Model **XR-100CR** is a new high performance X-Ray Detector, Preamplifier, and Cooler system which uses a thermoelectrically cooled Si-PIN Photodiode as an X-Ray detector. Also mounted on the cooler are the input FET and a novel feedback circuit. These components are kept at approximately -30°C, and can be monitored by an internal temperature sensor. The hermetic TO-8 package of the detector has a light tight, vacuum tight 1 mil (25 µm) Beryllium window to enable soft X-Ray detection.

Power to the XR-100CR is provided by the PX2CR Power Supply. The PX2CR is AC powered and includes a spectroscopy grade Shaping Amplifier. The XR-100CR/PX2CR system ensures stable operation in less than one minute from power turn-on.

The resolution for the 5.9 keV peak of ^{55}Fe is 220 eV FWHM with 12 µs shaping time constant (standard) and 186 eV FWHM with 20 µs shaping time (optional).

### FEATURES
- Si-PIN Photodiode
- Thermoelectric Cooler
- Beryllium Window
- Hermetic Package (TO-8)
- Wide Detection Range
- Easy to Operate

### APPLICATIONS
- X-Ray Fluorescence
- Nuclear Medicine
- X-Ray Lithography
- Portable Instruments
- OEM
- Teaching & Research
- Mössbauer Spectrometers
- Space and Astronomy
- Environmental Monitoring
- Nuclear Plant Monitoring
- Archeology
- Toxic Dump Site Monitoring
- PIXE
- Process Control

![^55Fe Spectrum at 20 kcps ICR](image)
X-Rays interact with silicon atoms to create an average of one electron/hole pair for every 3.62 eV of energy lost in the silicon. Depending on the energy of the incoming radiation, this loss is dominated by either the Photoelectric Effect or Compton Scattering. The probability or efficiency of the detector to “stop” an X-Ray and create electron/hole pairs increases with the thickness of the silicon. See Figure 2.

In order to facilitate the electron/hole collection process, a 100 Volt bias voltage is applied across the silicon. This voltage is too high for operation at room temperature, as it will cause excessive leakage, and eventually breakdown. Since the detector in the XR-100CR is cooled, the leakage current is reduced considerably, thus permitting the high bias voltage. This higher voltage decreases the capacitance of the detector, which lowers system noise.

Electron-hole pairs created by X-rays which interact with the silicon near the back contact of the detector are collected more slowly than normal events. These events result in smaller than normal charge collection and produce false peaks. Such events are characterized by slow risetime, and the PX2CR Amplifier incorporates a Rise Time Discrimination circuit (RTD) which prevents these pulses from being counted by the MCA. See Figure 6. All spectra shown in this specification were taken using RTD.

The thermoelectric cooler cools both the silicon detector and the input FET transistor to the charge sensitive preamplifier. Cooling the FET reduces its leakage current and increases the transconductance, both of which reduce the electronic noise of the system.

Since optical reset is not practical when the detector is a photodiode, the XR-100CR incorporates a novel feedback method for the reset to the charge sensitive preamplifier. The reset transistor, which is typically used in most other systems has been eliminated. Instead, the reset is done through the high voltage connection to the detector by injecting a precise charge pulse through the detector capacitance to the input FET. This method eliminates the noise contribution of the reset transistor and further improves the energy resolution of the system.

A temperature monitor chip is mounted on the cooled substrate to provide a direct reading of the temperature of the internal components, which will vary with room temperature. Below -20 °C the performance of the XR-100CR will not change with a temperature variation of a few degrees. Hence, closed loop temperature control is not necessary when using the XR-100CR at normal room temperature.

**VACUUM OPERATION**

The XR-100CR can be operated in air or in vacuum down to $10^{-8}$ Torr. There are two ways the XR-100CR can be operated in vacuum: 1) The entire XR-100CR detector and preamplifier box can be placed inside the chamber. In order to avoid overheating and dissipate the 1 Watt of power needed to operate the XR-100CR, good heat conduction to the chamber walls should be provided by using the four mounting holes. An optional Model 9DVF 9-Pin D vacuum feedthrough connector on a Conflat is available to connect the XR-100CR to the PX2CR outside the vacuum chamber. 2) The XR-100CR can be located outside the vacuum chamber to detect X-rays inside the chamber through a standard Conflat compression O-ring port. Optional Models EXV6 / EXV9 (6 or 9 inch) vacuum detector extenders are available for this application. See Figure 8.
**SPECIFICATIONS**

**MODEL XR-100CR**

**X-Ray Detector**

**GENERAL**
- **Detector Type:** Si-PIN
- **Detector Size:** 2.4 x 2.8 mm (7 mm²), standard
- **Silicon Thickness:** 300 µm  See Figure 3.
- **Energy Resolution @ 5.9 keV, 55Fe**
  - Standard: 220 eV FWHM with 12 µs shaping time
  - Optional: 186 eV FWHM with 20 µs shaping time
  - 280 eV FWHM with 6 µs shaping time
- **Background counts:** <3 x 10⁻³/s, 2 keV to 150 keV
- **Detector Window:** Be, 1 mil thick (25 µm)  See Figure 3.
- **Charge Sensitive Preamplifier:** Amptek custom design with reset through the H.V. connection

**Size:** 6 x 6.3 x 3.5 inches (15.3 x 15.3 x 8.9 cm)
- **Weight:** 2.5 lbs (1.15 kg)
- **Input AC power to the PX2CR is provided through a Standard IEC 320 plug (110/250 VAC, 50-60 Hz).  See Figure 5.**
- **The four (4) DC Voltages needed to operate the XR-100CR are supplied through a female 9-Pin D-Connector on the PX2CR.**
- **The Pin list to this connector is given below.**
- **The multiconductor cable which connects the PX2CR to the XR-100CR is provided with the system.**

**INPUTS**
- **Test Input:** 1 mV/keV, positive
- **Preamp Power:** ±9 Volts @ 15 mA
- **Detector Power:** +100 Volts @ 1 µA
- **Cooler Power:** Current = 0.7 A maximum 
  Voltage = 2 Volts maximum

**OUTPUTS**
1) **Preamplifier**
   - **Sensitivity:** 1 mV/keV
   - **Polarity:** Negative Signal Out, 1 kΩ max. load
   - **Feedback:** Reset through H.V. detector capacitance
2) **Temperature Monitor**
   - **Sensitivity:** 1 µA corresponds to 1 °K

**OPTIONS**
- **Other detector sizes (13 mm² Si-PIN) and Beryllium windows (0.3 mil - 7.5 µm) are available on special order.**
- **See also XR-100T-CZT specifications using Cadmium Zinc Telluride (CZT) detectors for high efficiency and high resolution Gamma Ray detection (1.5 keV FWHM @ 122 keV, 57Co).**

**CONNECTORS**
- **Preamp Output:** BNC coaxial connector
- **Test Input:** BNC coaxial connector
- **Other connections:** 6-Pin, LEMO connector with 5 ft cable

**6-PIN LEMO CONNECTOR**
- **Pin 1:** Temperature Monitor
- **Pin 2:** + H.V. Detector Bias, +110 Volt max.
- **Pin 3:** -9 Volt Preamp Power
- **Pin 4:** +9 Volt Preamp Power
- **Pin 5:** Cooler Power Return
- **Pin 6:** Cooler Power (0 to +2.1 Volt @ 0.7 A max.)
- **CASE:** Ground and Shield

**MODEL PX2CR**

**Power Supply & Shaping Amplifier**

**GENERAL**
- **Polarity:** Positive Unipolar
- **Shaping Time:** 12 µs standard (6 µs and 20 µs optional)
- **Pulse Width:** 22 µs.  See Figure 4.
- **Shaping Type:** 7 pole “Triangular” with Base Line Restoration, Pileup Rejection and Rise Time Discrimination (RTD).
- **Sensitivity:** 0 to 1 V/keV (10 turn pot)
- **Gain:** 0 to X1000
- **Gain Shift:** See Figure 16.
- **Output Impedance:** <1 Ω

**SHAPING AMPLIFIER**
- **The output pulse produced by the PX2CR Shaping Amplifier is optimum for most applications using the Si-PIN photodiode detectors, and can be connected directly to the input of a Multi-channel Analyzer (MCA).**
- **For optimum portability and versatility, use the Amptek MCA8000A “Pocket MCA” with over 16k data channels.**

**SIGNAL CONNECTIONS**
- **Input from XR-100CR:** Front panel BNC
- **Output to MCA:** Front panel BNC
- **Pileup Rejection (PU):** Rear panel BNC, Positive TTL
  - For the duration of this output gate, any detected pulse must be rejected by the MCA.
- **Input Count Rate (ICR):** Rear panel BNC, Positive TTL <2 µs
  - When connected to a counter, the ICR countrate corresponds to the total number of X-Ray events that strike the detector.
Figure 2. X-Ray Transmission through Be Windows

Figure 3. Detection Efficiency of Silicon Detectors

Figure 4. PX2CR Amplifier Output

Figure 5. XR-100CR Connection Diagram

This diagram shows the internal connections between the AXRCR hybrid sensor and the electronics within the case.

Figure 6. Comparison of 109Cd Spectra WITH and WITHOUT Rise Time Discriminator (RTD)
Applications

**Figure 7.** $^{55}\text{Fe}$, $^{57}\text{Co}$ and Test Pulser Spectra

**Figure 8.** XR-100CR for Vacuum Use
Shown with optional accessories EXV6 and Conflat compression O-ring port.

**Figure 9.** $^{241}\text{Am}$ Spectrum

**Figure 10.** Lead (Pb) Fluorescence from $^{109}\text{Cd}$

**Figure 11.** Amptek XR-100CR Si-PIN Detector Compared with Si(Li) Detector

X-Ray Fluorescence Spectra of 316 Stainless Steel from $^{109}\text{Cd}$
Figure 12. XR100CR, MCA8000A, and Laptop Computer

Figure 13. Sample Spectrum

Figure 14. First X-Ray Spectrum from Mars Using XR-100T Detector, Courtesy of the University of Chicago

Figure 15. Resolution and Peak Shift vs. Countrate for $^{55}$Fe, 5.9 keV, 12 µs Shaping

Figure 16. Output vs. Input Rate for Different Shaping Time Constants

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