approximately 30 Ω and will drive 1 kΩ loads as well as several feet of unterminated cable. In applications requiring highest linearity, load resistance should be greater than 5 kΩ. This output has a quiescent D.C. output level, or Baseline, of approximately 0.8 V. In most applications the pulse should be capacitively coupled to external circuitry.

Pin 12

The output at Pin 12 is a timing pulse with an unloaded risetime of approximately 20 ns and a falltime of 2.8 µs capable of driving a load of 500 Ω. This output has approximately the same linearity characteristics as the shaped output at Pin 8. Grounding this pin could damage the unit.

Bipolar Pulse

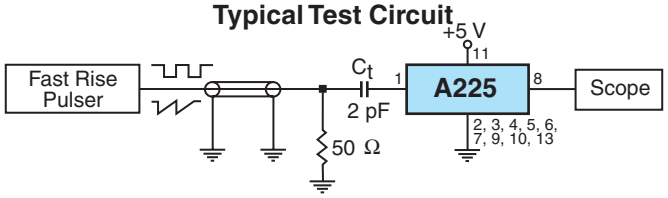
In applications requiring a bipolar pulse, the unipolar output can be differentiated with an RC differentiator. The time constant should be approximately 1.8 µs, suggested values are: C = 1 nF, R = 1.8 kΩ. In most cases this pulse should be buffered in order to drive subsequent circuitry.

Test Circuit

The A225 can be tested with a pulser by using a small capacitor (usually 1 to 2 pF) to inject a test charge into the input. The unit will respond to the negative-going edge of the test pulse, which should have a transition time of less than 20 ns. This negative going edge should be followed by a relatively flat part of the waveform so that it appears as a step function.

For example, a square wave is a good test waveform. (Keep the square wave frequency low enough that the response to the positive-going edge can be ignored.) Alternately, a "sawtooth" waveform or a tail pulse with long fall time (> 100 µs) may be used. Charge transfer to the input is according to Q = Ct·V, where Q = total charge, Ct = value of test capacitor, and V = amplitude of voltage step. DO NOT connect the test pulser to the input directly or through a large capacitor (> 100 pF) as this can produce a large current in the input FET and cause irreversible damage.

Typical Test Circuit



Negative going pulse

Rise Time < 20 ns, fall time > 10 µs, or square wave.

Amplitude: 22 mV = 1 MeV (Si)

1 MeV (Si) = (1 x 10^{6} eV x 1.6 x 10^{-19} C / 3.6 V = 0.044 x 10^{-12} C

V = Q / Ct = (0.044 x 10^{-12} C) / (2 x 10^{-12} F) = 22 mV

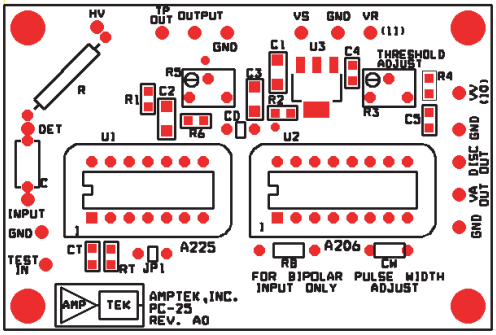
Hence, a 22 mV step into 2 pF test capacitor will simulate the charge of a 1 MeV energy deposition into a silicon detector.

Compensation

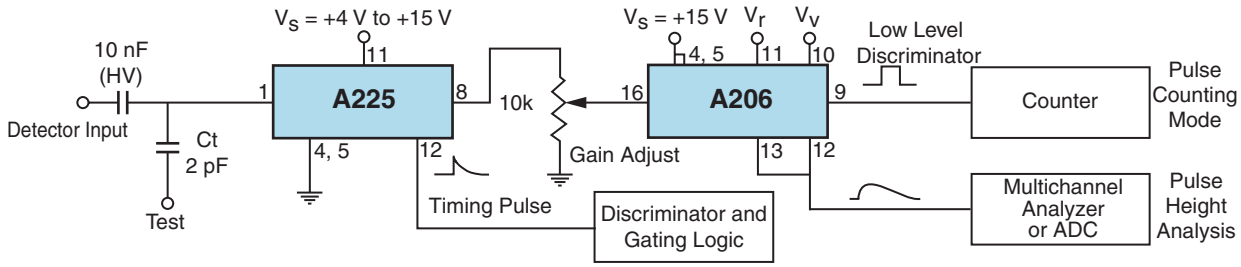
The A225 is internally optimized for detector capacitance up to approximately 50 pF. In applications with large detector capacitance and requiring short timing pulse risetime, a compensation capacitor from 0 to 250 pF may be connected from Pin 14 to ground. The exact value should be experimentally determined with the detector connected to the input. Note that this compensation will not normally be necessary if the timing pulse is not used, or its risetime is not critical.

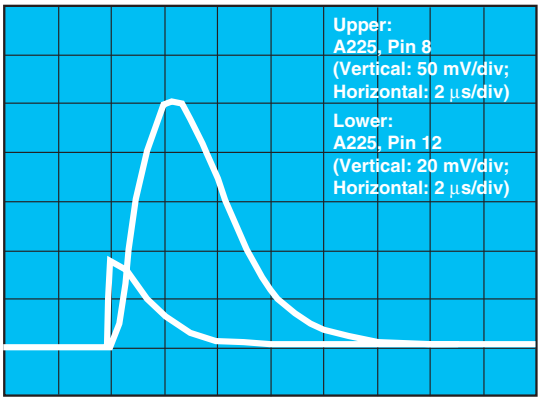
PC-25 TEST BOARD for the A225/A206

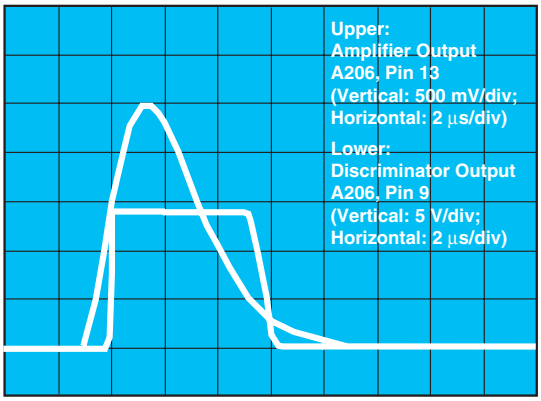
The PC-25 is a printed circuit board which accepts the A225 charge sensitive preamplifier and shaping amplifier and the A206 voltage amplifier and discriminator. It is designed to be used for two purposes: to facilitate testing of these devices, together or separately, and to simplify their use in many applications. The board provides input test circuitry, gain adjustment, voltatge reference to the A206, and convenient access to all active device pins. Ground plane construction minimizes noise pickup.



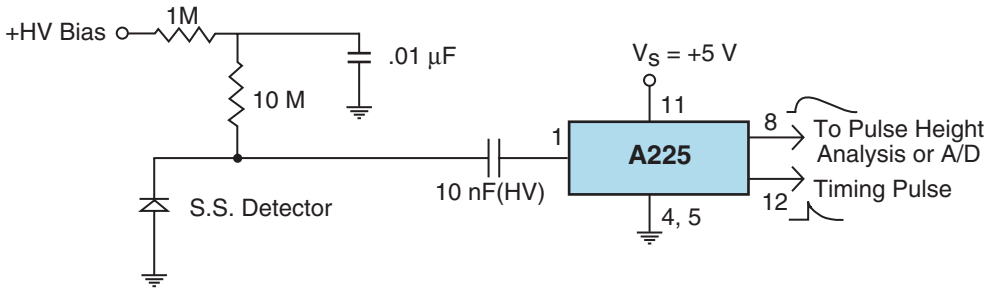
The A225/A206 Complete High Resolution System and Typical Waveforms



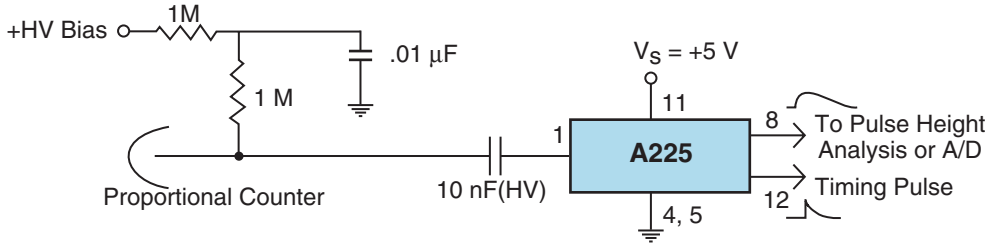




Connection of the A225 to a Solid State Detector



Connection of the A225 to a Proportional Counter



A225F

The A225F is a high density version of the Amptek A225 and features a Single In-line Package (SIP).

Please visit our web site at www.amptek.com for complete details.

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