

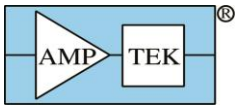
Products for *Your* Imagination



X-123 User Manual

Rev B1 – July 2018

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1 Introduction

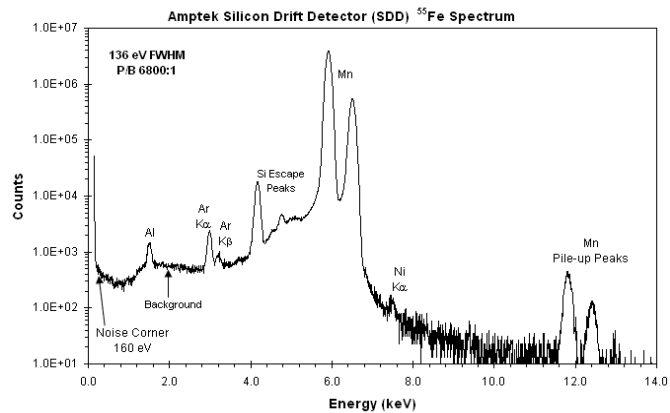
1.1 X-123 Description

The X-123 combines, in a single package, Amptek's high performance X-ray spectroscopy components: (1) an X-ray detector (options include the FastSDD, SDD, SiPIN, or CdTe) and preamplifier, (2) the DP5 digital pulse processor and MCA, and (3) the PC5 power supply. The result is a complete system which can fit in your hand with no performance compromise. It requires only +5 VDC power and a standard communication interface. With the X-123, anyone can rapidly obtain high quality X-ray spectra.

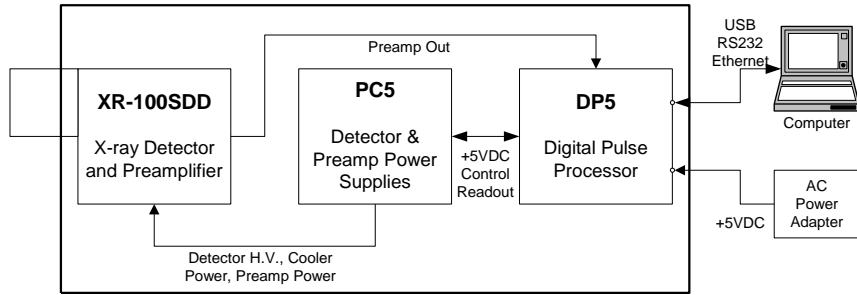
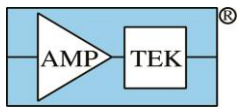
The detector is mounted on a thermoelectric cooler along with the input FET and coupled to a custom charge sensitive preamplifier. The thermoelectric cooler reduces the electronic noise in the detector and preamplifier, but the cooling is transparent to the user: it operates like a room temperature system.

The pulse processor is the DP5, a second generation 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 PC5 supplies the power to the detector, including low voltages for the preamps, high voltage to bias the detector, and a supply for the thermoelectric cooler which provides closed loop control with a maximum temperature differential of 85 °C. All of these are under software control. The X-123SDD input is unregulated +5 VDC with a current of about 400-900 mA, depending on configuration.

The complete system is packaged in 7 x 10 x 2.5 cm³ aluminum box. The detector is mounted on an extender; with lengths from 3/8" to 9" (vacuum flanges are available). In its standard configuration, only two connections are required: power (+5 VDC) and communications (USB, RS232, or Ethernet). An auxiliary connector provides several additional inputs and outputs, used if the X-123 will be integrated with other equipment. This includes an MCA gate, timing outputs, and eight SCA outputs. The X-123SDD is supplied with data acquisition and control software. It also includes a Software Development Kit (SDK), to integrate the unit with custom software. Optional accessories include software for analyzing X-ray spectra, several collimation and mounting options, and X-ray tubes to complete a compact system for X-ray fluorescence.



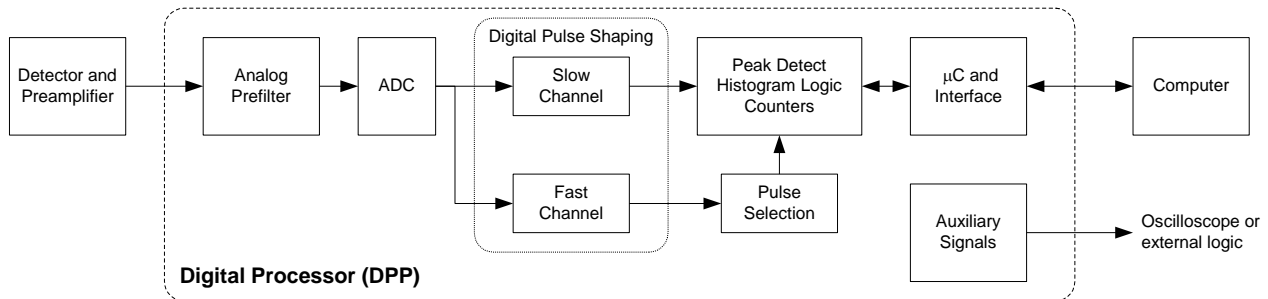
Photograph of complete X-123 (left) and a typical ⁵⁵Fe spectrum (right).



Block diagram of the X-123SDD

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 data acquisition and control application used across the family; Amptek also offers an SDK for custom software solutions.

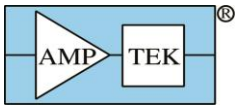
The products in the DP5 family differ in the sensor for which they are designed, which leads to changes in the analog prefilter, power supplies, and form factor. They also differ in their completeness: some of Amptek's products are "complete", with elements (a) through (i), while others offer only a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

1.3 X-123 Options and Variations

Detector

The X-123 is available with any of Amptek's standard detectors: FastSDD, SDD, SiPIN, and CdTe. Each of these is recommended for a different application and the X-123 hardware will only accommodate one detector type.

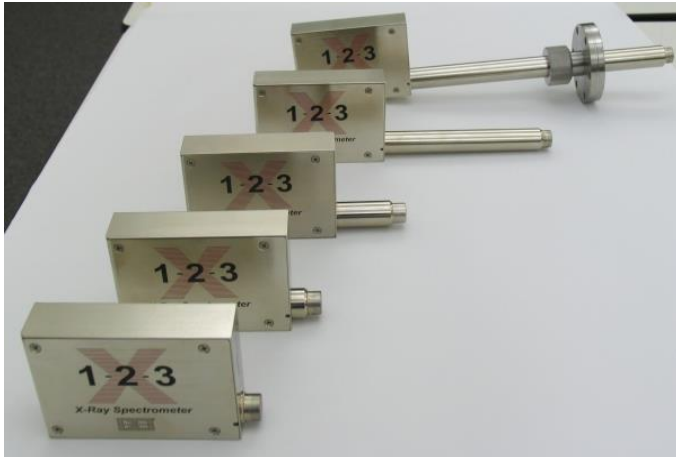
- The **X-123-FastSDD** is Amptek's highest performance detector, providing both the highest resolution (as low as 125 eV FWHM at ⁵⁵Fe) and highest count rates (above 1 Mcps). It is available with the C2 low energy window, for measuring low energy X-rays, down to the Be K_α line. The X-123-FastSDD is recommended for count rates > 100 kcps and, with the C2 window, for measurements < 1 keV.



- The **X-123-SDD** is a high performance detector with broad applications in XRF. It has good resolution (as low as 125 eV FWHM at ⁵⁵Fe) and good count rates (tens to hundreds of kcps). It provides the performance needed for most XRF applications at lower cost than the FastSDD.
- The **X-123-SiPIN** is recommended for cost sensitive XRF applications with less demanding resolution and/or count rate requirements. It is available with areas of 6, 13, or 25 mm² with typical resolutions of 150 to 200 eV FWHM at ⁵⁵Fe. It is best at count rates of a few to tens of kcps.
- The **X-123-CdTe** is recommended for higher energy X-rays, above 30 keV or so. The 0.5 mm silicon used in the other detectors loses sensitivity above 15 keV, while the CdTe detector remains near 100% efficient for all characteristic X-rays, to 100 keV. It is often used in characterizing X-ray tubes as well as XRF for rare earth metals, lead, mercury, and other higher Z materials.

Extender

In the X-123, the detector is mounted on an extender, as seen in the photo above. This is usually convenient for placing the detector inside shielding and in close proximity to a sample. The standard X-123 has a 1.5" extender but is available with a 3/8" extender (short), a 5" extender, and a 9" extender. The 5" and 9" options are commonly used in vacuum applications, extending through a vacuum flange into a vacuum chamber.

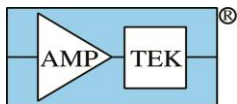


PA210/PA230 Interface

Another option, shown to the right, is to separate the detector/preamplifier from the rest of the electronics, contained in the metal enclosure. A 10 pin flat flex connector runs from the preamp to the X-123 box. This has the advantage of more flexibility in mounting but can be more susceptible to electromagnetic interference, grounding, etc.

Vacuum

The X-123 is suitable for vacuum applications, e.g. in EDS. The photo illustrates an X-123 with 9" extender and vacuum flange. This is not suitable for high vacuum (Amptek provides other systems appropriate for high vacuum) and the entire X-123 should not be placed in vacuum.



1.4 Prop65 Warning

WARNING

This product contains the following chemicals, which are known to the State of California to cause cancer, birth defects or other reproductive harm if exposed to them through improper use, storage, or disposal of the product:

Prop 65 Chemical	Type of Toxicity	CAS No.	Product part containing the chemical
Beryllium	Cancer	--	Detector window

Please consult this owner’s manual for proper use, storage, care and disposal of the product. For more information, go to: www.p65warnings.ca.gov

1.5 Warranty

WARRANTY

AMPTEK, INC. warrants to the original purchaser this instrument to be free from defects in materials and workmanship for a period of one year from shipment. AMPTEK, INC. will, without charge, repair or replace (at its option) a defective instrument upon return to the factory. This warranty does not apply in the event of misuse or abuse of the instrument or unauthorized alterations or repair. AMPTEK, INC. shall not be liable for any consequential damages, including without limitation, damages resulting from the loss of use due to failure of this instrument. The factory MUST be notified prior to return shipment. All products returned under the warranty must be shipped prepaid to the factory with documentation describing the problem and the circumstances under which it was observed. The instrument will be evaluated, repaired or replaced, and promptly returned if the warranty claims are substantiated. A nominal fee will be charged for unsubstantiated claims. Please include the model and serial number in all correspondence with the factory.

Technical Questions

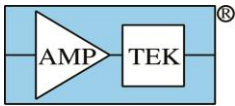
For all technical questions, please contact the factory via:

PHONE: +1 781 275 2242

FAX: +1 781 275 3470

Email: Amptek.sales@ametek.com

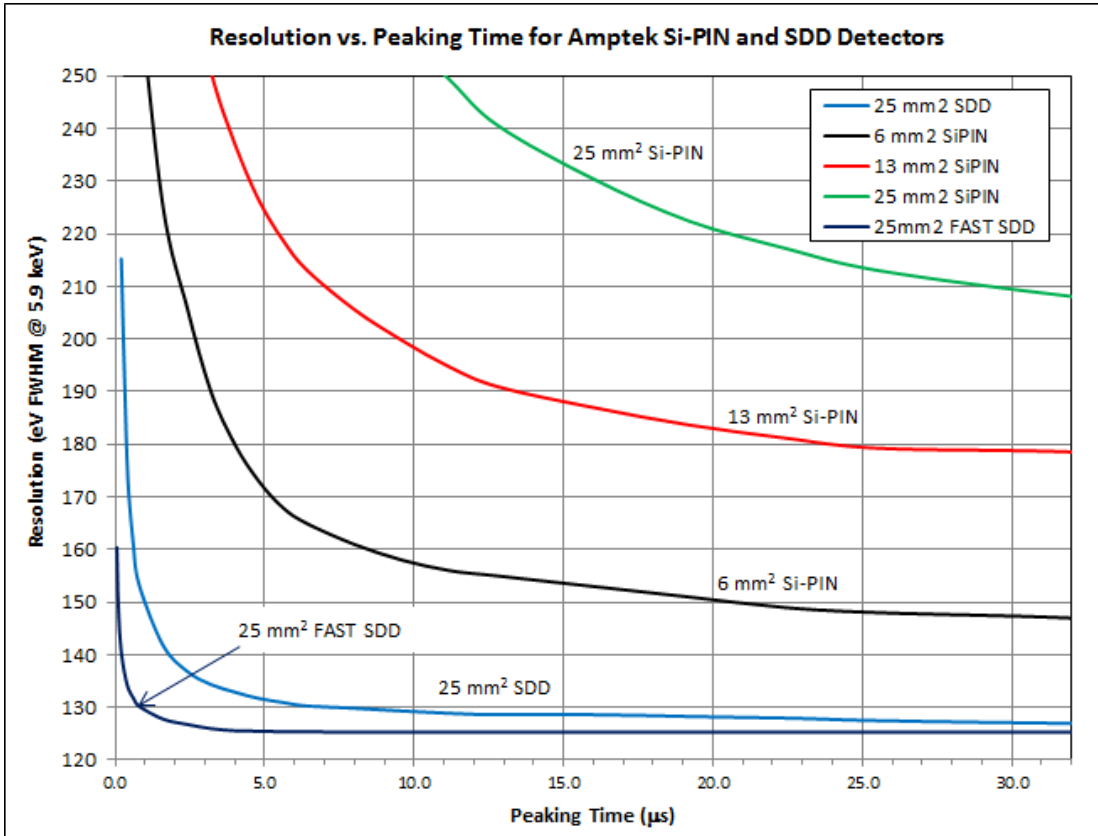
www.amptek.com



2 Specifications

2.1 Spectroscopic Performance

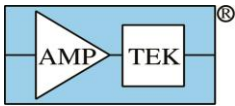
The performance specifications – the resolution, count rate, etc. – are determined by the detector which has been chosen. The plots below show typical performance, for ⁵⁵Fe at full cooling. Refer to Amptek’s detector specifications for more information.



2.2 Processing, physical, and power

The DP5 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	7 x 10 cm x 2.5 cm (2.7 x 3.9 x 1 in) Excludes extender
Extender	1.5” (3.8 cm) standard Options: None, 3/8”, 5”, 9”, and vacuum flanges
Weight	200 g (7 oz)

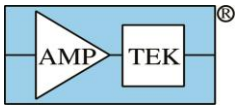


Power						
Characteristic	Symbol	Min	Typ	Max	Units	Conditions
Supply Voltage	V_{IN}	4.0	5.0	5.5	V	
Supply Current	I_{IN}			0.9	A	$V_{IN} = 5.0$ V, initial cooldown
			0.70	A	$V_{IN} = 5.0$ V, steady state full cooling	
			0.50	A	$V_{IN} = 5.0$ V, $\Delta T = 70$ °C	
			0.40	A	$V_{IN} = 5.0$ V, $\Delta T = 50$ °C	
			0.35	A	$V_{IN} = 5.0$ V, no cooling or bias	
Inrush Current	I_{INRUSH}		2		A	<100 μ sec
Input Capacitance	C_{IN}		50		μ F	

The power dissipated by the X-123 depends most strongly on the detector temperature, which is set in software. At full cooling, $\Delta T = 70$ °C, the X-123 draws about 0.7 A at 5 V, or 3.5 W. If the detector is not cooled as much, power dissipation decreases to less than half of this. The table above is for a typical detector, but the actual value depends on the type of detector (e.g. its area) and varies between units.

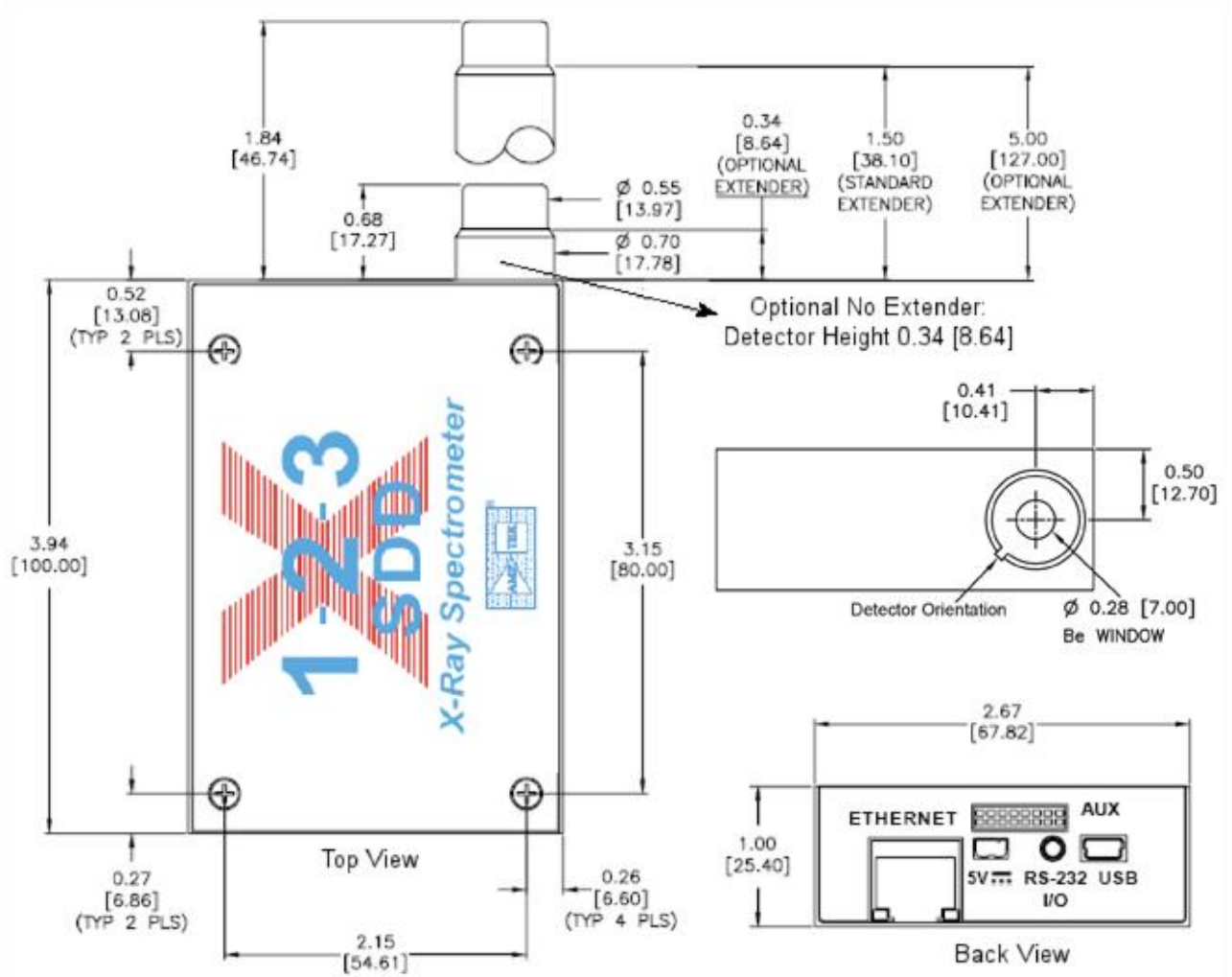
Note that USB power is rated to 2.5 W, therefore the X-123 cannot be powered over USB.

The inrush current is that required to charge up a set of capacitors, with a total of 50 μ F capacitance.

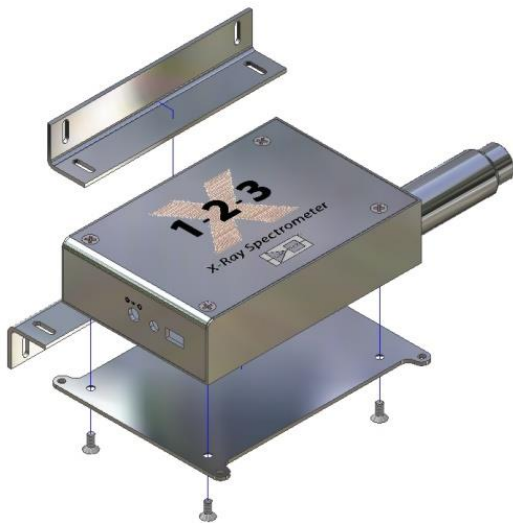


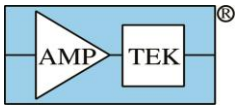
3 Mechanical Interface

3.1 Dimensions



3.2 Mounting hardware





3.3 Connectors

Power

Power Jack on X-123SDD: Hirose MQ172-3PA(55) [obsoleted in 2016, replaced by MQ172-3PA(30)]..

Mating Plug: Hirose MQ172-3SA-CV(50) [obsoleted in 2016, replaced by MQ172-3SA-CV(30)]
[The replacements are form/fit/function compatible.]

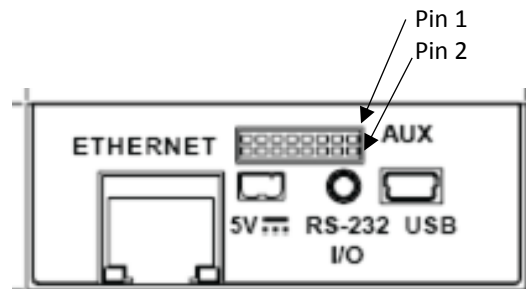
Pin #	Name
1	VIN
2	GND
3	Do Not Connect

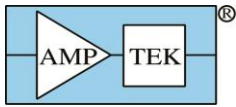
Auxiliary

16-pin ² mm spacing

Mates with cable assembly (Samtec P/N) TCSD-08-S(D)-xx.xx-01-F-N.

Pin #	Name	Pin #	Name
1	SCA1	2	SCA2
3	SCA3	4	SCA4
5	SCA5	6	SCA6
7	SCA7	8	SCA8
9	AUX_IN_1	10	AUX_OUT_1
11	AUX_IN_2	12	AUX_OUT_2
13	IO2	14	IO3
15	GND	16	GND





Ethernet

Standard Ethernet connector (RJ-45)

USB

Standard USB 'mini-B' jack. (The X-123SDD is 'self-powered': it draws no power from the USB.)

RS-232

Standard 2.5 mm stereo audio jack. The X-123 is supplied with an adapter that connects this to a DB9 serial connector.

Contact	Signal
Tip	TXD (output from X-123)
Ring	RXD (input to X-123)
Sleeve	GND

3.4 *Thermal*

The X-123 dissipates up to 3.5 W of power. It is important that the body of the X-123 be attached to a heat sink. If proper heat sinking is not used, then the X-123 chassis temperature rises, and thus the detector temperature rises and spectroscopic performance is compromised.

4 Electrical Interface

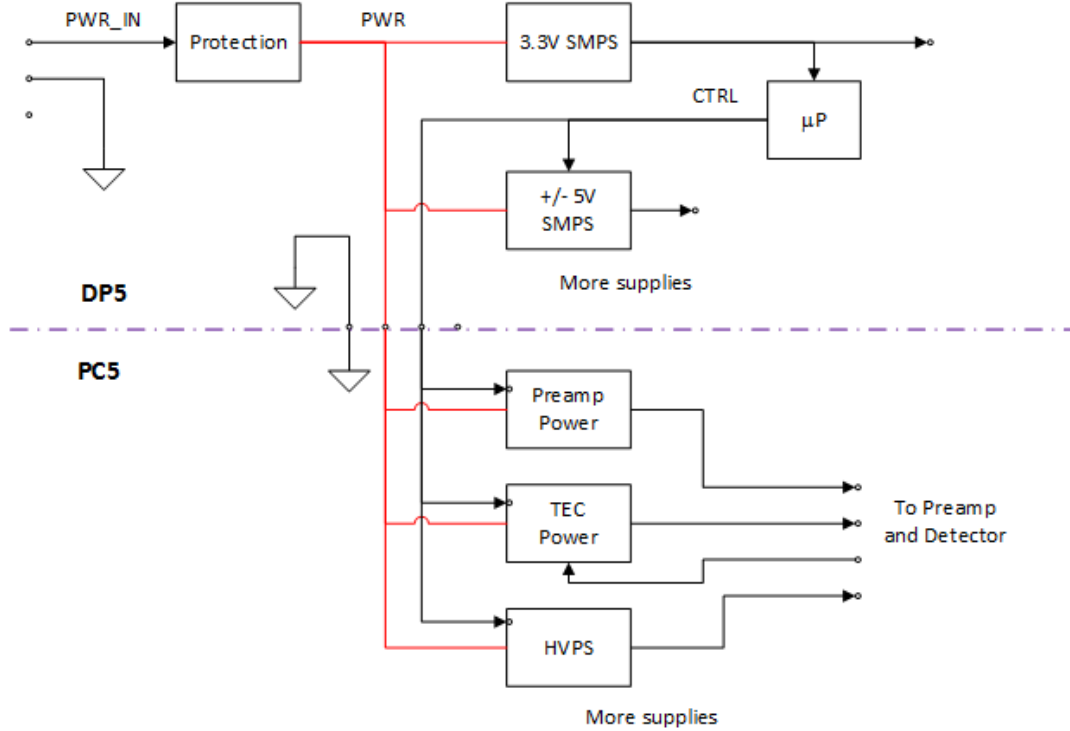
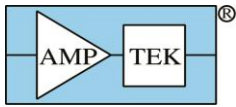
Only the power interface differs from that described in the family wide manual.

4.1 *Power Interface*

A schematic illustrating the circuit at the power input is shown below. The PWR_IN line goes through a protection circuit, then to different switching power supplies in parallel. Five of these are located on the DP5, five on the PC5. Each has a 4.7 μF input capacitor. Some turn on as soon as power is applied, while others are under control of the microprocessor.

- Protection: The protection device protects against reverse input polarity and has over- and under-voltage lockouts. The X-123 will not power on with an input voltage below 3.8 V or above 5.5 V. The input protection network operates over the range of -40 V to +60 V. Beyond this range, damage to the X-123 will occur¹.
- Grounding: The chassis ground of the X-123, which is tied to the box and to the other boards, is connected to the return current pins in the power connector.

¹ This applies to X-123s from 2016 or later. Earlier X-123s contained a DP5 Rev C (or earlier), which did not have the over- and under-voltage protection (this was added to the DP5 Rev D.) An input voltage higher than 5.5 V may damage these units. The earlier DP5s did have reverse polarity protection.

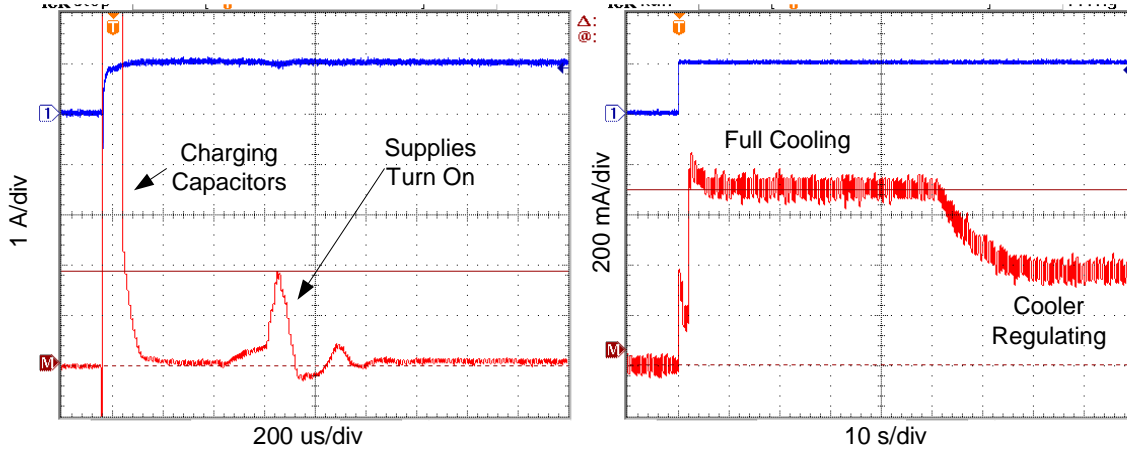
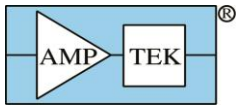


Schematic of power supply architecture.

Turn-On Transients

The figure below illustrates the transient currents seen as the X-123 turns on.

- 1) When 5 VDC is first applied to the power input, a large transient current is drawn to charge up the 50 μ F of input capacitance, from the input capacitors on all the supplies.
- 2) About 400 μ sec later, the low voltage switching supplies turn on. The maximum inrush current is about 2 A, with a duration of <100 μ sec. It is important that the external supply be able to provide this current. If this current is limited, some of the supplies can be destroyed.
- 3) After the DP5 is powered up, it then powers up the PC5, based on configuration settings stored in the DP5. Depending on the "Set Power-on State" configuration option, this either happens automatically (approx. 2 seconds after power is applied), or upon command from the host PC. The unit draws about 300 mA at 5 V.
- 4) When the cooling is turned on, I_{IN} goes to its maximum, drawing approximately 700 mA.
- 5) In this figure, the set point was 230 K, the ambient 295 K, and a SDD on a two stage cooler was used. After about 50 seconds, the temperature approached the set point and so began regulating. The current decreased to its steady state value, 400 mA.



5 X-123 Design

5.1 Detector and preamplifier

The X-123 uses the same detectors as Amptek's other products. There are no changes to the detectors and all detector options are available.

The preamplifiers have the same basic circuit as the PA210 and PA230 units. They run from +/-5 V.

5.2 Analog prefilter

The analog prefilter is unchanged from the standard DP5 design.

5.3 Power supplies

Power supplies are found on both the DP5 and PC5 boards. These boards are described in their own, specific user manuals.

The overall architecture and the interface between DP5 and PC5 power supplies were discussed in the previous interface section.