DIGITAL PULSE PROCESSOR

DP4

Features

- Signal processor for x-ray and γ-gamma ray spectroscopy
- Suitable for nearly all detectors/preamplifiers
- Replaces both shaping amplifier and MCA
- Supports both reset and feedback preamplifiers
- Can be configured to include charge sensitive preamplifier for PMTs
- For OEM or custom laboratory use
- Highly configurable
- Low Power: 400 mW typical

Pulse Processing

- Trapezoidal shaping
- Command peaking time from 0.8 to 102.4 µs
- Command flat top duration from 0.2 to 51.2 µs
- >1,000,000 cps periodic
- Pile-up rejection & rise time discrimination

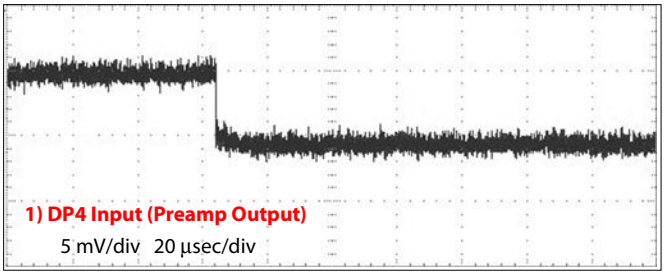
Multichannel Analysis

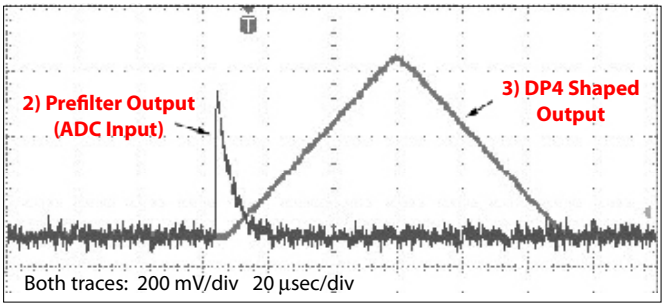
- Up to 8k output MCA channels

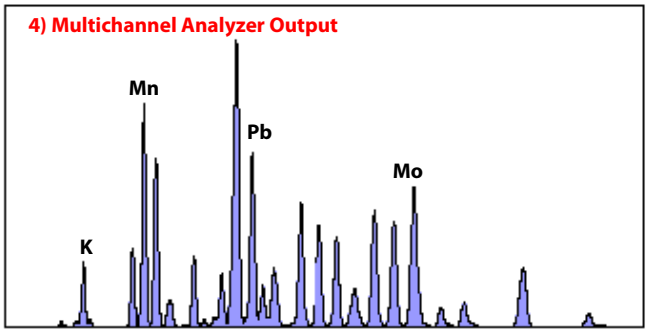
Communications

- Oscilloscope mode available - DAC output for pulse monitoring and adjustment
- Interfaces available: RS232, USB, I²C, auxiliary
- Onboard µcontroller with 8051-compatible core
- Includes embedded software and software for PC data acquisition and control
- Many configurable auxiliary inputs and outputs available

Shown in Actual Size: 3.5 in. x 2.5 in







Trace 1 above shows the input to the DP4, which is the output from a reset-type charge sensitive preamplifier. This is processed by the analog prefilter producing the prefilter output shown in Trace 2. This is digitized and then processed digitally, producing the DP4's shaped output shown in Trace 3. Finally, the DP4 creates a multi-channel anlayzer (MCA) type output spectrum shown in Graph 4.

Overview

The Amptek DP4 is a state of the art, high performance, low power digital pulse processor. It digitizes the preamplifier output signals, replacing both the shaping amplifier and MCA in a traditional, analog spectroscopy system. The DP4 offers several clear advantages over traditional systems, including improved performance (very high resolution, reduced ballistic deficit, higher throughput, and enhanced stability), enhanced flexibility, low power consumption, small size, and low cost.

The DP4 implements the pulse processing using dedicated circuitry in a FPGA. It includes an 8051 compatible micro-controller for controlling the unit. Interface hardware includes RS232, USB, I²C, and several general purpose I/O lines. The DP4 is suitable for OEMs and for laboratory users who need custom capabilities and are familiar with electronics.

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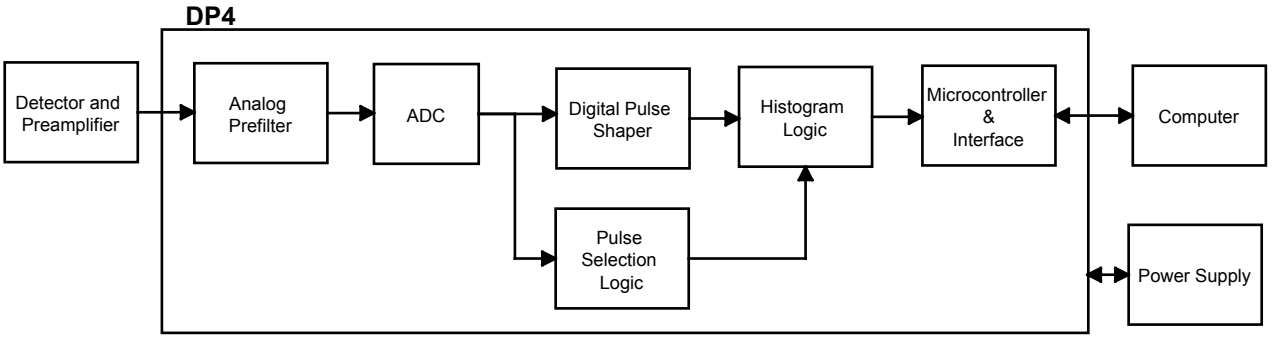
Specifications

Pulse Processing Performance	
Gain Settings	Four programmable coarse gain settings are available: x10.8, x20.7, x55.4, x106.2. Fine gain is adjustable between 0.75 and 1.25.
Full Scale	100 mV input pulse @ x10 gain.
Pulse Shape	Trapezoidal. A semi-gaussian amplifier with shaping time τ has a peaking time of 2.2 τ and is comparable in performance with the trapezoidal shape of the same peaking time.
Peaking and Flat Top Times	Twenty four programmable peaking times between 0.8 and 102.4 µs. For each peak time, sixteen flat top durations are available, >0.2 µs.
Max Count Rate	The pulse processing electronics have a cycle time of 1 µs. With a peaking time of 0.8 µs, a 1MHz periodic signal can be acquired.
Throughput	Dead time is 1.25 x peaking time. Unlike an analog system, there is no separate dead time for digitization and events can be counted less than a full pulse width apart.
Pile-Up Reject	Pulses separated by more than the fast channel resolving time, 600 ns, and less than 1.25 x peaking time are rejected.
MCA Performance	
Number of channels	Commandable to 256, 512, 1k, 2k, 4k, or 8k channels.
Bytes per channel	3 bytes (24 bits). 16.7 M counts per channel
Minimum Acquisition Time	<10 ms
Data Transfer Time	1k channels in 10 ms (USB) or 500 ms (RS-232)
Hardware	
Microprocessor	Cypress CY7C64603 'EZUSB FX' with 8051-compatible core
Memory	32K MCA memory, 8K EEPROM, 8K µC RAM
Firmware	Signal processing is programmed via firmware, which can be upgraded in the field.

Communications	
RS232	A standard RS232 serial interface is available at up to 57.6 Kbaud.
USB	Standard USB 1.1 interface (USB 2.0 compatible).
I^2C	The µC contains an I^2C port, allowing the DP4 to interface with peripherals.
Auxiliary	Four additional lines connect to the µC for additional interfacing options.
Connections	
Analog Input	The analog input accepts positive or negative going pulses from a charge sensitive preamplifier. NOTE: Can be configured with a charge sensitive preamplifier for use with PMTs. Contact Amptek for details.
Power and Serial Interface	The power and serial interface are provided on a single 16 pin connector. The power inputs are +3.3 V and ±5 V. The serial connections include RS232, USB, and I^2C.
DAC Output	This output is used in oscilloscope mode, to view the shaped pulse and other diagnostic signals. Range: 0 to 1 V.
Power	
+3.3 V	Average current 100-200 mA, depending on configuration. Start-up current is 500 mA.
±5 V	Average current 10 mA each.
Physical	
Size	3.5" x 2.5"
Weight	28 g
Software	
See page four.	

Block diagram of the DP4 in a complete system



DP4 Architecture

The DP4 is a component in the complete signal processing chain of a nuclear instrumentation system. The input to the DP4 is the preamplifier output. The DP4 digitizes the preamplifier output, applies real-time digital processing to the signal, detects the peak amplitude (digitally), and bins this value in its histogramming memory, generating an energy spectrum. The spectrum is then transmitted over the DP4's serial interface to the user's computer. Clearly, the DP4 must be used with other components, including a detector and preamplifier, a computer, and a power supply.

Analog Prefilter

The input to the DP4 is the output of a typical charge sensitive preamplifier. The analog prefilter circuit prepares this signal for accurate digitization. The output of the prefilter is shown on the first page.

NOTE: The DP4 can be ordered with a charge sensitive preamplifier on the board for use with PMTs.

ADC

The ADC digitizes the output of the analog prefilter at a 20 MHz rate. The digitized values are sent, in real time, into the digital pulse shaper.

Digital Pulse Shaper

The ADC output is processed continuously using a pipeline architecture in an FPGA to generate a real time shaped pulse. The shaped pulse is a purely digital entity. For diagnostic purposes, its output can be displayed on a PC or through the DAC output, but this is not necessary.

The peak value of the digital shaped pulse is determined by a peak detect circuit in the pulse shaper. The peak value for each pulse, a single digital quantity, is the primary output of the pulse shaper.

The DP4 uses trapezoidal pulse shaping, which offers high energy resolution, reduces ballistic deficit, and provides excellent baseline stability at high count rates.

Pulse Selection Logic

The pulse selection logic rejects pulses for which an accurate measurement cannot be made. It includes pile-up rejection and risetime discrimination. At high count rates, the DP4 has both better pile-up rejection and higher throughput than a traditional, analog shaping amplifier.

Histogramming Memory

The histogramming memory operates as in a traditional MCA. When a pulse occurs with a particular peak value, a counter in a corresponding memory location is incremented. The result is a histogram, an array containing, in each cell, the number of events with the corresponding peak value. This is the energy spectrum and is the primary output of the DP4.

Interface

The DP4 includes hardware and software to interface between these various functions and the user's computer. A primary function of the interface is to transmit the spectrum to the user. The interface also controls data acquisition, by starting and stopping the processing and by clearing the histogram memory. It also controls certain aspects of the analog and digital shaping, for example setting the analog gain or the pulse shaping time.

The interface includes µcontroller and serial interface hardware. RS232 and USB are currently implemented. The interface also contains an I^2C interface and several µcontroller pins that are unallocated but are available to the user.

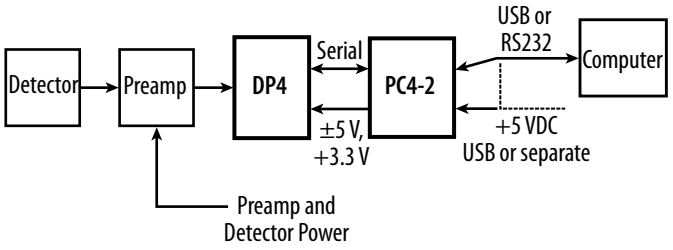
DP4 Interface Boards

Amptek's DP4 Digital Pulse Processor is a component in the complete signal processing chain of a nuclear instrumentation system. It must be used with other components, including (at a minimum) a detector and preamplifier, a computer with a serial interface and software to communicate, and a power supply. The DP4 does not have any power supplies and does not have standard serial connectors.

Amptek provides two different boards (PC4-2, PC4-3) which may be used to connect the DP4 to a computer and power supplies. These boards are not required to use the DP4 but can make it easier and faster to begin running the DP4. Both boards pass the serial signals, RS232 and USB, straight through to more common connectors. The boards differ in how they handle power:

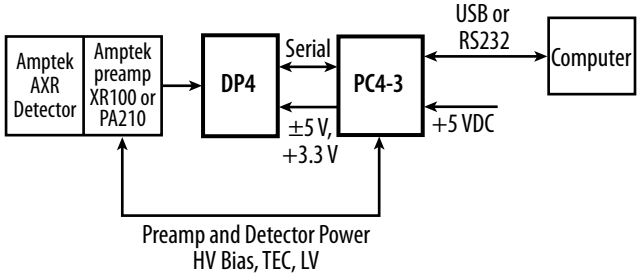
PC4-2 provides power to the DP4 from a +5 VDC source, either the USB bus or an external supply. This board has standard mini-USB and RS232 serial connectors and a DC power socket. Dimensions: 2.5 in. x 2.5 in.

Block diagram of the PC4-2 in a complete system



PC4-3 provides power to both the DP4 and Amptek's XR-100 detectors from a +5 VDC source. This board is intended for those using Amptek's detectors and preamps. It has a standard mini-USB connector but otherwise uses 0.1" connectors. The USB interface cannot supply enough current to operate the XR100, so an external DC supply is required, which must be between 2.5 and 5.5 V. Dimensions: 3.5 in. x 2.5 in.

Block diagram of the PC4-3 in a complete system



Software

There are two distinct software packages that are needed for the DP4 (both included): embedded software that runs on the µcontroller on the DP4, and acquisition and control software that runs on the attached computer. These are fully functional programs, allowing complete control of the hardware.

With the DP4, the user may tailor the software for both the embedded processor and the interface to do exactly what is required for a particular application. This is a key advantage to the use of the DP4.

Embedded Software

The embedded software is responsible for controlling the pulse processing, controlling the MCA, carrying out some data processing, and interfacing with the personal computer. The demonstration program is written in 8051 assembly language.

Various capabilities can be added to the embedded software. For example, the user can write code to implement memory groups, or apply a dead time correction. The DP4 can also be interfaced to other hardware via the I²C and auxiliary pins. Inputs on these pins can gate data acquisition or the DP4 can control hardware via these pins.

Interface Software

ADMCA Software

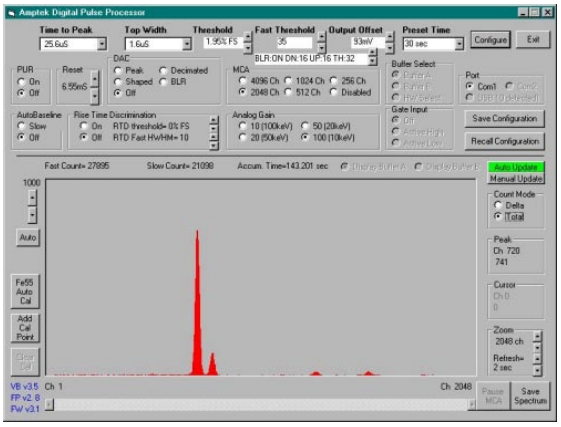
The DP4 can be controlled by the Amptek ADMCA display and acquisition software. This software can be used for control and display of the DP4 and supports regions of interest (ROI), calibrations, peak searching, and so on. The ADMCA software includes a seamless interface to the XRF-FP quantitative X-ray analysis software package.

VB Demonstration Software

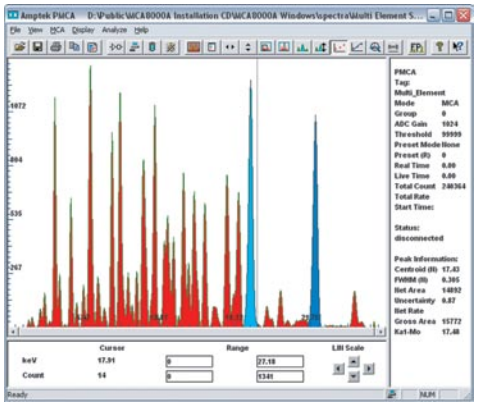
The VB demonstration software runs on a personal computer and permits the user to set the DP4 parameters, to start and stop data acquisition, and to save data files. It is provided with source code and can be modified by the user. This software is intended as an example of how to manually control the DP4 through either the USB or RS232 interface without the DPP API (see below).

DPP API

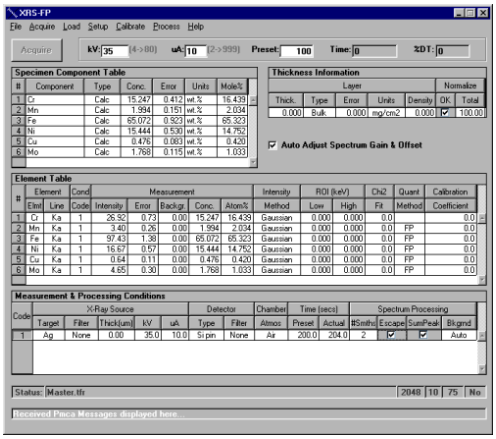
The DP4 comes with an Application Programming Interface (API) in the form of a DLL library. The user can use this library to easily write custom code to control the DP4 for custom applications or to interface it to a larger system. Examples are provided in VB and VC++ on how to use the API.



Example of demonstration software supplied with the DP4 for data acquisition (source code provided).

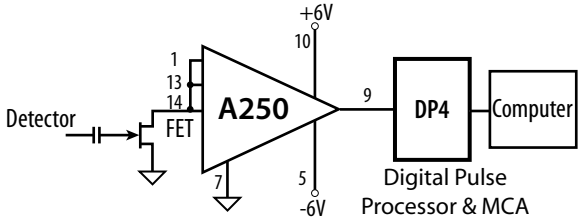


Example of MCA8000A display and acquisition software with interface to XRF-FP quantitative analysis software.



Example of XRF-FP X-ray analysis software.

The A250 connected to the DP4 Digital Pulse Processor and MCA



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