DIGITAL PULSE PROCESSOR

DP4

Features

- **Replaces both shaping amplifier and MCA**
- **Supports both reset and feedback preamplifiers of either polarity**
- **For OEMs or custom laboratory users**

Pulse Processing

- **Trapezoidal shaping**
- **Peaking time commandable from 0.8 to 100 µs**
- **Adjustable flat top duration**
- **>1,000,000 cps periodic**
- **Pile-up rejection & risetime discrimination**

Multichannel Analysis

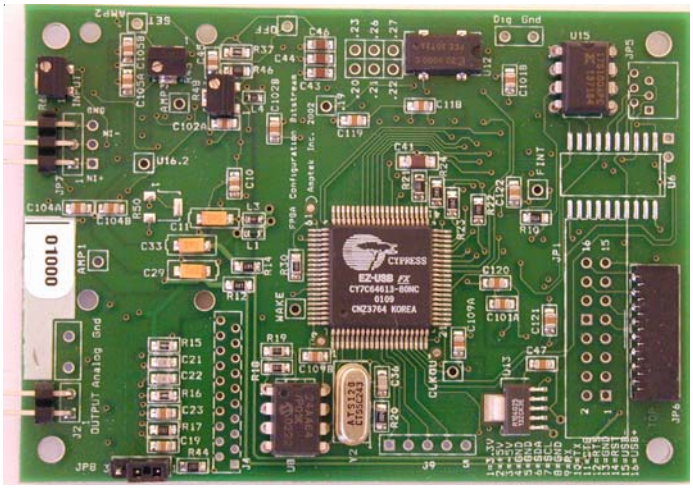
- **Up to 8k output MCA channels**

Communications

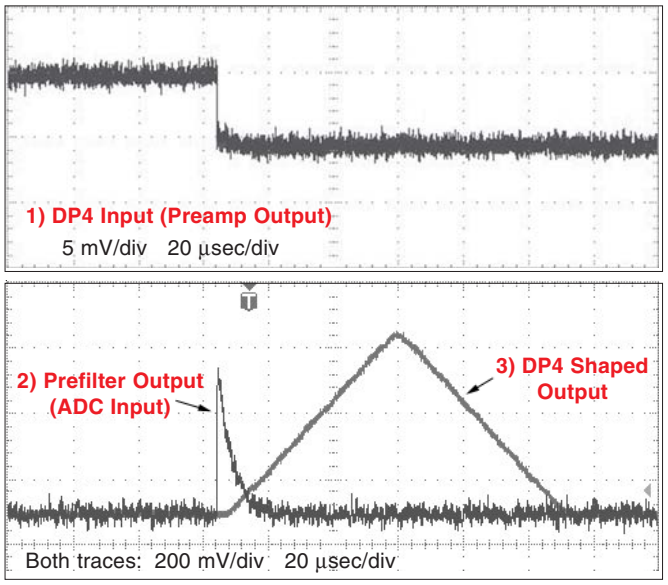
- **Oscilloscope mode available - DAC output for pulse monitoring and adjustment**
- **Interfaces available: RS-232, USB, I²C, auxiliary**
- **Onboard µcontroller with 8051-compatible core**
- **Includes demonstration software for 8051 and for PC interface**

Physical

- **Low Power: 400 mW typical**
- **Small Size: 3.5 in X 2.5 in**



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 multichannel 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. It includes an 8051 compatible microcontroller for controlling the unit. Interface hardware includes RS232, USB, I²C, and several general purpose I/O lines. The DP4 is supplied with demonstration software, including both the embedded software running on the DP4 and interface software running on a PC via the RS232 or USB port. Because the DP4 is supplied with the source code, which runs on the µcontroller, a user can tailor the software for specific applications and can use the DP4 µcontroller for additional uses. The DP4 is suitable for OEMs and for laboratory users who need custom capabilities.

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Specifications

Pulse Processing Performance

Gain Settings: Four programmable coarse gain settings are available: x10, x20, x50, x100. 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 µsec. For each peak time, sixteen flat top durations are available, > 0.2 µsec

Max Count Rate: The pulse processing electronics have a cycle time of 1 µsec. With a peaking time of 0.8 µsec, a 1MHz periodic signal can be acquired.

Throughput: Dead time is 1.25x 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 nsec, and less than 1.25x 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 msec

Data Transfer Time: 1k channels in 10 msec (USB) or 0.5 sec (RS-232)

Hardware

Microprocessor: Cypress CY7C64613 '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

RS-232: A standard RS-232 serial interface is available at up to 57.6 Kbaud. This is used in the demonstration software.

USB: A standard USB interface is available in the demonstration software. (Compatible with USB 1.1 and 2.0 at full-speed (12 mbps).)

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.

Maximum Input: 100 mV @ x10 gain.

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 RS-232, 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.

DP4 Architecture

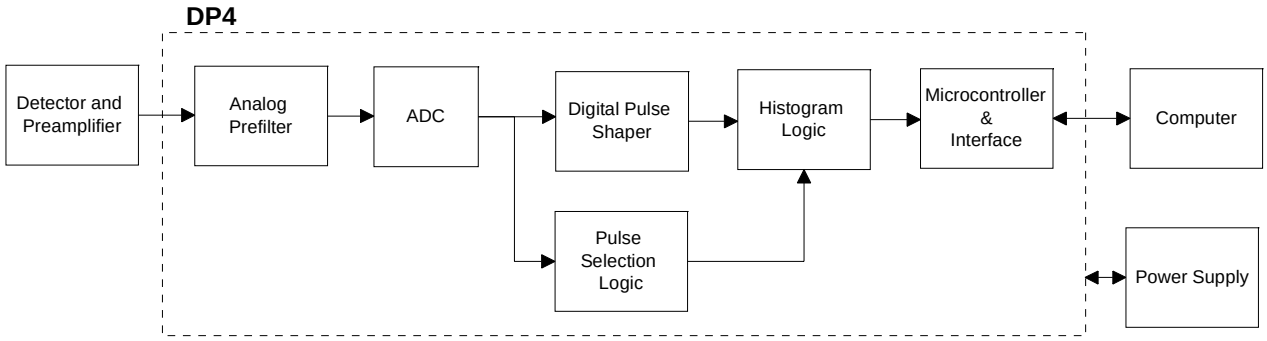


Figure 1. Block diagram of the DP4 in a complete system.

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.

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 to generate a real time shaped pulse. The shaped pulse is a purely digital entity. Its output can be routed to a DAC, for diagnostic purposes, 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 a microcontroller and serial interface hardware. RS232 and USB are available. The interface also contains an I^2C interface and several microcontroller pins that are unallocated but are available to the user.

Software

There are two distinct software packages that are generally used for the DP4: embedded software that runs on the microcontroller on the DP4, and acquisition and control software that runs on the attached computer.

The DP4 is shipped with demonstration versions of both software packages. These are fully functional programs, allowing complete control of the hardware, but do not necessarily contain all of the functionality needed for a specific application. Source code is provided for both programs.

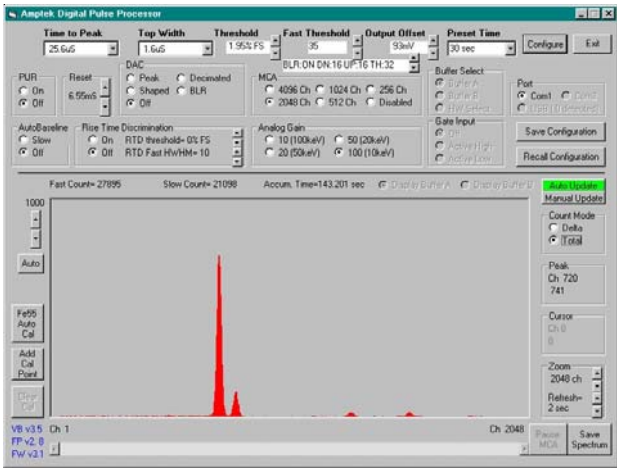
With the DP4, the user may tailor the software for both the embedded processor and the interface to do exactly what is required for a particular application. This is a key advantage to the use of the DP4.

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.

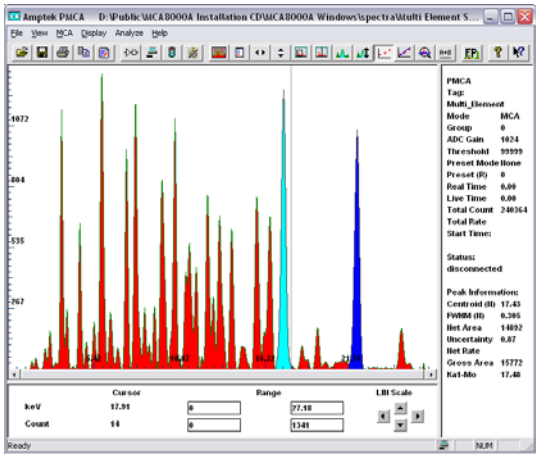
Various capabilities can easily be added to the embedded software. For example, the user can write code to preset data acquisition times, implement memory groups, or apply a dead time correction. An MCS capability could be programmed. The DP4 can also be interfaced to other hardware via the I^2C and auxiliary pins. Inputs on these pins can gate data acquisition or the DP4 can control hardware via these pins.

Interface Software: The 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 written in Visual Basic and can be modified by the user. (Source code is provided.) In addition, the DP4 can be controlled by the Amca acquisition and control software.

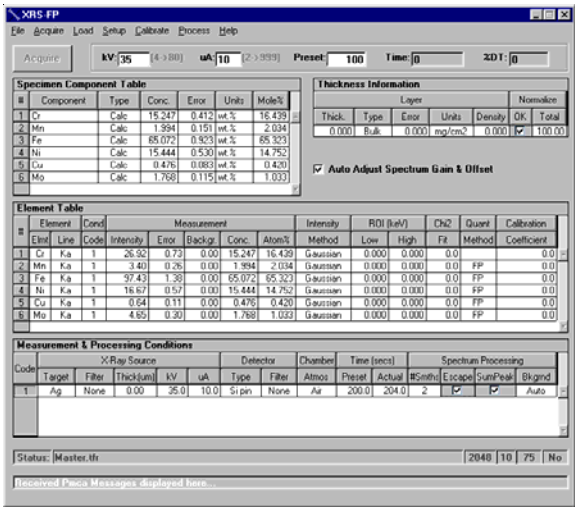
Display and Analysis Software: The Amca software can be used for display and acquisition as well as setting regions of interest, implementing calibrations and so on. The Amca software includes a seamless interface to an X-ray spectrum analysis software package, XRF-FP. More information on these two packages can be found on Amptek's web site.



Example of demonstration software supplied with the DP4 for data acquisition and control.



Example of MCA8000A display software.



Example of XRF-FP X-ray analysis software.

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