PX5 User Manual

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AMPTEK, Inc. 14 DeAngelo Drive, Bedford, MA 01730-2204 USA

+1 781 275-2242 Fax: +1 781 275-3470 www.amptek.com Amptek.sales@ametek.com

1 Introduction

1.1 PX5 Description

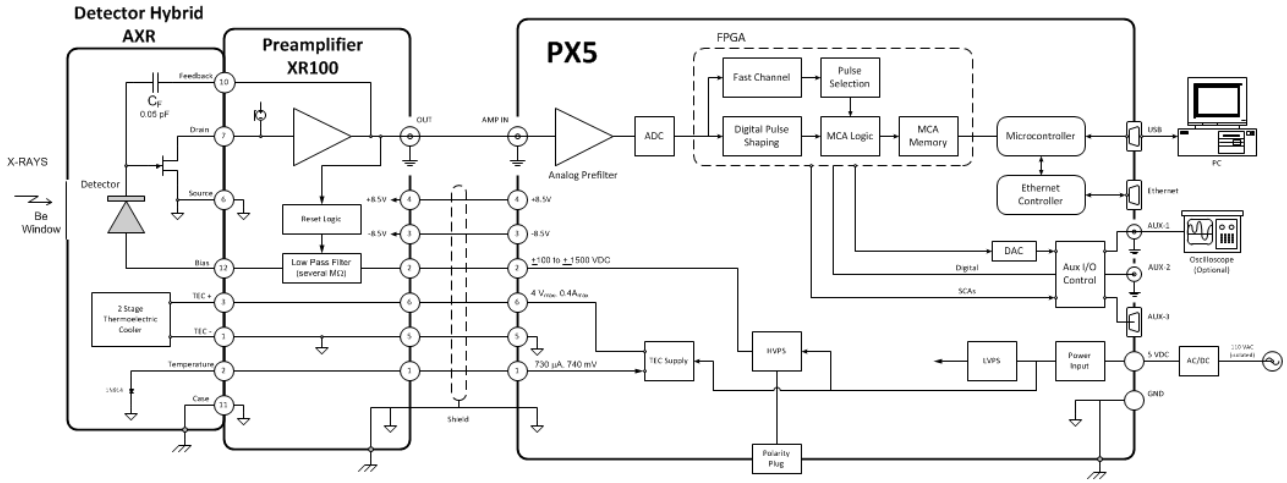
The PX5 is a high performance digital pulse processor and power supply module. It is a component in a complete nuclear spectroscopy system, which must also include a detector and preamplifier. A complete system can be assembled by combining the PX5 with one of Amptek's detectors and preamps (several options and configurations may be used) or a user can supply his own detector and preamplifier, and/or power supply. The PX5 is similar in many ways to a combination of Amptek's DP5 signal processor and PC5 power supply module, but has several enhancements and is packaged for laboratory use. The DP5 and PC5 are printed circuit board assemblies, suited primarily to OEM applications as part of a complete system.

The PX5 is designed primarily for use with high resolution solid state detectors. It works very well with Amptek's SDD, SiPIN, and CdTe X-ray detectors. A variant (with custom power supplies) yields high performance with HPGe γ-ray detectors.

The PX5 is a digital pulse processor (DPP) which replaces both the shaping amplifier and MCA found in analog systems. The digital technology improves several key parameters: (1) better performance, specifically better resolution and higher count rates; (2) greater flexibility since more configuration options are available, selected by software, and (3) improved stability and reproducibility. The DPP digitizes the preamplifier output, applies real-time digital processing to the signal, detects the peak amplitude, and bins this in its histogram memory. The spectrum is then transmitted to the user's computer.

The PX5 includes all power supplies necessary to operate Amptek's detectors. Operating off +5 VDC, it produces high voltage (commandable over a +/-1500V range), low voltages for the preamps, and provides closed-loop control for the thermoelectric cooler. The PX5 supports USB, RS232, and Ethernet, and the auxiliary connectors provide several additional inputs and outputs. This includes a DAC output, an MCA gate, timing outputs, eight SCA outputs, and others. The PX5 is supplied with the DPPMCA data acquisition and control software, along with interface subroutines to integrate the unit with custom software (DPP FW6 SDK). Optional accessories include software for analyzing X-ray spectra, several collimation and mounting options, vacuum accessories, and X-ray tubes to complete a compact system for X-ray fluorescence (XRF).

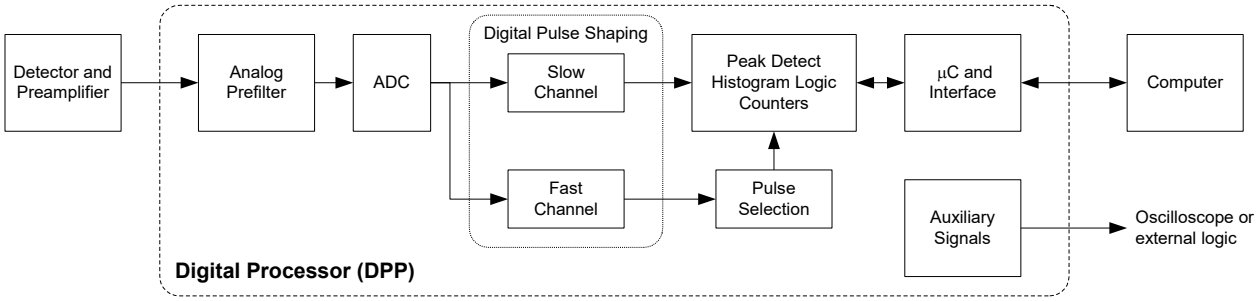
Photograph of PX5 front (top) and back (bottom).



Block diagram of the PX5 connected to an Amptek XR100 detector.

1.2 DP5 Family

Amptek has a family of products built around its core DP5 digital pulse processing technology, designed for pulse height spectroscopy. It was originally designed for the detection of ionizing radiation, principally X-ray and gamma-ray spectroscopy. A generic system, illustrated below, includes (a) a sensor, a.k.a. detector, (b) a charge sensitive preamplifier, (c) analog prefilter circuitry, (d) an ADC, (e) an FPGA which implements pulse shaping and multichannel analysis, (f) a communications interface, (g) power supplies, (h) data acquisition and control software, and (i) analysis software.



The core DP5 technology shared by all the systems includes the ADC, the FPGA, the communication interface, and the data acquisition and control software. All products in the DP5 product family include nearly the same digital signal processing algorithms, the same communication interfaces (both the primary serial interfaces and the auxiliary I/O), and use the same data acquisition and control software. The DPPMCA software package is a complete, compiled data acquisition and control software package used across the family; Amptek also offers an SDK for custom software solutions.

The products in the DP5 family differ in the sensor for which they are designed, which leads to changes in the analog prefilter, power supplies, and form factor. They also differ in their completeness: some of Amptek's products are "complete" while others offer only a portion of the functionality for the user to integrate into a complete system.

Amptek has written a "User Manual for Amptek's DP5 Product Family" which summarizes those characteristics which are common across the entire DP5 family. This manual concentrates on only those aspects which are unique to the PX5.

1.3 Options and Variations

The PX5 is designed for maximum flexibility, so most configuration variations are set in software or by a hardware jumper. The one variant available is the PX5-HPGe. This product is designed for solid state radiation detectors and preamps which (a) require higher bias than the 1500V available in the standard PX5, (b) require NIM-standard +/- 12V and +/-24V low voltage supplies for the preamps, and (c) have relatively short (<100 μs) time constant RC preamplifiers. This product has its own manual.

2 Specifications

The PX5 specification table is identical to that found in the "User Manual for Amptek's DP5 Product Family". The physical and power specifications are listed below.

Physical	
Dimensions	6.5" x 5.5" x 1.5" / 165 x 135 x 40 mm
Weight	1.6 lbs / 750 g
Power	
Nominal Input:	+5 VDC at 500 mA (2.5 W) typical. Current depends strongly on T_{det}, ranging from 350 to 1100 mA at 5 VDC
Input Range:	+4 V to +5.5 V (at 0.4 to 0.27 A typical)
Initial transient:	2 A for <100 μs
Power Source:	External supply

3 Mechanical Interface

3.1 Dimensions

6.5" x 5.5" x 1.5" / 165 x 135 x 40 mm (excluding connectors)

3.2 Control

Front Panel ON/OFF: This switch turns the PX5 on and off. If the PX5 is off and you hold the switch down for >3 seconds (when it beeps a second time), then the PX5 returns to the configuration settings that were in use when it was powered off (stored in EEPROM), which includes turning on the HV and cooling supplies, if they were previously on. If you hold the switch for <3 seconds, the PX5 boots unconfigured.

When the HV polarity is positive (negative), the "power on" switch on the front panel lights green (red). This switch blinks when the PX5 is acquiring data and is steady when not acquiring data.

3.3 Connectors

Power

Power Plug mates with 3.5 mm x 1.3 mm x 9.5 mm female barrel, center positive, plug connector.

Pin #	Name
1	VIN (+5 V DC)
2	GND

USB

Standard USB 'mini-B' jack.

Ethernet

Standard Ethernet connector (RJ-45)

Analog In

Standard BNC connector.

Pin	Signal	Comment
1	Input	IN+ of input amplifier
2	GND	Can jumper to IN- of amplifier

XR100 Power

6-pin Lemo Connector: Part# ERA.1S.306.CLL

Mates with Part# FFA.1S.306.CLAC57

1	Temperature
2	Bias (up to ±1500V) **WARNING: Using the wrong polarity will destroy the detector and will NOT be covered under warranty. Always check that the correct HV polarity is set before turning on the PX5.**
3	-8.5 or -5 VDC (software selectable)
4	+8.5 or +5 VDC (software selectable)
5	Cooler - (grounded)
6	Cooler +
Ground on shield	

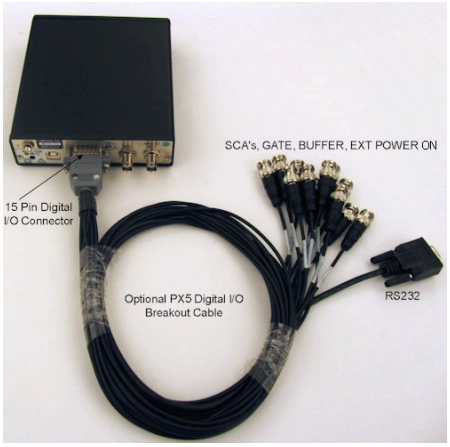
AUX1 and AUX2

Standard BNC connectors. See electrical interface for signals.

AUX 3

Digital I/O: 15 pin D connector (female). Mates with Amptek breakout cable assembly or customer-supplied cable

Pin #	Name	Pin #	Name
1	Gnd	9	SCA 8 Out
2	RS232 - TX	10	External Power On/Off
3	RS232 -RX	11	SCA 7 Out
4	SCA 6 Out	12	SCA 1 Out
5	SCA 5 Out	13	SCA 2 Out
6	Gnd	14	SCA 3 Out
7	Aux 3	15	SCA 4 Out
8	Aux 4		



High Voltage Jumper

WARNING: Using the wrong polarity will destroy the detector and will NOT be covered under warranty. Always check that the correct HV polarity is set before turning on the PX5.

The PX5 can produce both negative and positive high voltage. The polarity is set by the jumper seen below. There is also a software command for the HV polarity. It is the jumper that actually sets the polarity; the PX5 compares the actual hardware setting (through the jumper) with the software setting. If they disagree, the PX5 disables the high voltage.

Amptek SiPIN and CdTe detectors require positive high voltage. Using negative HV will destroy the SiPIN and CdTe and will not be covered under warranty. Amptek silicon drift detectors (SDD) require negative high voltage. Using positive HV will destroy the SDD and will not be covered under warranty.

Left: PX5 high voltage jumper set to positive for Si-PIN or CdTe detector. Right: PX5 high voltage jumper set to negative for silicon drift detector (SDD)

If the HV jumper is not installed, or does not make proper contact (loose screw, etc.), then the PX5 will make a continuous audible alarm, and HV will be disabled.

4 Electrical Interface

4.1 Power Interface

Absolute Maximum Power Supply Voltage	+5.5 VDC
Absolute Minimum Power Supply Voltage	+4.0 VDC

Input power outside this range will damage PX5 components.

4.2 Analog Input Interface

Absolute Maximum Input Voltage Range	-11V to +11V.

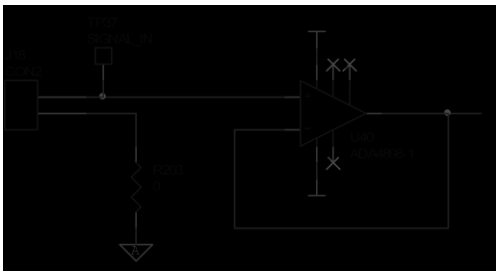
Input voltages outside this range will damage PX5 components.

Polarity: Either positive or negative. Configure in software

Reset or resistive: Either is acceptable but must be configured in software.

Step size: 5 mV to 1V.

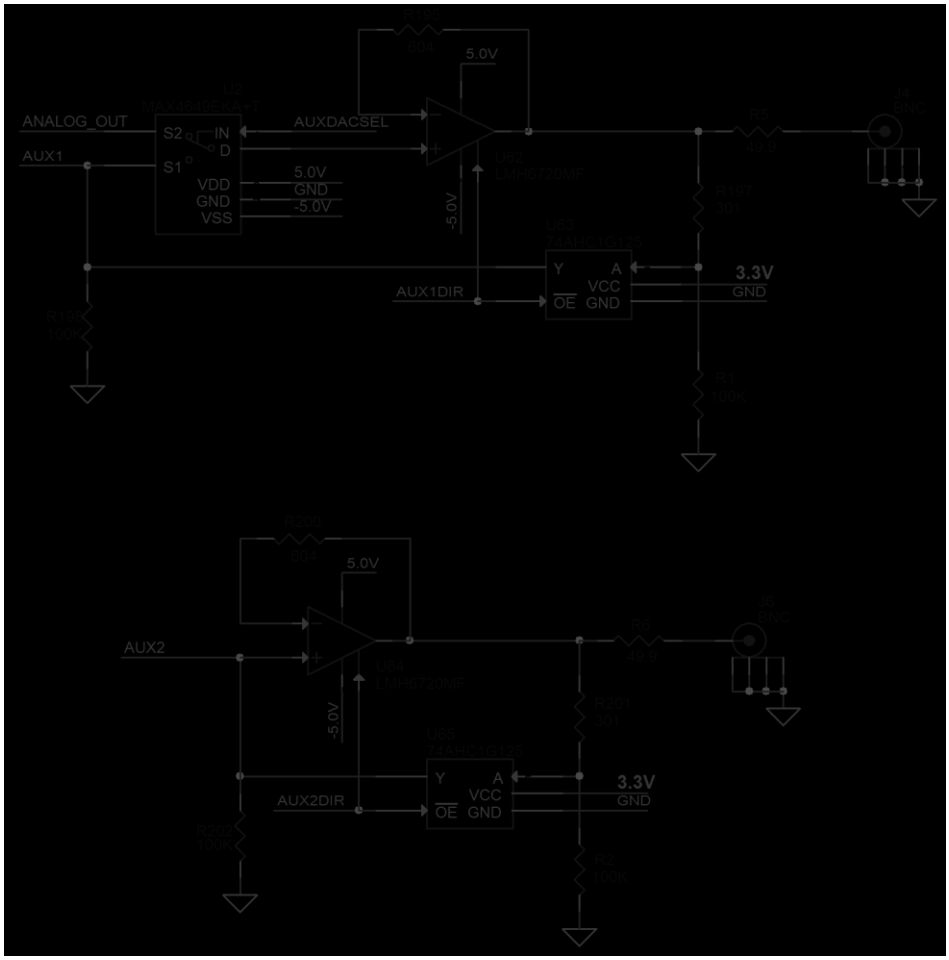
Shown below is a simplified schematic of the analog input. There are several jumpers on the board which permit this front end to be reconfigured for use with a variety of different detectors and preamplifiers. Contact Amptek to discuss these options



V_PA can be set to +/-5V or to +/- 8.5V. The input amplifier's output voltage swing is +/- 3.3V or +/- 6.8V, depending on V_PA. The absolute max is +11 to -11V.

4.3 AUX1 and AUX 2 Interface

The schematic below illustrates the AUX1 and AUX2 interfaces. Based on software commands, AUX-1 can be used to (a) output diagnostic analog signals showing pulse shapes, (b) output logic signals, or (b) input logic signals for COUNTER. In software, one first selects which of the three functions is used, and then must select which signal is used for the DAC output, for the AUX1 logic output, or for the input. The AUX-2 BNC can be used to input or output digital signals, including the GATE function.



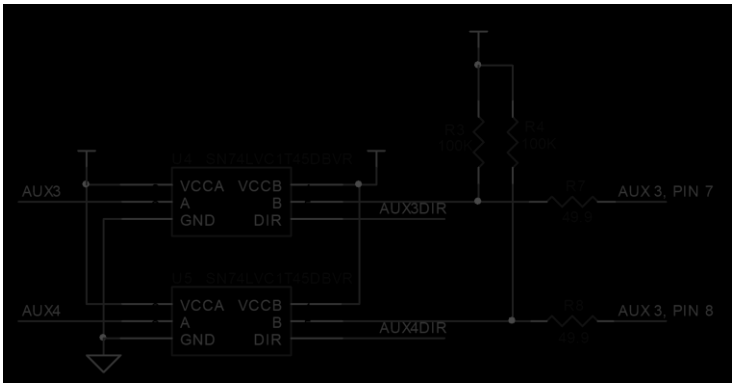
Schematic for AUX-1 BNC connector (top), and AUX-2 BNC connector (bottom)

The AUX signals have an unusual characteristic when used as inputs, due to clamping from the op amp. They are compatible with 3V/5V CMOS. They may be compatible with TTL with an appropriate pull-up resistor. The minimum input 'high' voltage is about 2.6V-2.7V, and the input will draw about 1mA briefly until it switches state - then the current will drop. The input acts like a flip-flop - if the input is disconnected the input will remain in its previous state.

4.4 AUX3 Interface

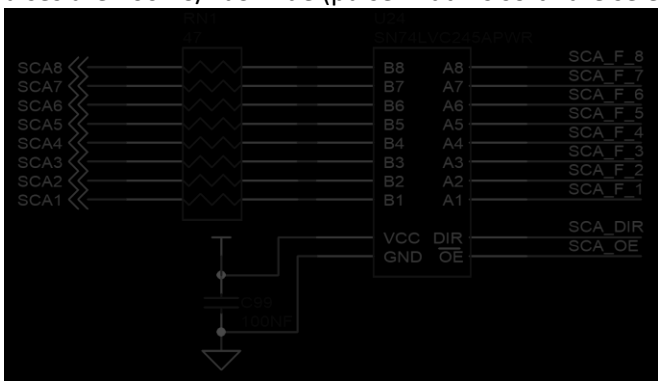
AUX3 and AUX4

These auxiliary connections can be used to input or output logic signals. The circuit is shown below.



Single Channel Analyzers (SCAs)

- Each of the eight SCAs has an independently assignable LLD and a ULD. If the shaped pulse peaks within the range of an SCA, between its LLD and ULD, then a logic signal is output.
- These output pulses are 100 nS/1uS wide (pulse width is software selectable.)



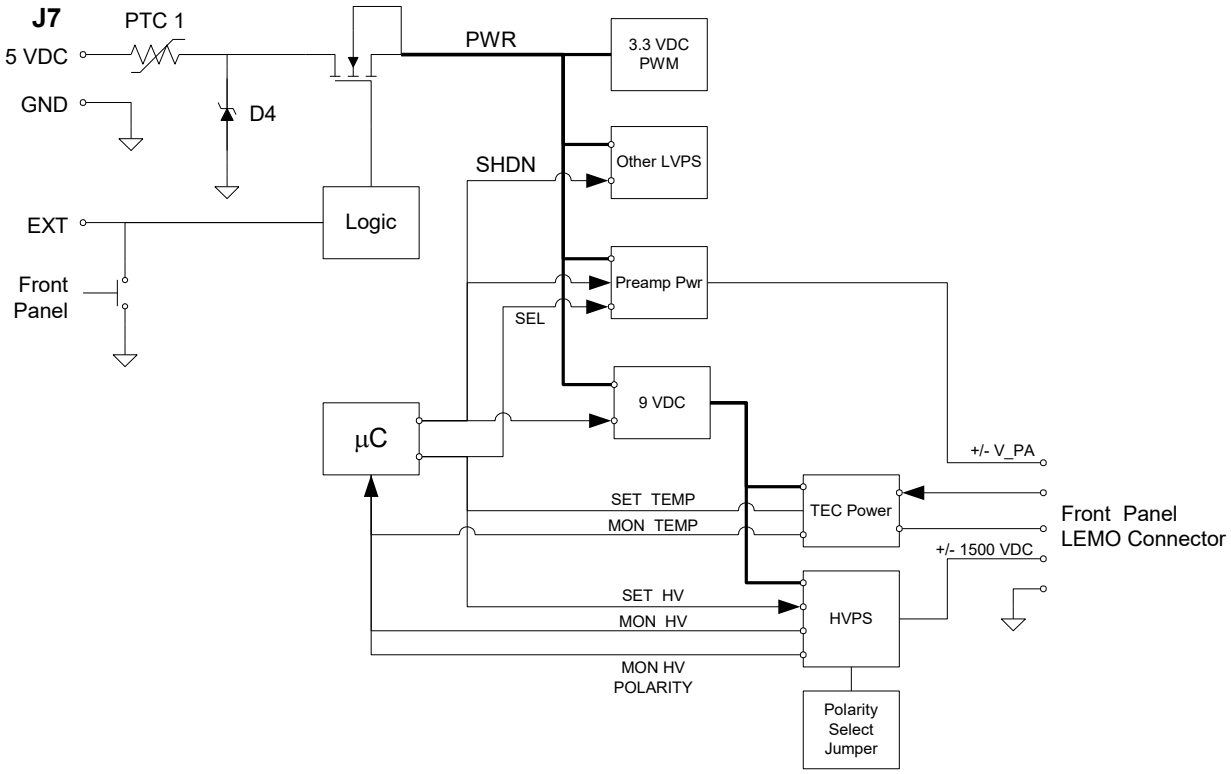
5 PX5 Design

5.1 Signal Processing

There are three components to the signal processing chain: an analog prefilter, an ADC, and the FPGA. The ADC and the FPGA are identical to those of the DP5. The analog prefilter has a wider input gain range, a switch to change the input high pass filter (to optimize for the highest count rates), and a digital pot to cancel the tail of resistive preamplifiers. But the overall architecture is unchanged from the DP5 and that described in the “User Manual for the DP5 Product Family”.

5.2 Power Supply Architecture

The PX5 has several different switch-mode power supplies. A block diagram is shown below.



Some key points of the overall architecture are as follows:

- The input power is nominally +5 VDC (4 V to 5.5 V acceptable).
- Reverse polarity protection is provided by PTC1 and D4.
- The FET controller will not allow the PX5 to turn on if the input voltage is below 3.25V or above 5.8V. If the PX5 is on, and the input power drifts outside this range, then the PX5 will switch off.
- F1 is a polyfuse, i.e. a resettable fuse. It goes to a high impedance with very high current but returns to low impedance after power is removed. It does not need replacing after use.
- The front panel switch is a momentary switch. When the switch is depressed, the edge is detected by the logic and the MOSFET switches open or closed. The EXT line on J3 permits the user to switch the power off or on remotely.
- When power is applied, the 3.3V supply in the PX5 turns on and the digital circuitry is powered. When the PX5 is configured, the microcontroller turns on its low voltage supplies. Based on the configuration choices, the preamp power, 9VDC supply, and the HV and cooler supplies may be enabled.
- There are several different pulse width modulated power supplies used in the PX5. Nominal switching frequencies are >1 MHz, except for the HVPS, which runs at about 60 kHz.

5.3 High voltage power supply

WARNING: Using the wrong polarity will destroy the detector and will NOT be covered under warranty. Always check that the correct HV polarity is set before turning on the PX5.

- The high voltage power supply can provide positive or negative polarity, at voltages up to 1500 VDC and currents up to 30 μA. It is suitable for solid state detectors.
- The polarity is changed by a jumper on the bottom of the PX5. To change polarity, turn off the PX5, unthread the two screws, remove the jumper, turn it around, carefully re-insert it, then thread the screws. The polarity is indicated by the line on the jumper. The polarity is also indicated by the color of the LED ring on the front panel power switch: green (red) for positive (negative).
- The polarity is set in hardware. There is also a polarity flag in software. The PX5 μC compares the hardware jumper with the software flag. If they do not agree, then HV supply is disabled. To enable, change one or the other to make them agree.
- The magnitude of the power supply is controlled by a DAC so can be commanded in software to 1500 VDC. The output is monitored by an ADC (it typically reads a few volts when the HV is turned off).
- The HV supply has a series resistance of 0.5 kΩ for current limiting.

5.4 Thermoelectric cooler power supply

- The TEC supply provides closed loop temperature control for the thermoelectric cooler in Amptek's X-ray detectors. The forward voltage across a diode (1N914) inside the detector hybrid is used to measure the temperature. The TEC supplies up to 3.6V to drive the two stage cooler.
- The cooler can typically provide a temperature differential of up to 75-80°C. At room temperature, 22°C or 295K, the cooler can typically reach 220K. At elevated temperatures, the detector will be warmer. Note that ΔT is defined relative to the stud on the back of the detector. If this does not have a good heat sink, then the detector will be warmer.

5.5 Preamp power supplies

- The preamp power supplies can be configured in software for +/- 5VDC or +/- 8.5 VDC. Amptek's XR100 preamplifiers require +/-8.5 VDC for proper operation while the PA210/PA230 preamplifiers require +/- 5 VDC.
- The 5VDC setting is appropriate for Amptek's PA210 family of preamplifiers. NOTE: THESE PREAMPS CAN BE DAMAGED IF 8.5 VDC IS APPLIED.
- Note: The preamp power supply also provides power to the front end analog circuitry in the PX5. If preamp power is disabled, then the front end of the PX5 is not powered and hence it does not work.