DP5 User Manual

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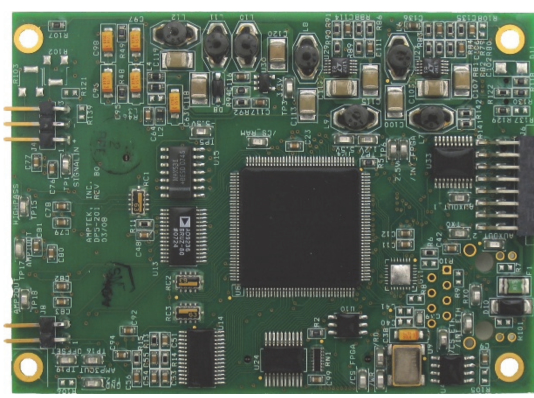
1 Introduction

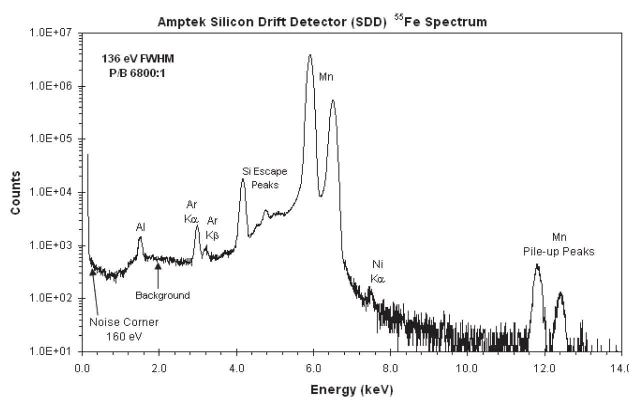
1.1 DP5 Description

The DP5 is a high performance digital pulse processor. It is a board level component in a complete nuclear spectroscopy system, which generally also includes (1) a detector and preamplifier and (2) power supplies. A complete system can be assembled by combining the DP5 with one of Amptek's detectors and preamps (several options and configurations may be used) and with Amptek's PC5 power supply. Alternately, a user can supply their own detector, preamplifier, and/or power supply. The DP5 was designed primarily for use with high resolution solid state detectors. The DP5 is a printed circuit board assembly, suited primarily to OEM applications as part of a complete system.

The DP5 is 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 computer.

In its standard configuration, only three connections are required: power (+5 VDC), communications (USB, RS232, or Ethernet), and an analog input from the preamplifier. An auxiliary connector provides several additional inputs and outputs, used if the DP5 will be integrated with other equipment. This includes an MCA gate, timing outputs, and eight SCA outputs. The DP5 also includes an "interconnect", designed principally to interface with Amptek's power supply boards but available to OEMs. The DP5 is supplied with the ADMCA data acquisition and control software, along with a DLL library of interface routines, 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.

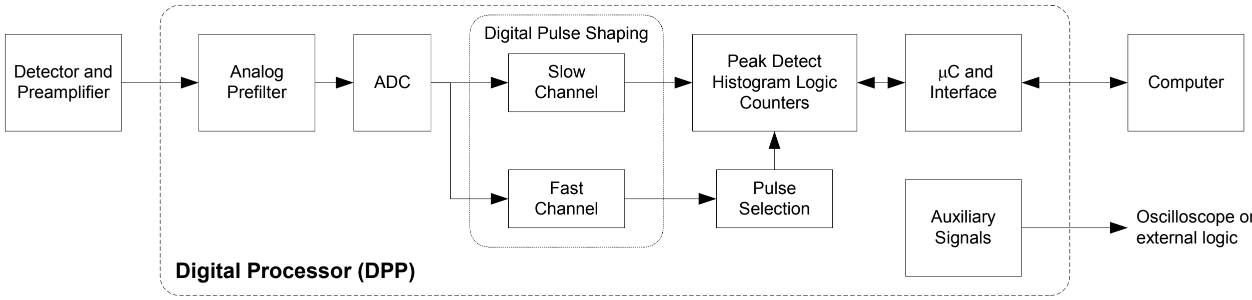




Photograph of DP5 (left) and a typical ^{55}Fe spectrum (right), obtained with an XR-100-SDD.

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 only those aspects which are unique to the DP5 circuit board.

1.3 DP5 Options and Variations

Configurations

The DP5 was designed so that it can be configured to support a wide variety of detectors. Many parameters can be set via software commands. Other configuration options are set via hardware jumpers or minor changes to the components on the core board (changes to the BOM). These BOM changes are indicated by a set of configuration indicators.

Revision D

Amptek recently released a new revision of the DP5 board, termed "D", which made a few minor changes to the function. The changes are invisible to most customers. Key changes included (1) changing a power supply circuit to improve reliability, (2) changing the analog prefilter to improve resolution, particularly with Amptek's FastSDD® detectors, and (3) some changes to the coarse gain settings available.

Reset vs resistive feedback

By default, the DP5 is configured for a reset preamplifier (no exponential tail). A minor hardware change is required to reconfigure for resistive feedback, to cancel the preamplifier pole. In versions C and prior, the customer needed to install a pair of potentiometers. In version D, the pole is cancelled digitally but several components need to be installed at Amptek for this.

Higher and lower rates

The analog prefilter includes a high pass filter which removes the DC offset arising from the preamplifier, to take advantage of the full range of the ADC. For most applications, this high pass filter has a 3.2 μs time constant. For the highest rates, typically above several hundred kcps, this leads to pulse pileup into the ADC; a 1.6 μs time constant is recommended for these applications. For detectors with exceptionally long peaking times, a 6.4 μs time constant can be used.

Scintillators

Amptek configured early versions of the DP5 for use with scintillators, changing the first amplifier stage into a charge amplifier. Eventually, we released a completely different product in the same family, the DP5G, which includes the charge amplifier and is optimized for use with scintillators, and then incorporated the DP5G in the GammaRad-5 and TB-5. We recommend customers use one of these products rather than the DP5 for scintillation spectroscopy.

2 Specifications

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.

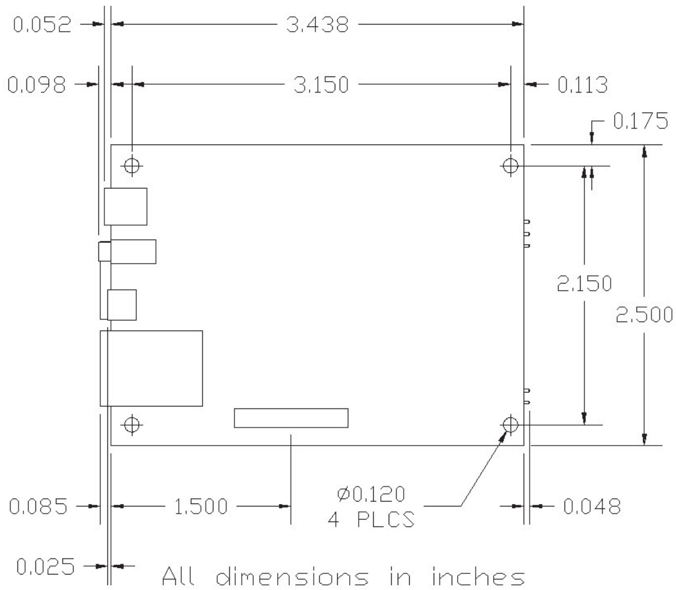
Physical	
Dimensions	8.9 x 6.4 cm (3.5 x 2.5 in)
Weight	37 g

Power	
Nominal Input:	@ +5 VDC: 300 mA (1.5 W) typical with 80 MHz clock 270 mA (1.3W) typical with 20 MHz clock
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 or USB bus

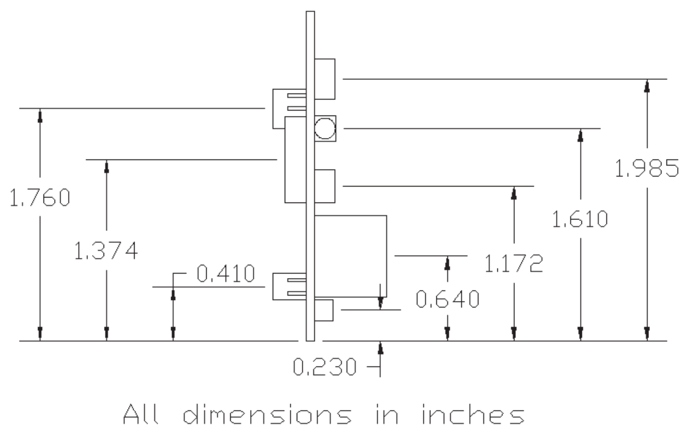
The standard configuration requires an external supply. The DP5 board can be powered from USB but this requires a hardware reconfiguration, discussed in the power section.

3 Mechanical Interface

3.1 Dimensions



DP5 bottom side, showing key interconnects.



DP5 back/side view.

3.2 Connectors

Power (J9)

Power Jack on DP5: Hirose MQ172-3PA(55).

Mating Plug: MQ172-3SA-CV

Pin #	Name
1	VIN (+5 V DC)
2	GND
3	Do Not Connect

Auxiliary (J6)

16-pin 2 mm spacing. Mates with cable assembly (Samtec P/N) TCMD-08-S-XX.XX-01.

When looking at the connector, the upper right position is Pin 1 and the lower right position is Pin 2.

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 (J2)

Standard Ethernet connector (RJ-45)

USB (J7)

Standard USB 'mini-B' jack.

RS-232 (J10)

Standard 2.5 mm stereo audio jack.

Contact	Signal
Tip	TXD (from DP5)
Ring	RXD (to DP5)
Sleeve	GND

Analog In (J4)

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

DAC Out (J8)

Pin	Signal
1	Output
2	GND

Signal Input from PC5 (J3)

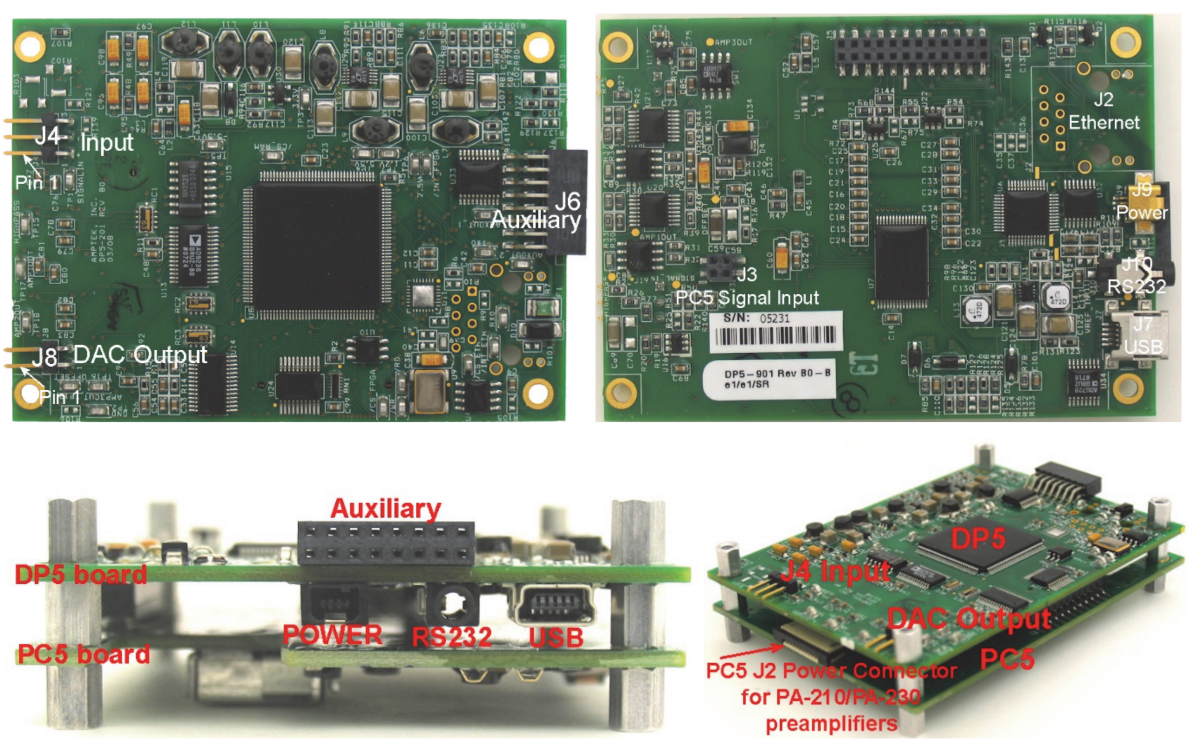
This is a 2 x 2 connector with 2 mm spacing used to route the input signal from the PC5 to the DP5. When the DP5 is used together with the PC5 and the PA-210/PA-230 preamplifier, the signal comes in on the PC5 through the same connector that supplies the preamp and detector power. This minimizes the connections needed to the preamplifier. J3 pin 1 (signal) connects to J4 (analog in) pin 1.

Main Interconnect (J5)

The primary purpose of J5 is to connect the DP5 to the PC5, Amptek's power supply board for Amptek preamplifiers and detectors. It provides input power in either direction, from DP5 to PC5 or vice-versa and permits the DP5 to control PC5 supplies. Its secondary purpose is to permit addition of planned auxiliary boards such as Bluetooth, WiFi, or X-ray tube controllers. These can connect to the DP5 or to the DP5/PC5 stack. The connector is a 2X12 Socket Strip Samtec part number SMM-112-02-S-D-LC.

Pin #	**Name**	**Use**	**Pin #**	**Name**	**Use**
1	GND		13	RS232-RX	PC5, AUX, Test
2	GND		14	RS232-TX	PC5, AUX, Test
3	PWR EXT	PC5, AUX, Test	15	N/C	
4	PWR EXT	PC5, AUX, Test	16	N/C	
5	C2D	Test	17	IO0	AUX only
6	/RST/C2CK	Test	18	IO1	AUX only
7	AUX IN 1	AUX only	19	I^2C SCL	PC5, AUX, Test
8	AUX OUT 1	AUX only	20	I^2C SDA	PC5, AUX, Test
9	PS ENABLE	PC5 only	21	USB+	
10	1-WIRE	PC5 only	22	USB-	
11	AN_IN	AUX only	23	GND	
12	VBUS		24	GND	

- Mates with PCB mount connector (Samtec P/N) TMM-112-01-S-D-SM
- This is a 24 pin connector, with 2 mm spacing.



Photos of the DP5 and PC5 showing connector locations.

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 DP5 components.

4.2 Analog Input Interface

Absolute Maximum Input Voltage Range -5.5V to +5.5V

Polarity: Either positive or negative. Configure in firmware

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

Step size: 5 mV to 1V.

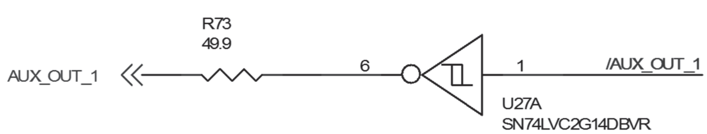
4.3 AUX Interface

AUX OUT						
Output High Voltage	V_{OH}	3.0 1.8	3.3		V V	Typ: No load Min: I_{OH} = -100 µA Min: I_{OH} = -16 mA
Output Low Voltage	V_{OL}		0.0	0.1 1.2	V	Typ: No load Min: I_{OH} = 100 µA Min: I_{OH} = 16 mA
Output Resistance	R_{OUT}		50		Ω	
AUX IN						
Input Voltage		0		5.5	V	
Positive-going Input Threshold	V_{T+}	1.4		2.35	V	
Negative-going Input Threshold	V_{T-}	0.7		1.45	V	
Input Resistance	R_{IN}		100		KΩ	
SCA OUT						
Output High Voltage	V_{OH}	2.9 2.0	3.3		V V	Typ: No load Min: I_{OH} = -100 µA Min: I_{OH} = -12 mA
Output Low Voltage	V_{OL}		0.0	0.2 1.0	V	Typ: No load Max: I_{OH} = 100 µA Max: I_{OH} = 12 mA
Output Resistance	R_{OUT}		47		Ω	

- The AUX OUT lines are the output of a 74LVC2G14 (Vdd=3.3V) with 50 Ω series resistance.
- The AUX IN lines are input to a 74LVC2G14 (Vdd=3.3V) with 100 k Ω to ground.
- The I/O lines are connected to a MAX7328 (V_{dd}=3.3V), which are open-drain with a weak pull-up.

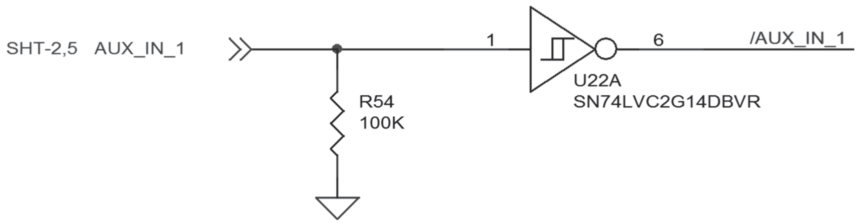
AUX_OUT_1 and _2

- AUX_OUT_1 is connected to the Interconnect (J5), to the auxiliary connector (J6), and can be jumpered to the stereo jack (J10). AUX_OUT_2 is only connected to the auxiliary connector (J6).



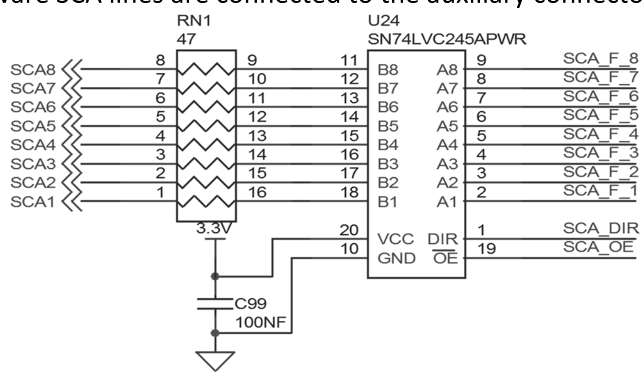
AUX_IN_1 and _2

- AUX_IN_1 is connected to the Interconnect (J5), to the auxiliary connector (J6), and can be jumpered to the stereo jack (J10). AUX_IN_2 is only connected to the auxiliary connector (J6).



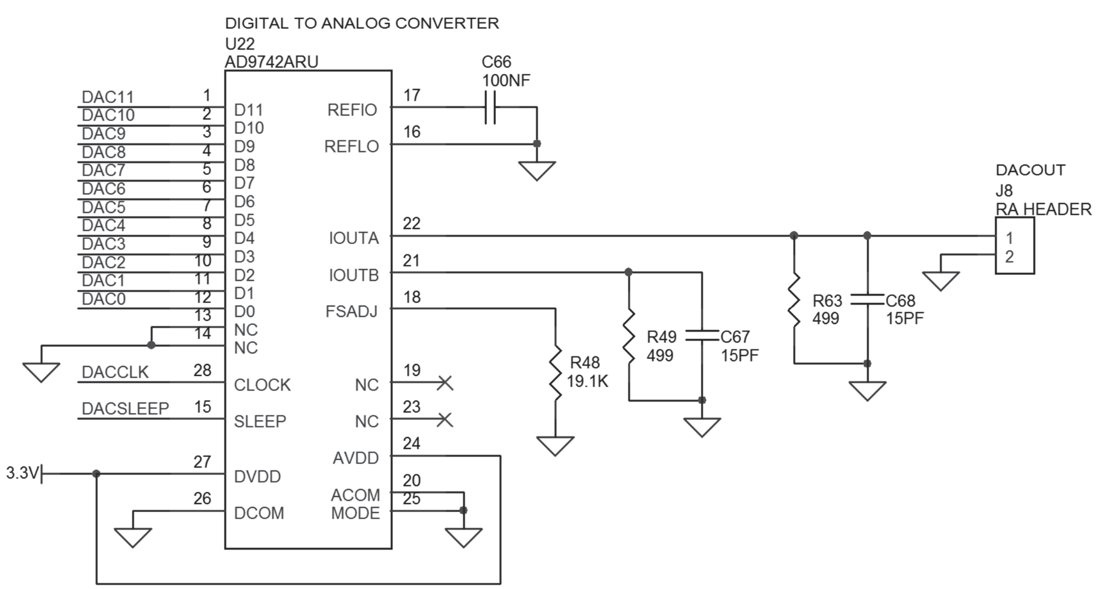
SCA Lines

- The eight hardware SCA lines are connected to the auxiliary connector (J6).



DAC_OUT

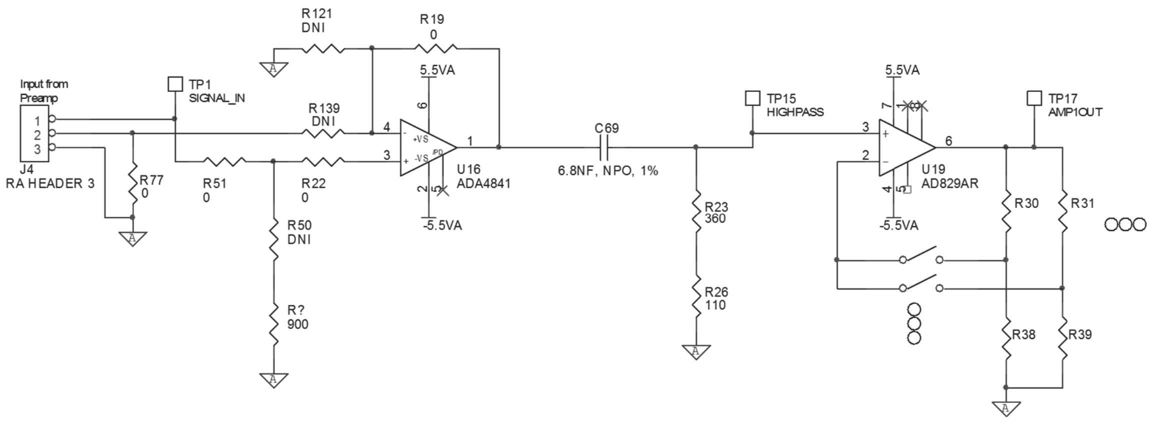
- The DAC output is used to display diagnostic signals for debugging and analysis.



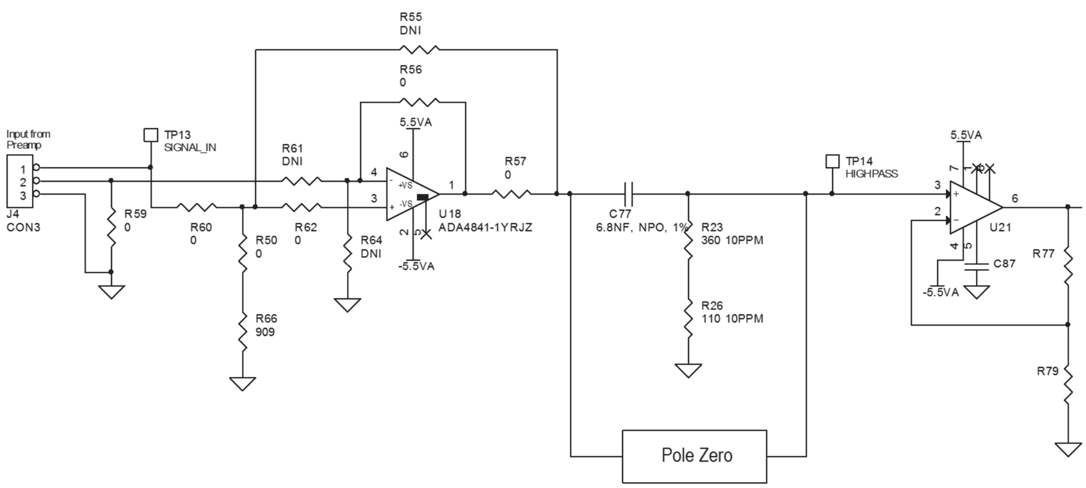
5 DP5 Design

5.1 Analog prefilter

Shown below is a simplified schematic of the analog input. The many zero ohm and DNI resistors permit this front end to be reconfigured for many applications.



Schematic for Rev C and earlier

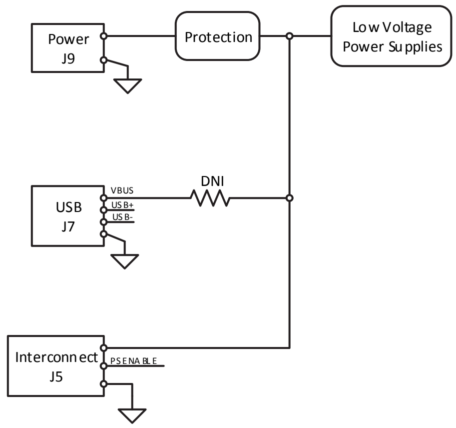


Schematic for Rev D

- The figure here shows the circuit configured for use with detectors using a reset preamplifier operating from +/-5V. There are three stages to this circuit: (1) U16 operates as a unity gain buffer, with a single-ended input, (2) C69 and (R23+R26) operate as a high pass filter to remove the offset from the preamp, and (3) U19 provides voltage gain. Two gain settings are shown but there are actually four settings and then a second amplifier with four more gains. Note that the Rev D schematic is similar but that part numbers have changed.
- The many configurations are discussed in section 6. Some common examples include (1) installing resistors in R50 and R51 to attenuate the signal from a preamp with a larger reset range, (2) removing R77 and installing R139 to obtain a differential input, or (3) installing resistors in R19 and R121 to obtain additional gain. The U16 amplifier has an input range of +4.5 to -4.5V (absolute max of +5.5 to -5.5V). The input must be kept within this range or permanent damage to the opamp is possible.

5.2 *Power supplies*

The figure below is a block diagram of the power supplies in the DP5.



Some key points of the overall architecture are as follows:

- The input power is nominally +5 VDC (4 V to 5.5 V acceptable). Power is usually drawn from the J9 connector. However, the DP5 may be powered from the USB bus or can be powered via the J5 interconnect. Alternately, the interconnect may be used to supply power to a daughter board.
- There is a footprint with no component installed which lets one power the DP5 from the USB bus. Install a zero ohm jumper in R118 on board revisions C and earlier (R28 on revision D). Note that this ties the USB bus to the J9 power input and the J5 interconnects.
  - ➢ Only power the DP5 from one source at a time. If one attempts to power simultaneously from the USB bus and from an external supply, the two regulators will be “fighting” each other.
  - ➢ The USB bus can power the DP5 by itself but it cannot source enough current to also power the PC5 or to power an X-123. These must be powered from an external supply.
- In Rev C and earlier, circuit protection includes a polyfuse and a diode for reverse polarity protection. Beginning with Rev D, there is over- and under-voltage protection.
- When the PC5 is used with the DP5, power is supplied to the PC5 via the J5 interconnect. The DP5 uses the PS Enable line to turn on the supplies in the PC5, after checking the HV polarity.
- Nominal switching frequencies are >1 MHz.

5.3 *Main Interconnect*

The main interconnect, J5, was designed to connect the DP5 to Amptek’s PC5 power supply board. and to other daughter boards. J5 includes several signals, such as AUX_IN_1 and AUX_OUT_1, which have already been described. The following signals are only found on J5.

- C2D and /RST/C2CK: These lines connect directly to the µC. They are used during manufacturing to initially program the µC. Additionally, pulling pin 6 low will hold the µC in reset. Floating it or pulling it high allows normal operation.
- PS ENABLE: Open-drain output used by the DP5 to enable the PC5 power supplies. It is pulled low to turn OFF the PC5 supplies, and floated to turn ON the PC5 supplies. (The PC5 has a 10k pull-up to 3.3V on this signal.)

- 1-WIRE: Dallas 1-wire interface. Not currently used but available for custom configurations.
- IO0, IO1: These two pins connect to a I^2C port expander controlled by the µC. They can be used to communicate with or control external hardware. They can be controlled via serial commands.
- AN_IN: This is an uncommitted analog input. The DP5 µC ADC periodically converts this signal, and the result appears in the Status Packet. The input range is 0 - 2.4V, with a high input impedance.
- SDA, SCL: These are the I^2C bus signals. The DP5 µC is the bus master, though it is possible to communicate with another master, or other slave peripherals.

6 DP5 Application Advice

6.1 Troubleshooting and Advice

- □ Grounding is critical to performance! Please see the Amptek application note, entitled "Grounding and shielding in Amptek Products".
  - □ Amptek **strongly** recommends using a single point ground for the system. Ground currents flowing through multiple connections, through a lab bench, etc. often induce noise.
  - □ We have observed several laptops in which the AC adapter introduced ground noise. In these cases better performance was found by (1) using a 3-prong to 2-prong adapter on the power supply of any notebook computer and (2) making a separate ground connection to the DP5. Note that the DP5's AC/DC supply is isolated.
- □ Configuration suggestions
  - □ The DPMCA software contains default configuration settings for Amptek's detectors. These may not be optimum for your application but should provide a good starting point. In DPMCA, choose the "Acquisition Setup" toolbar button, then "Read Amptek Detector Configuration", then select the appropriate unit.
  - □ The "fast" and "slow" thresholds have a significant impact on performance. After setting other configuration options, reset the thresholds, using the "Autotune" button in ADMCA or manually.
  - □ The baseline restoration setting can have a significant impact on performance. It stabilizes the spectrum over count rate but also suppresses low frequency noise and interference. Turning BLR parameters ON will improve resolution, peak stability and suppress spectral artifacts. Amptek recommends always using BLR.

6.2 Use of the DP5 with Amptek Detectors

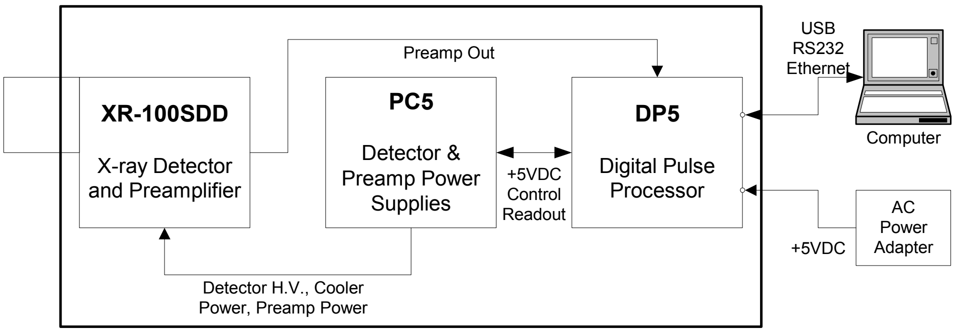
Amptek's DP5 Digital Pulse Processor is easily configured for use with Amptek's family of detectors and preamplifiers. The DP5 generally comes configured for use with reset type preamplifiers, which are used in Amptek's detectors. This section is intended to guide a user through the set-up of the DP5 for use with these detectors. Configuration of the DP5 for other preamplifiers is described in later sections.

The DP5 only has power supplies on-board for its own requirements. Amptek detectors require many additional power supplies (preamp, HV, cooler, etc.). The PC5 power board provides the necessary power supplies to power Amptek detectors (both XR100 and the PA-210/PA-230 preamplifiers). This section assumes the use of the PC5 power board. The user can provide the power supplies for the detector, in which case the appropriate XR100 manual should be consulted for the proper detector power requirements.

Users with an XR100

The hardware should be connected as shown in the figure below. The XR100 output can be connected to an oscilloscope to monitor the preamp if necessary (see XR100 manual). Connect the USB cable to a PC (RS-232 is also available). Apply power to the system using the AC adapter. In the configuration shown below, both the DP5 and the PC5 are powered from the AC adapter. The DP5 passes the power to the PC5 which then generates the necessary voltages for the XR100.

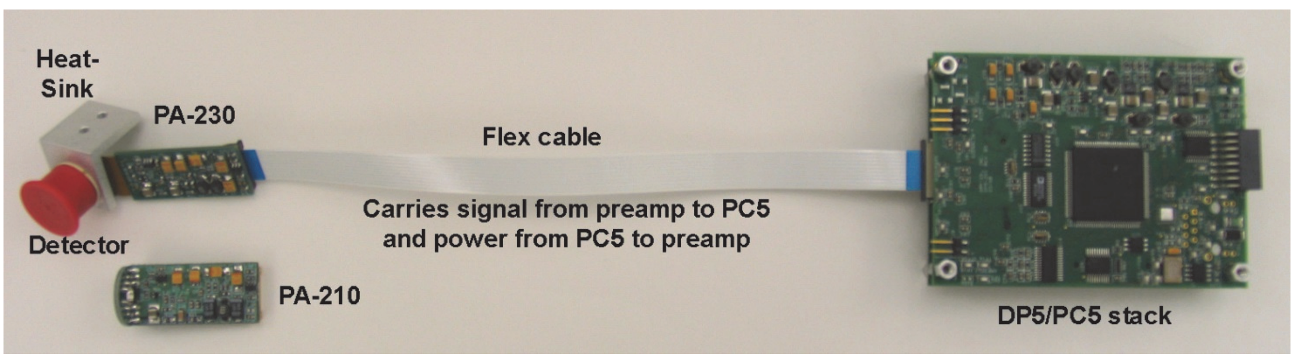
The system can be configured for custom OEM use without an AC power adapter where the user is supplying the +5 V. In this case power is connected to the PC5 directly and the PC5 passes the +5 V to the DP5. Please see the PC5 user manual for information on this configuration.



Block diagram showing the connections between the DP5 and PC5 with Amptek detectors.

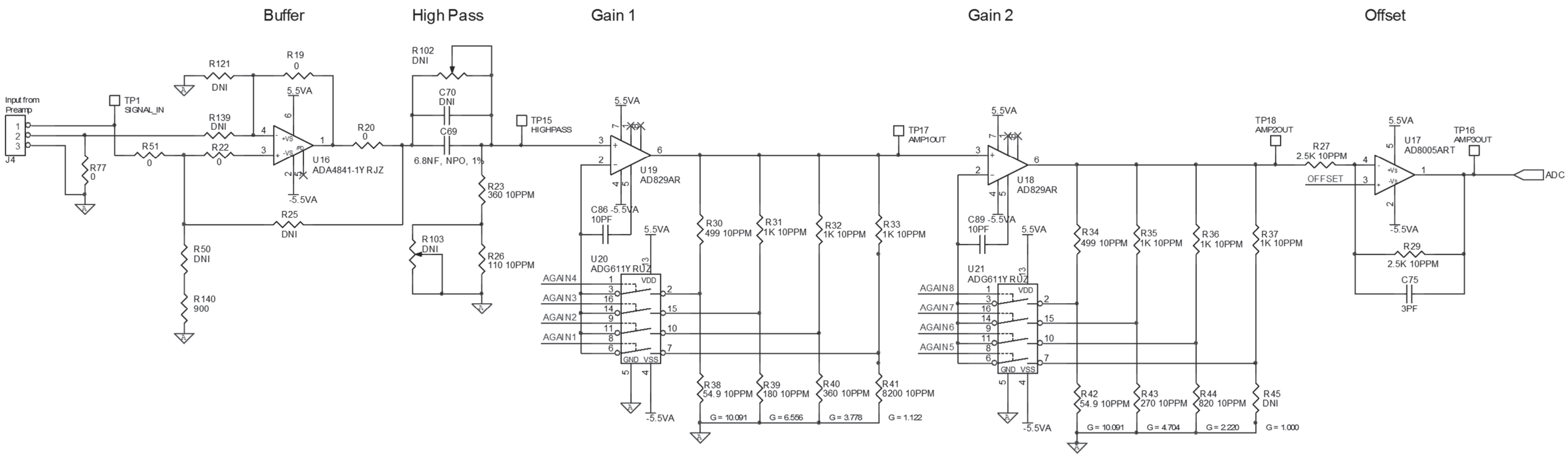
Users with a PA-210 or PA-230 Preamplifier

Many OEMs use the DP5/PC5 with the PA-210 or PA-230 preamplifier. This total OEM solution is configured as shown below. In this configuration both the signal from the preamplifier and the supply voltages to power the preamp and detector are passes through the flex cable that connects the PA-210/PA-230 to the PC5 power board. The PC5 then passes the signal to the DP5 using the J3 connector.



The DP5 and PC5 connected to the PA-230 (PA-210) preamplifier. The flex cable carries both signal and power thereby minimizing the connections necessary in the system

6.3 Customizing the analog prefilter (DP5 rev C and prior)



The analog prefilter circuit includes four main elements: (1) input buffer, (2) a high pass filter with a 3.2 µs time constant, (3) two gain stages, and (4) an amplifier providing DC offset.

Buffer

In its standard configuration, the first stage is a unity gain buffer. Many custom configurations involve tailoring the buffer, e.g. converting to a differential input, dividing the preamp output so it is within the range of the prefilter, etc.

High Pass Filter

The high pass filter, (C69)(R23 + R26) provides a 3.2 µs pole. This time constant is zeroed in the digital logic. For preamps with resistive feedback, R102 zeroes the preamp pole and R103 maintains the 3.2 µs pole.

Gain Stages

There are two nearly identical gain stages, with gains of approximately 1 to 10, yielding an overall system gain of 1.1 to 102.

Offset

The "offset" amplifier provides a DC offset to keep the ADC input within its allowable range. The polarity of the signal is inverted digitally, so with positive or negative polarity is permissible. This stage can also provide some gain and provides an anti-aliasing filter.

ADC Input

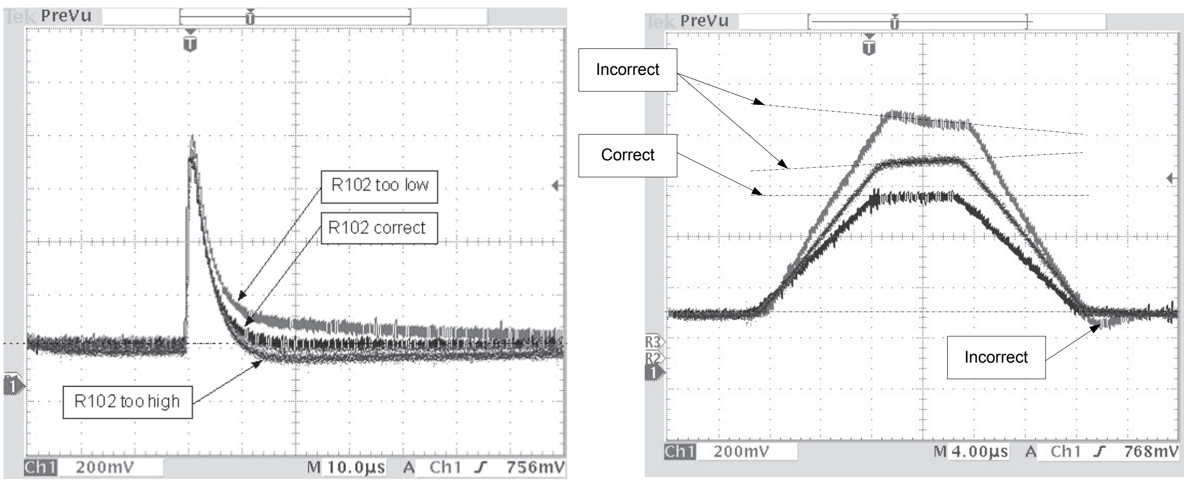
When customizing the configuration of the analog prefilter, the most important consideration is the ADC input (seen at AMP3OUT). The input range is 0 to 2V. This must include the maxima of the input pulses and also the noise around the baseline. We recommend that the largest steps in the spectrum be 1V at this point (to accommodate pile-up) and a DC offset of about 200 mV (so the noise excursions are above zero). Only resets should go below zero. Note: For non-inverting preamps, the signal steps here will be negative going, the baseline should be 1.8V, and the step size should again be 1V. The pulses should exhibit a single pole of nearly 3.2 µs.

Preamplifier Tail Cancellation

The most common change required is to add a pole zero resistor to cancel the tail of a preamplifier with continuous feedback. The following procedure is suggested:

1) Estimate the value of R102. If τ is the preamplifier time constant, the time in which the preamp tail decays to 1/e of its peak value after a step, then R102 = τ/6.8 nF. For τ=1 ms, R102=147kΩ.

2) Install R102. It is usually best to first install a pot to accommodate tolerances. With the pot installed and set to the approximate value, turn on the system and measure at AMP3OUT with an oscilloscope, with signals coming through. Look for a long undershoot or overshoot, comparable to the preamp tail as shown in the oscilloscope trace below (left). If there is an overshoot, decrease R102. If there is an undershoot, increase R102. Once the precise value is found, a fixed resistor may be installed.



Left: Oscilloscope traces showing AMP3OUT under several conditions: R102 properly adjusted, too large, and too small. When R102 is correct, there is neither undershoot nor overshoot on the tail. Right: Oscilloscope traces showing the DAC shaped output under several conditions. When R103 is incorrect, the top of the trapezoid is sloped and there is no undershoot or overshoot at the end.

3) The presence of R102 will change the time constant of the high pass filter, leading to a slope on the trapezoidal top and to an undershoot or overshoot of short time constant. Typical waveforms are shown in the oscilloscope trace above (right). Using the DP4 DAC output, set the peaking time to a short value and the flat top duration as long as permitted. Adjust R103 until the top is flat and no undershoot or overshoot is visible.

4) The presence of R102 also leads to a DC offset into the circuitry. A preamp generally has some DC offset at its output, and R102 combines with (R23+R26) to form a DC divider, coupling a fraction of this offset into the amplifiers, which is then amplified. In software, adjust the DC offset until AMP3OUT is in the correct range.

This procedure will only work if the tail from the preamplifier is a simple exponential (a single pole) and is constant. If there are multiple poles in the preamplifier response, then the dominant pole may be cancelled. The remaining pole(s) may or may not affect proper operation. If the time constant varies, i.e. with temperature or count rate, then the pole will not be cancelled under all conditions.

High rate support

At high enough rates, where the peaking time is typically 1 μs or below, the tail pulses into the ADC pile-up enough to exceed the ADC's range. In this case, the high pass filter should be set to 1.6 μs rather than 3.2. This is best done by changing R23 and R26. When this hardware step is carried, two software changes must be made.

First, the FPGA must be told that the 1.6 μs tail has been used. This is carried out in Firmware Manager, on the Calibration tab. Select the proper button.

Second, a time constant in the FPGA must be calibrated, again using Firmware Manager. Due to component tolerances, the high pass filter will have a time constant that does not exactly equal the 1.6 μs expected by the FPGA. This results in undershoot or overshoot at the end of the trapezoidal pulse and this affects resolution at high count rates. To properly calibrate, view the shaped pulse on an oscilloscope and adjust the time constant in Firmware Manager. This is discussed in more detail in "Understanding the DP5"

Attenuating Preamp Signal

The buffer amplifier has an input range of +/-4.5V. For reset preamplifiers operating from +/-5VDC and for preamplifiers with continuous reset, the preamp signal can generally be connected directly into this amplifier. For reset preamplifiers with a larger output swing, such as the XR100, the preamp output must be attenuated into the buffer amplifier.

The XR100 includes a 100Ω output resistor. If a 0Ω resistor is installed in R50, the signal is attenuated to 90% of its nominal value and thus falls within range. Other ranges can be accommodated by installing nonzero values into R50 or R51.

Differential Input: Resistor R77 ties the non-inverting input to ground. A differential input can be useful in systems with significant ground currents. Remove R77, then install 499Ω resistors into R19, R139, R51, and R140. Install a 0Ω resistor into R50. Note that the output impedance of the preamp is now in series with R51, so R51 may need to be reduced.

Adding Gain: Some preamplifiers with continuous feedback have low gain, so the output signals are quite small. To improve performance, R19 and R121 can be used to provide gain before the high pass filter. One must ensure that the output of U16 remains within range.

Implementing a charge amplifier: The U16 amplifier can be reconfigured to operate as a charge amplifier, i.e. as a charge sensitive preamplifier. It will not be a low noise preamp, but can be adequate if used with detectors having current gain, e.g. a scintillator and PMT. In place of R19, install the feedback cap C_F and feedback resistor R_F. The preamp will have a conversion gain of $1/C_F$ (mV per coulomb).

The product of R19 and C_F sets the preamp time constant, which must be zeroed using R102 as discussed above. Alternately, the product R19 and C_F can be set to 3.2 μs, in which case one must short across C69 and remove R23.

Additionally, a 0Ω resistor should be installed in R139 and R77 removed. The input to the charge amp is pin 2 of J4 (the DP5 input is usually pin 1). In some cases, a large value resistor is installed in R77 (100k) for current limiting. A 0Ω resistor should be installed in R50, while R51 should be removed.

6.4 *Customizing the analog prefilter (DP5 rev D)*

The DP5 Rev D uses different part numbers but the overall circuit topology is similar. The biggest change, for customization, lies in the preamplifier tail cancellation.

Preamplifier Tail Cancellation

Revision D has introduced a major and important change in pole zero cancellation. Instead of installing two potentiometers, which the user carries out, Amptek will install a set of components which include a digital potentiometer and an opamp. This new circuit has several key advantages:

- It has far better precision and stability than ten turn pots. With the old circuit, it was very difficult and tedious to find a setting which cancelled the tail well enough for use with HPGe detectors; the digital setting is much easier!
- It separates the adjustment of the preamp pole from the input pole. In the old circuit, one would adjust the pot to cancel the preamp tail, then have to adjust the input pole cancellation, then refine the preamp tail cancellation, and so on. The new digital pot only changes the preamp pole and does not affect input pole cancellation.

The procedure to adjust the tail is exactly the same as in Amptek's PX5-HPGe. Please refer to the PX5-HPGe manual, which discusses this in detail, with example oscilloscope traces and spectra.