Charge Sensitive Preamplifier

A250

STATE-OF-THE-ART

- External FET allows matching to detector
- FET can be cooled
- Noise at room temperature ~ 100 electrons RMS
- Low power (19 mW typical)

Features
- Ultra low noise
- Low power
- Fast rise time (2.5 ns at 0 pF)
- External FET (allows selection or cooling)
- Positive or negative signal processing
- Pin selectable gain
- Small size (14 pin hybrid DIP)
- High reliability screening
- One year warranty

Applications
- Aerospace
- Nuclear physics
- Portable instrumentation
- Nuclear monitoring
- Particle, gamma, and x-ray imaging
- Medical and nuclear electronics
- Electro-optical systems

Overview

The A250 is a hybrid state-of-the-art Charge Sensitive Preamplifier for use with a wide range of detectors having capacitance from less than one, to several thousand picofarads. Such detectors include silicon, CdTe, CZT, and HgI₂ solid state detectors, proportional counters, photomultiplier tubes, piezoelectric devices, photodiodes, CCD’s, and others.

To permit optimization for a wide range of applications, the input field effect transistor is external to the package and user selectable. This feature is essential in applications where detector and FET must be cooled to reduce noise. In all applications, it allows the FET to be matched to the particular detector capacitance, as well as to noise and shaping requirements. In larger quantities, the A250 may be specially ordered with an internal FET.

The noise performance of the A250 is such that its contribution to FET and detector noise is negligible in all charge amplifier applications, i.e., it is essentially an ideal amplifier in this respect.

The internal feedback components configure the A250 as a charge amplifier; however, it may be used as a high performance current or voltage preamplifier by choice of suitable feedback components.

While these preamps were designed for multidetector satellite instrumentation, their unique characteristics make them equally useful in a broad range of laboratory and commercial applications.

Figure 1: Typical Application

COOLING (OPTIONAL)

A250

PULSE HEIGHT ANALYZER OR A/D

A275

SHAPING AMPLIFIER

CHARGE SENSITIVE PREAMPLIFIER
## INPUT CHARACTERISTICS

| Sensitivity (C_f = 1 pF) | 44 mV/MeV (Si)  
|                        | 55 mV/MeV (Ge)  
|                        | 36 mV/MeV (CdTe)  
|                        | 38 mV/MeV (Hgl_2)  
|                        | 1 V/pC  
|                        | 0.16 µV/electron  

Sensitivity can be reduced by connecting Pin 2 and/or 3 to Pin 1, thus providing C_f = 3, 5, or 7 pF. Additional external capacitors can be added for further reduction of gain. In general, the sensitivity is given by A = 1/C_f (pF) V/pC. For silicon, the sensitivity is A = 44/C_f (pF) mV/MeV.

### Noise

- **Noise** Input FET dependent. See Figure 2.
- **Noise slope** Input FET dependent. See Figure 2.

Data presented in Figure 2 is representative of results obtained with recommended FETs, and is characteristic of the FET and shaping time constants, rather than the A250, which is effectively noiseless. In general, the choice of input FET is based on its noise voltage specification (ηV/√Hz) and its input capacitance (C_{iss}).

For low capacitance detectors, a FET with small C_{iss} should be chosen, such as 2N4416 or 2SK152.

For very high capacitance detectors, two or more matched high C_{iss} FETs such as the 2N6550 may be paralleled to achieve the best noise performance.

### Dynamic Input Capacitance

> 40,000 pF with two 2SK147 FETs and C_f = 5 pF

### Polarity

- **Polarity** Negative or positive

## OUTPUT CHARACTERISTICS

### Polarity

- **Polarity** Inverse of input

### Rise Time

- **Rise Time**
  - 2.5 ns at 0 pF input load with 2SK152
  - 4.5 ns at 100 pF input load with 2N6650 or 2SK152. See Figures 3 and 4.

### Output Impedance

- **Output Impedance** Pin 8: 100 Ω; Pin 9: < 10 Ω.

### Integral Nonlinearity

- **Integral Nonlinearity**< 0.03% for 0 to +2 V unloaded  
- < 0.006% for 0 to -2 V unloaded

### Decay Time Constant

- **Decay Time Constant** 300 MΩ x C_f = 300 µs, 900 µs, 1.5 ms, 2.1 ms. User selectable T=R_f C_f

### Positive Clipping Level

- **Positive Clipping Level** > +2.8 V

### Negative Clipping Level

- **Negative Clipping Level** < -4.6 V

## GENERAL

### Gain-Bandwidth Product

- **Gain-Bandwidth Product** f_T > 300 MHz with 2N4416 FET  
- f_T > 1.5 GHz with two 2SK147 FETs  
See Figure 7.

### Operating Voltage

- **Operating Voltage** ±6 V, (±8 V maximum)

### Operating Current

- **Operating Current** ±1.2 mA plus the FET drain current (I_{ds}). Where: I_{ds} (mA) = 3/R (kΩ) - 0.25. As a special case, the internal 1 K resistor may be used for R, by connecting Pin 13 to 14, giving I_{ds} = 2.75 mA.

### Power Dissipation

- **Power Dissipation** 14 mW + 6I_{ds}

### Variation of Sensitivity with Supply Voltage

- **Variation of Sensitivity with Supply Voltage** < 0.15%/V at ±6 V.

### Temperature Stability

- **Temperature Stability** < 0.1% from 0 to +100 °C < 0.5% from -55 to +125 °C

### Operating Temperature

- **Operating Temperature** -55 to +125 °C

### Storage Temperature

- **Storage Temperature** -65 to +150 °C

### Screening

- **Screening** Amptek High Reliability

### Options

- **Options** RC Feedback Kit (1 GΩ resistor, 0.1 pF capacitor)  
- Internal FET (consult factory)  
- NASA GSFC S-311-P-698 screening  
- Amptek High Reliability Screening

### Other Configurations (Package)

- **A250F with internal FET (SIP Package)**  
- **A250F/NF with external FET (SIP Package)**

### Pin Configuration (14 pin hybrid DIP)

- **Pin Configuration**
  - **Pin 1** 300 MΩ resistor in parallel with 1 pF feedback capacitor. Connect this pin to the detector and the gate of the FET.
  - **Pin 2** 2 pF feedback tap
  - **Pin 3** 4 pF feedback tap
  - **Pin 4** -6 V direct
  - **Pin 5** -6 V through 50 Ω
  - **Pin 6** Compensation (0 – 30 pF to ground) for low closed loop gain configuration (where a large feedback capacitor is used together with small detector capacitance).
  - **Pin 7** Ground and case
  - **Pin 8** Output through 100 Ω
  - **Pin 9** Output direct
  - **Pin 10** +6 V through 50 Ω
  - **Pin 11** +6 V direct
  - **Pin 12** Ground and case
  - **Pin 13** Provide 2.75 mA drain current to the external FET by connecting Pin 13 to 14. (See operating current specifications.)
  - **Pin 14** Input. Should be connected to the drain of the FET. This pin is held internally at +3 Volts.
A250 Specifications (con't)

Figure 2: A250 Noise Characteristics

Noise as a function of detector capacitance, input FET, feedback capacitor, and shaping times

Figure 3: A250 Rise Time

Output rise time versus detector capacitance and FET

Figure 4: A250 Output Response

Output response with A250 configured as a charge sensitive preamplifier; 2SK152/3mA, $R_f = 300 \, \text{M}\Omega$, $C_f = 1 \, \text{pF}$, $C_d = 0 \, \text{pF}$

Figure 5: A250 Output Response

Output response with A250 configured as a Transimpedance Amplifier (current to voltage); 2N4416/3mA, $R_f = 60 \, \text{k}\Omega$, $C_f = 0 \, \text{pF}$, $C_d = 0 \, \text{pF}$

Figure 6: A250 Configured as a Low Noise Voltage Amplifier

Typical $RF = 1 \, \text{M}\Omega$, $RI = 10 \, \text{k}\Omega$; $\text{GAIN}: Vo = VI(RF/RI)$

Figure 7: A250 Small Signal Phase & Amplitude vs. Frequency

For low capacitance FET: 2N4416 ($C_{iss} = 4 \, \text{pF}$, $I_{ds} = 3 \, \text{mA}$)  
For high capacitance FET: 2 x 2SK147 ($C_{iss} = 180 \, \text{pF}$, $I_{ds} = 1.5 \, \text{mA}$ each)

Figure 8: A250 Connection Diagram

Figure 9: A250 Mechanical dimensions.

(Top View) (Side View)
A250 Applications

Figure 10: A Two Detector Telescope System.

Figure 11: The A250 Connected to a Solid State Detector.

Figure 12: The A250 Connected to a Proportional Counter.

Figure 13: The A250 Connected to a DP5/PX5 DPP & MCA.

For more information, please see http://www.amptek.com

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