X-55 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 X-55 System Description

The X-55 provides a complete high-performance X-ray spectroscopy system in very small package, the size of Amptek's XR100 preamplifier. The X-55 includes (1) an X-ray detector (FASTSDD®, SDD, or Si-PIN) and preamplifier and (2) the DP5-X digital pulse processor and power supply. The result is a complete system which can fit in your hand with no performance compromise, requiring only +5 VDC power and a USB interface. It is a specialized version of Amptek's X-123, providing the same performance for most applications, in a package approximately half the size. The X-123 offers additional features, such as use with CdTe detectors, RS232 and Ethernet support, and several auxiliary signals.

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 DP5-X is a high performance digital pulse processor and power supply module, designed specifically for OEMs using Amptek's Si-PIN, SDD, and FASTSDD® detectors. It includes the key functions previously found in the DP5 and PC5 but at much smaller size and lower cost

The complete X-55 is packaged in 7.5 x 4.4 x 2.9 cm^3 aluminum box. The detector is mounted on a 1.5" extender. The X-55 is supplied with data acquisition and control software, using the same FW6 software interface as Amptek's DP5, X-123, and other processors. It also includes a Software Development Kit (SDK), to integrate the unit with custom software.

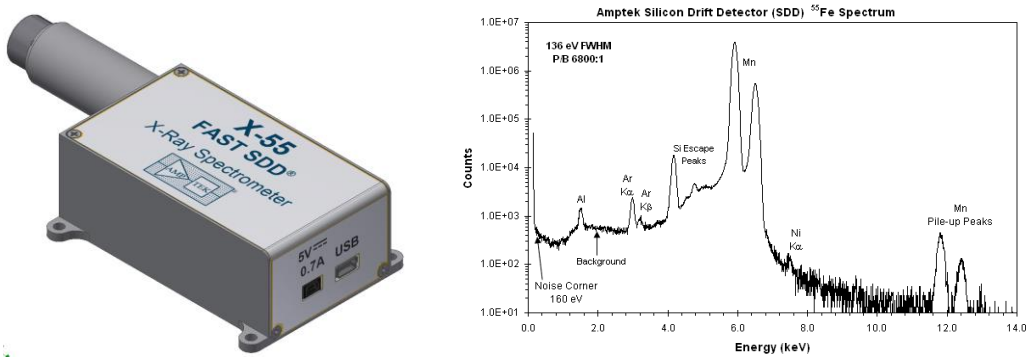
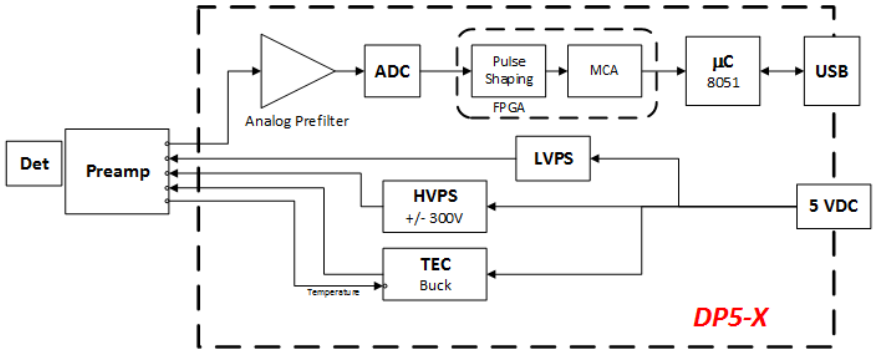


Image of X-55 with (left) and a typical ^{55}Fe spectrum (right).

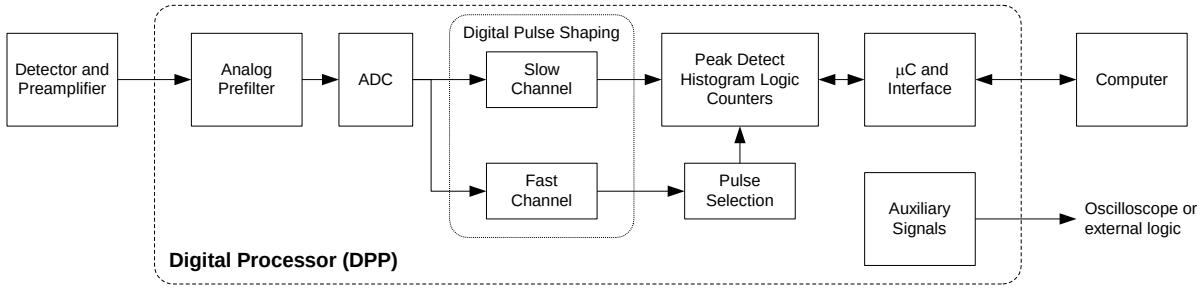


Block diagram of theX-55 in a system,

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.

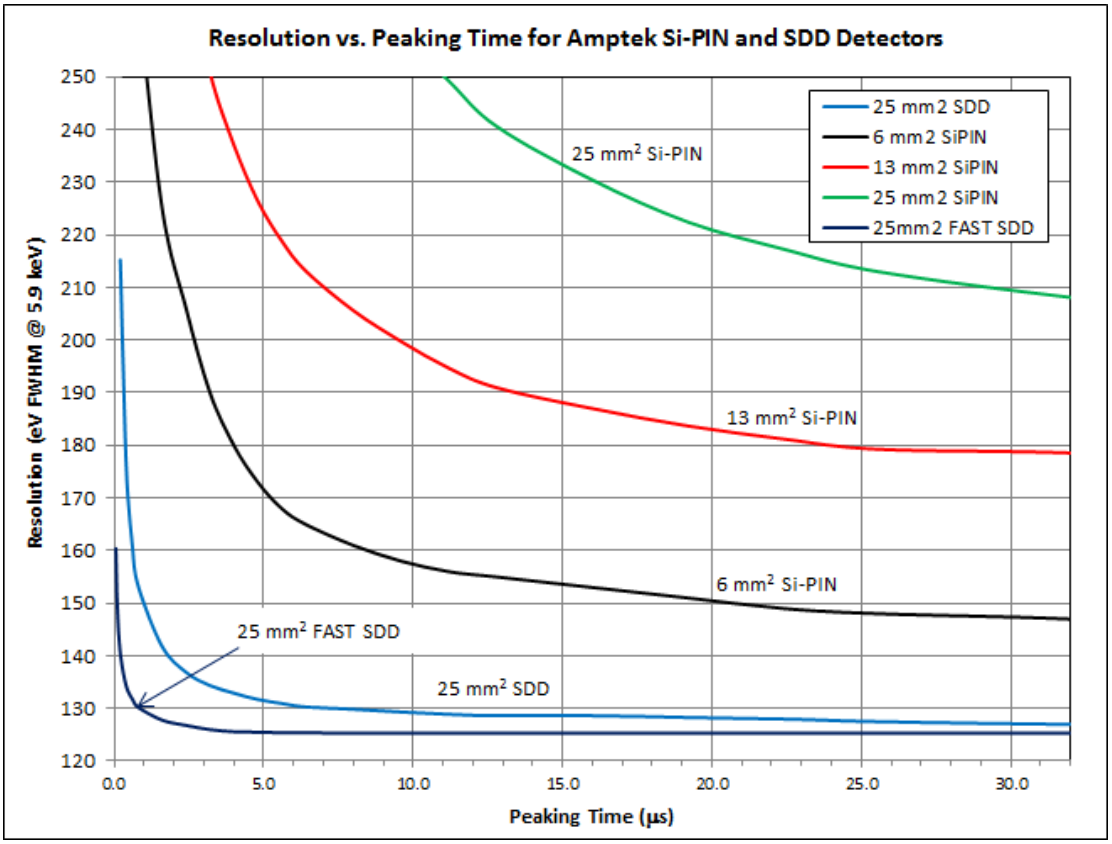
1.3 X-55 Options

- The X-55 is available with Amptek's Si-PIN, SDD, or FASTSDD® detectors.
- The DP5-X board inside the X-55 is available in several options. These are discussed in the DP5-X User Manual.

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 ^{55}Fe at full cooling. Refer to Amptek's detector specifications for more information.



2.2 Processing, physical, and power

The X-55 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.

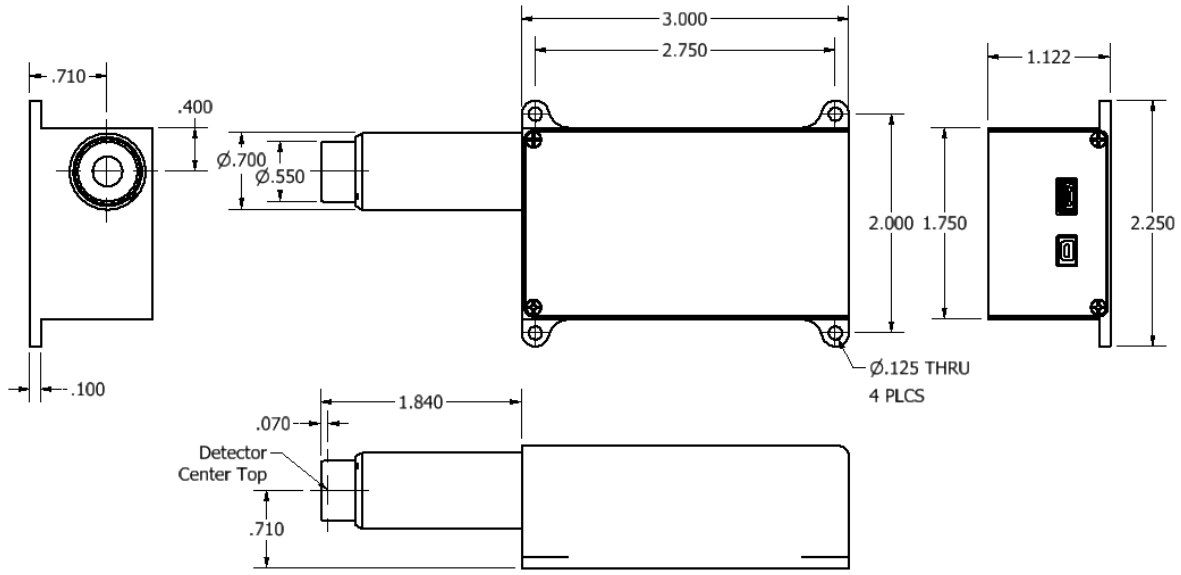
Physical	
Dimensions	7.6 x 4.4 x 2.9 cm (3.00 x 1.75 x 1.13 in)
Extender	1.5" (3.8 cm)
Weight	125 g (4.4 oz)

Power (with detector)						
Characteristic	**Symbol**	**Min**	**Typ**	**Max**	**Units**	**Conditions**
Supply Voltage	V_{In}	4.0	5.0	12.0	V	
Supply Current	I_{IN}	0.85		0.30	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, ΔT=70 °C
			0.40		A	V_{IN} = 5.0 V, ΔT=50 °C
			0.35		A	V_{IN} = 5.0 V, no cooling or bias
Inrush Current	I_{INRUSH}		2		A	<100 μsec
Input Capacitance	C_{IN}		50		μF	

- The table above shows power dissipation with a detector and preamp installed.
- The power dissipated by the X-55 depends most strongly on the detector temperature, which is set in software. At full cooling, ΔT=70 °C, the DP5-X 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 for only 2.5 W, therefore the X-55 cannot be powered over USB.
- The X-55 can be powered from a relatively wide input voltage range, from 4V to 12V DC, simplifying use in battery power applications. The total power dissipation increases with input voltage, due to the reduced efficiency of step down converters.
- The inrush current is that required to charge up a set of capacitors, with a total of 50 μF capacitance.
- The maximum inrush current is about 2 A, with a duration of <100 μs. It is important that the external supply be able to provide this current without voltage droop. LIMITING THE INRUSH CURRENT CAN DAMAGE THE POWER SUPPLY CHIPS.

3 Mechanical Interface

3.1 Dimensions



3.2 Connectors

Power

Power Jack on DP5-X: Hirose MQ172-3PA(30).

Mating Plug: Hirose MQ172-3SA-CV(30)

Pin #	Name
1	VIN
2	GND
3	Do Not Connect

USB

Standard USB 'mini-B' jack. (The DP5-X is 'self-powered': it draws no power from the USB.)

3.3 Thermal

The X-55 dissipates up to 3.5 W of power, which is a large amount of power for such a small board. There is good thermal conduction through the ground plane of the board to the corner holes. It is important that the DP5-X be attached via these posts to a heat sink. If proper heat sinking is not used, then the DP5-X can overheat and will have trouble cooling the detector, compromising performance, and operating life.

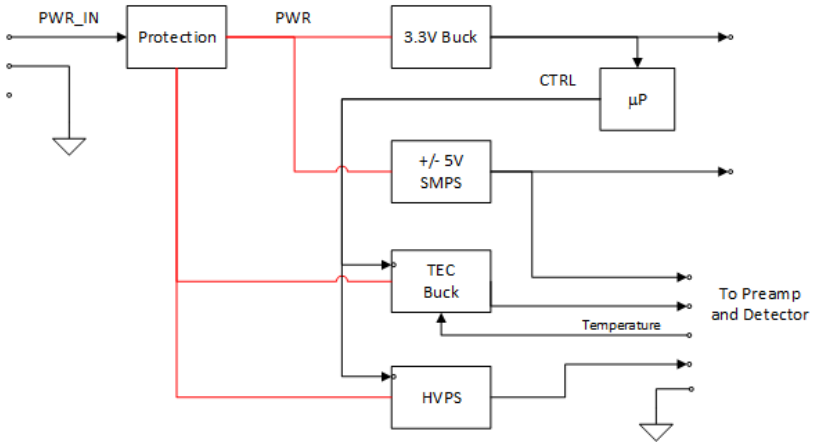
4 Electrical Interface

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. 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 DP5-X will not power on with an input voltage below 4 V or above 12 V. The input protection network operates over the range of -40 V to +60 V. Beyond this range, damage to the DP5-X will occur.
- Grounding: The DP5-X board ground is attached to (1) all four corner posts, (2) to the ground pins on the power, USB, and auxiliary connectors, and (3) to the ground pin on the preamp connector



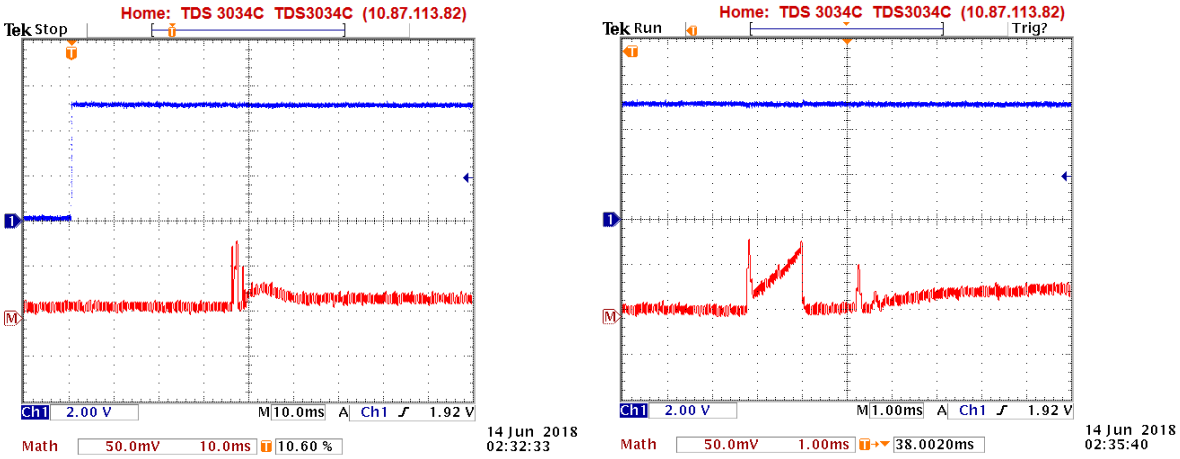
Schematic of power supply architecture.

Turn-On Transients

The figure below illustrates the transient currents seen as the DP5-X turns on.

1) When 5 VDC is first applied to the power input, negligible current is drawn, as the power supply supervisor waits for the input power to stabilize.
2) About 35ms later, the low voltage switching supplies turn on. The maximum inrush current is about 2 A, with a duration of <100 µs. It is important that the external supply can provide this current. If this current is limited, some of the supplies can be destroyed.
3) After the DP5-X low voltage supplies come up, it then powers the HV bias and the thermoelectric cooler, based on configuration settings stored in the DP5-X EEPROM. 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.
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 an 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.



Oscilloscope traces of turn-on transients. The blue trace shows 5V power input, the red trace shows the current, at 1A/div. The left plot illustrates the 35 ms delay. The right plot zooms in, with a 30 ms offset. Peak current is just under 2A.

5 X-55 Design

5.1 Detector and preamplifier

The X-55 only supports Amptek's Si-PIN, SDD, and FASTSDD® detectors. Amptek's CdTe detectors and the many other detectors available on the market must be used with the DP5.

5.2 DP5-X

The DP5-X design is discussed in its User Manual. Please refer to that manual for details, including test points and auxiliary connectors.