DIGITAL PULSE PROCESSOR

DP5

Features

- Replaces both shaping amplifier and MCA
- Supports both reset and feedback preamplifiers of either polarity
- Configurable with a charge sensitive preamplifier for use with PMTs
- For OEMs or custom laboratory users
- Highly configurable

Pulse Processing & MCA

- Trapezoidal shaping
- Peaking time commandable from 0.1 to 102.4 µs
- Commandable flat top duration from 0.05 to 51.2 µs
- 4,000,000 cps periodic
- Pile-up rejection & risetime discrimination
- Up to 8k output MCA channels

Communications

- Interfaces: RS-232, USB, Ethernet, I²C, auxiliary
- Oscilloscope mode - DAC output for pulse monitoring and adjustment
- Onboard µcontroller with 8051-compatible core
- Software for PC data acquisition and control (includes API)
- Many configurable auxiliary inputs and outputs

Physical

- Low Power: 600 mW typical
- Small Size: 3.5 in x 2.5 in

Overview

The Amptek DP5 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 DP5 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.

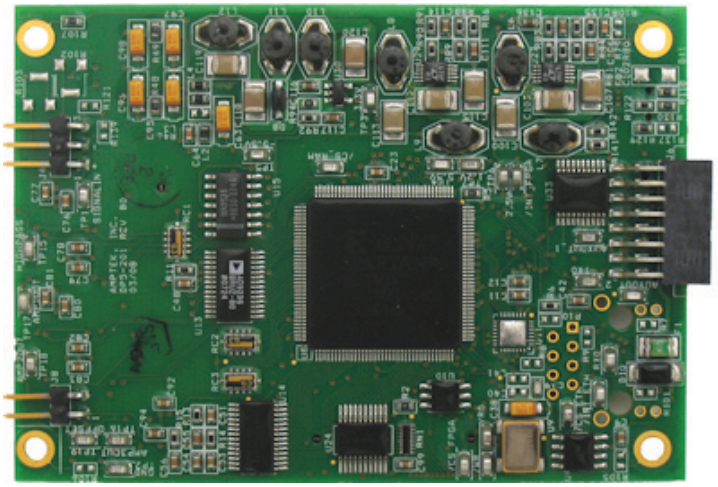
The DP5 represents the latest generation in digital pulse processing, an enhanced replacement for Amptek's DP4. The DP5 operates at higher count rates than the DP4, with faster shaping times, better pile-up rejection, and better dead time correction; offers lower electronic noise and a wider gain range; includes additional features such as a "List Mode" and additional spectral display options; and improved interfacing, including faster serial communication, an Ethernet interface, and onboard power supplies.

Its physical dimensions are compatible with the DP4. The software is designed to be as backward compatible as possible: software written for the DP4 will be fully functional, reproducing the DP4's capabilities, while additions with minor changes to the software will permit access to the full capabilities of the DP5.

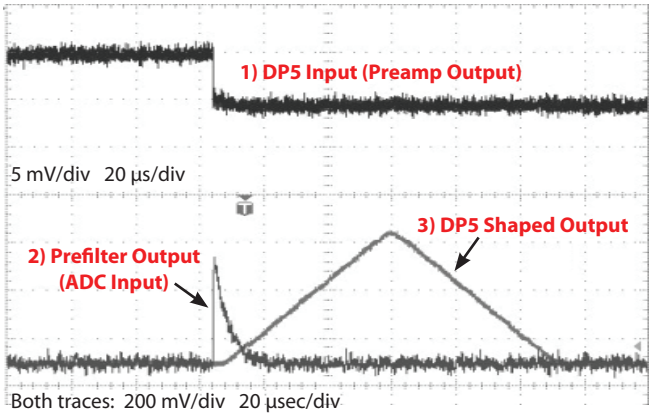
The DP5 is suitable for OEMs and for users needing custom capabilities.

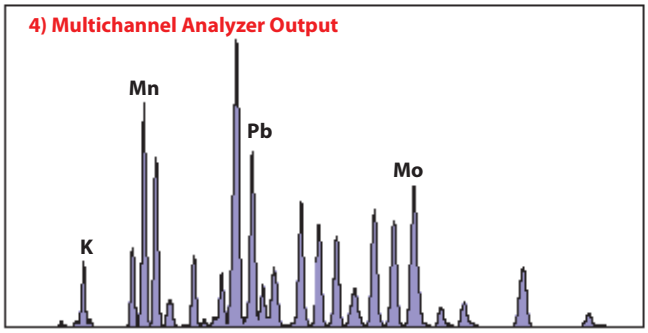
Applications

- X-ray and gamma ray detectors
- Nuclear Instrumentation
- Portable, battery operated systems
- OEM & Special Applications
- Process Control
- Research and Teaching



Shown in Actual Size: 3.5 in. x 2.5 in





Trace 1 above shows the input to the DP5, 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 DP5's shaped output shown in Trace 3. Finally, the DP5 creates a multichannel analyzer (MCA) type output spectrum shown in Graph 4.

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AMETEK® MATERIALS ANALYSIS DIVISION

Specifications

Pulse Processing Performance	
Gain	Combination of coarse and fine gain yields overall gain continuously adjustable from x0.84 to x127.5.
Coarse Gain 16 log spaced coarse gain settings from x1.12 to x102.00	

1.12	2.49	3.78	5.26	6.56	8.39	10.10	11.31
14.56	17.77	22.42	30.83	38.18	47.47	66.26	102.00

Fine Gain	Adjustable between 0.75 and 1.25, 10 bit resolution
Full Scale	1000 mV input pulse @ x1 gain.
Gain Stability	<20 ppm/°C (typical)
ADC Clock Rate	20 or 80 MHz, 12 bit ADC
Pulse Shape - Trapezoidal	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 Times	30 software selectable peaking times between 0.2 and 102 µs, corresponding to semi-Gaussian shaping times of 0.1 to 45 µs.
Flat Top Times	16 software selectable values for each peaking time (depends on the peaking time), >0.05 µs.
Max Count Rate	With a peaking time of 0.2 µs, 4 MHz periodic signal can be acquired.
Dead Time Per Pulse	1.05x peaking time. No conversion time.
Fast Channel Pulse Pair Resolving Time	120 ns
Pile-Up Reject	Pulses separated by more than the fast channel resolving time, 120 ns, and less than 1.05x peaking time are rejected.
Baseline Restoration - Asymmetric	16 software selectable slew rate settings.
MCA Performance	
Number of channels	Commandable to 256, 512, 1024, 2048, 4096, or 8192 channels.
Bytes per channel	3 bytes (24 bits), 16.7 M counts.
Preset Acquisition Time	10 ms to 466 days.
Data Transfer Time	USB: 1k channels in 12 ms; RS-232: 280 ms
Conversion Time	None
Presets	Time, total counts, counts in an ROI, counts in a channel.
MCS Timebase	10 ms/channel to 300 s/channel
External MCA Controls - Gate Input	Pulses accepted only when gated on by external logic. Input can be active high or active low.
Counters	Slow channel events accepted by MCA. Incoming counts (fast channel counts above threshold), event rejected by selection logic, and external event counter.

Hardware	
Microprocessor	Silicon Labs 8051F340 8051-compatible core.
External Memory	512 kb low-power SRAM
Firmware	Signal processing is programmed via firmware, can be upgraded in the field.
Communications	
RS-232	Standard serial interface ≤115 Kbaud.
USB	Standard 2.0 full speed (12 Mbps).
Ethernet	Standard 10base-T.
Connections	
Analog Input	The analog input accepts positive or negative going pulses from a charge sensitive preamplifier. 1x3 right angle header Molex part number 22-28-8032. NOTE: Can be configured with a charge sensitive preamplifier for use with PMTs. Contact Amptek for details.
Power	+5 VDC. Hirose MQ172-3PA (55).
RS232	Standard 2.5 mm stereo audio jack.
USB	Standard USB mini-b jack.
Ethernet	Standard Ethernet jack.
Auxiliary	2x8 16-pin 2 mm spacing (Samtec part number ASP-135096-01). Mates with connector Samtec P/N TCMD-08-S-xx.xx-01.
DAC Output	Used in oscilloscope mode to view the shaped pulse and other diagnostic signals. Range: 0 to 1 V. 1x2 right angle header Molex part number 22-28-8022.
Power	
+5 V	80 MHz clock: 200 mA (1 W) typical 20 MHz clock: 180 mA (0.9 W) typical
Input Range	+4 V to +5.5 V (at 0.25 to 0.18 A typical)
Initial Transient	2 A for <100 ns
Power Source	External supply or USB bus.
Physical	
Size	3.5" x 2.5"
Weight	32 g
General and Environmental	
Operating Temperature	-40 °C to +85 °C.
Warranty Period	1 year.
Typical Device Lifetime	5 to 10 years, depending on use.
Long-term Storage	10+ years in dry environment.
Typical Storage and Shipping	-40 °C to +85 °C, 10 to 90% humidity non-condensing.
Compliance	RoHS Compliant

Auxiliary Inputs and Outputs

The primary purpose of this connector is to bring out logic signals which are not required for the primary use of the DP5: acquiring spectra and transmitting them over the serial interface. These are generally "low level" logic signals associated with each pulse processed by the DP5. They are primarily used for synchronizing the DP5 data acquisition to external hardware and for direct counter/timer outputs from the DP5. The signals are described below. The connector is a 2x8 right angle Samtec part number ASP-135096-01.

Single Channel Analyzers	8 SCAs, independent software selectable LLDs and ULDs, LVCMOS (3.3 V) level (TTL compatible).
Digital Outputs	2 independent outputs, software selectable between 8 settings including INCOMING_COUNT, PILEUP, MCS_TIMEBASE, etc. LVCMOS (3.3V) levels (TTL compatible).
Digital Inputs	2 independent inputs, software selectable for MCA_GATE, EXTERNAL_COUNTER.
I/O	2 general purpose I/O lines for custom application.
Digital Oscilloscope	Displays oscilloscope traces on the computer. Software selectable to show shaped output, ADC input, etc., to assist in debugging or optimizing configurations.

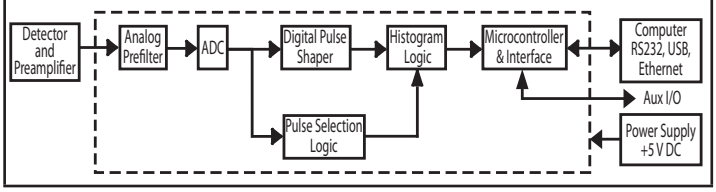
Auxiliary Connector Pin Assignments

Pin	Name	Pin	Name
1	SCA1	9	AUX_IN 1
2	SCA2	10	AUX_OUT 1
3	SCA3	11	AUX_ IN 2
4	SCA4	12	AUX_OUT 2
5	SCA5	13	IO2
6	SCA6	14	IO3
7	SCA7	15	GND
8	SCA8	16	GND

Architecture

The DP5 is a component in the complete signal processing chain of a nuclear instrumentation system. The input to the DP5 is the preamplifier output. The DP5 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 DP5's serial interface to the user's computer. The DP5 must be used with other components, including a detector and preamplifier and a computer.

Block diagram of the DP5 in a complete system.



Analog Prefilter: The input to the DP5 is the output of a charge sensitive preamplifier. The main functions of this circuit are (1) applying appropriate gain and offset to utilize the dynamic range of the ADC, and (2) carrying out some filtering and pulse shaping functions to optimize the digitization.

NOTE: The DP5 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 or 80 MHz rate then sends it in real time to the digital pulse shaper. 12 bit ADC is used.

Digital Pulse Shaper The ADC output is processed continuously using a pipeline architecture to generate a real time shaped pulse. This carries out pulse shaping as in any other shaping amplifier. The shaped pulse is a purely digital entity. Its output can be routed to a DAC, for diagnostic purposes, but this is not necessary.

There are two parallel signal processing paths inside the DPP, the "fast" and "slow" channels, optimized to obtain different data about the incoming pulse train. The "slow" channel, which has a long shaping time constant, is optimized to obtain accurate pulse heights. The peak value for each pulse in the slow channel, a single digital quantity, is the primary output of the pulse shaper. The "fast" channel is optimized to obtain timing information: detecting pulses which overlap in the slow channel, measuring the incoming count rate, measuring pulse risetimes, etc.

The DP5 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, risetime discrimination logic for an external gating signal, etc. At high count rates, the DP5 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 DP5. The unit also includes several counters, counting the total number of selected pulses but also counting input pulses, rejected events, etc. Auxiliary outputs include 8 different single channel analyzers, and both a DAC output and a digital output showing pulse shapes from several points in the signal processing chain.

Interface The DP5 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.

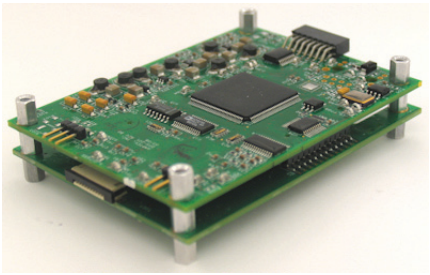
The interface includes a microcontroller and serial interface hardware. RS232, USB, and Ethernet are currently implemented.

PC5 and Interface

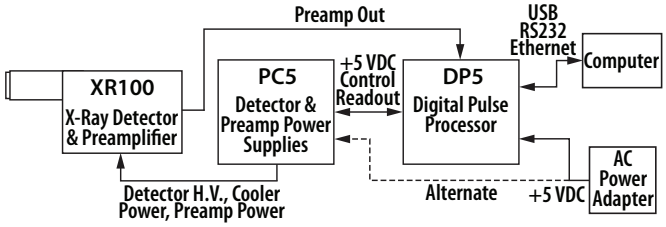
The DP5 itself has its own power supplied so only needs a +5 V DC input. When using the DP5 with Amptek detectors, additional power supplies are needed for the detector and preamp. Amptek provides the PC5 board that mates with the DP5 and provides power to Amptek detectors.

The PC5 provides power to Amptek XR-100 detectors from a +5 VDC source. This board is intended for those using Amptek detectors and preamps. 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.

DP5 (top) mated with the PC5 (bottom)



DP5 with PC5 and Amptek detector/preamp.



Software

There are two distinct software packages that are needed for the DP5: embedded software that runs on the microcontroller on the DP5 (firmware), and acquisition and control software that runs on the attached computer. A complete software platform with examples is provided to aid in software development for OEM and custom applications.

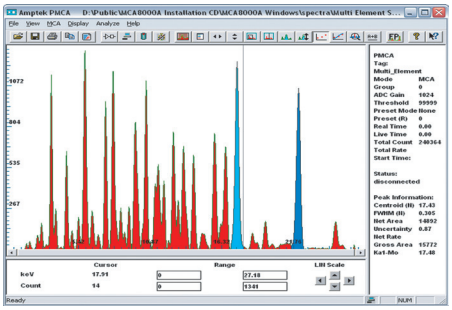
Embedded Software

The embedded software is responsible for controlling the pulse processing, controlling the MCA, carrying out some data processing, and interfacing with the personal computer. This software is fixed and cannot be modified by the user. Firmware updates will be released by Amptek and can be uploaded in the field by the user.

Interface Software

ADMCA Software The DP5 can be controlled by the Amptek ADMCA display and acquisition software. This software can be used for control and display of the DP5 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.

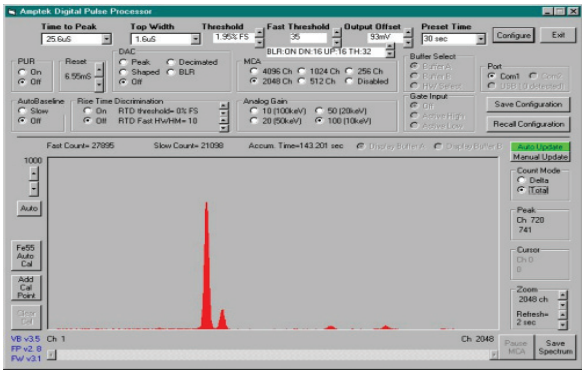
Example of ADMCA display and acquisition software with interface to XRF-FP quantitative analysis software.



DPP API The DP5 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 DP5 for custom applications or to interface it to a larger system. Examples are provided in VB, VC++, etc. on how to use the API

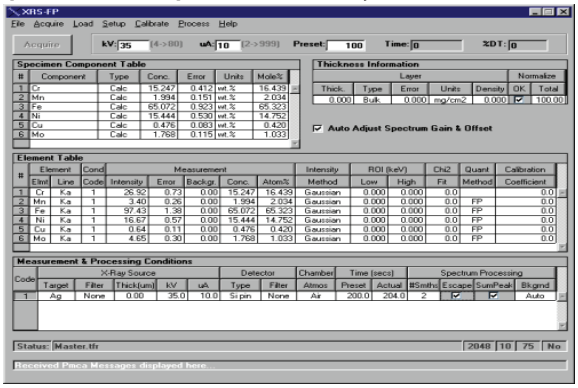
VB Demonstration Software The VB demonstration software runs on a personal computer and permits the user to set the DP5 parameters, to start and stop data acquisition, and to save data files. It is provided with source code and can be modified by the user. This software is intended as an example of how to manually control the DP5 through either the USB or RS-232 interface without the DPP API.

Example of demonstration software supplied with the DP5 for data acquisition (source code provided).



Optional Software XRF-FP Quantitative Analysis Software for X-ray Fluorescence applications. Please see our web site: http://www.amptek.com/fp.html.

Example of XRF-FP quantitative analysis software.



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