

## Digital Pulse Processor for Scintillation Detectors

# DP5G

### Features

- Integrated preamplifier, shaping amplifier, and MCA optimized for scintillation systems
- Processes PMT anode signal, giving complete spectrum
- Available as processor alone or with power supply and interface board
- For OEMs or custom laboratory users
- Highly configurable
- Low Power: 600 mW typical
- Small Size: 2.0 in x 1.75 in

### Pulse Processing & MCA

- Includes charge sensitive preamplifier
- Peaking time commandable from 0.1 to 102.4  $\mu$ s
- Commandable flat top duration from 0.05 to 51.2  $\mu$ s
- Pile-up rejection & risetime discrimination
- Up to 8k output MCA channels

### Communications

- Interfaces: RS-232, USB, Ethernet, I<sup>2</sup>C, auxiliary
- Oscilloscope mode - DAC output for pulse monitoring and adjustment
- Onboard  $\mu$ controller with 8051-compatible core
- Software for PC data acquisition and control (includes SDK)
- Many configurable auxiliary inputs and outputs

### Overview

The Amptek DP5G is a state-of-the-art, high performance, low power digital pulse processor designed for use in scintillation spectroscopy systems. Connected to the anode of a PMT, it includes a charge sensitive preamplifier and a digital pulse processor, which replaces both the shaping amplifier and the MCA in a traditional nuclear spectroscopy system. The DP5G offers several advantages over traditional systems, including higher performance, enhanced flexibility, small size, and low cost.

The DP5G is one component in a complete gamma-ray spectrometer, shown in the diagram below. The DP5G includes only the core signal processing functions. A complete system must also include a detector module (scintillator, PMT, HV supply, tube base) and interface circuitry with power supplies and connectors for the serial connection. Amptek can provide an OEM user with the DP5G alone, or can provide it with a PCG interface module, or can provide a complete system, including the detector module. The complete system is a separate Amptek product, the GammaRad5.

The DP5G represents the latest generation in digital pulse processing. The DP5 family is an enhanced replacement for Amptek's older DP4 family. The DP5G is a variant of the DP5, optimized for scintillation readout. The DP5 technology includes faster peaking times, improve pile-up rejection and pulse shape discrimination, better dead time correction, additional features such as a "List Mode", and enhanced interfaces.



*Shown in Actual Size: 2.0 in. x 1.75 in*

### Applications

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

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## Specifications

Pulse Processing Performance	
<b>Gain</b>	Combination of coarse and fine gain yields overall gain continuously adjustable from x1.2 to x8.1.
<b>Coarse Gain</b>	1.6, 2.6, 4.1, 6.5
<b>Fine Gain</b>	Adjustable between 0.75 and 1.25.
<b>ADC Clock Rate</b>	20 or 80 MHz, 12 bit ADC
<b>Pulse Shape - Trapezoidal</b>	Semi-Gaussian amplifier with shaping time $\tau$ has a peaking time of $2.2 \tau$ and is comparable in performance with the trapezoidal shape of the same peaking time.
<b>Peaking Times</b>	Software selectable peaking times between 0.05 and 102 $\mu$ s, corresponding to semi-Gaussian shaping times of 0.8 to 45 $\mu$ s.
<b>Flat Top Times</b>	63 software selectable values for each peaking time (depends on the peaking time), >0.05 $\mu$ s.
<b>Max Count Rate</b>	With a peaking time of 0.2 $\mu$ s, 4 MHz periodic signal can be acquired.
<b>Dead Time Per Pulse</b>	1.05x peaking time. No conversion time.
<b>Fast Channel Pulse Pair Resolving Time</b>	60, 120 ns @ 80 MHz 240, 480 ns @ 20 MHz
<b>Pile-Up Reject</b>	Pulses separated by more than the fast channel resolving time, and less than 1.05x peaking time are rejected.
<b>Baseline Restoration - Asymmetric</b>	16 software selectable slew rate settings.
MCA Performance	
<b>Number of channels</b>	Commandable to 256, 512, 1024, 2048, 4096, or 8192 channels, MCA or MCS.
<b>Bytes per channel</b>	3 bytes (24 bits), 16.7 M counts.
<b>Preset Acquisition Time</b>	10 ms to 466 days.
<b>Data Transfer Time</b>	USB: 1k channels in 6 ms RS-232: 280 ms

<b>Conversion Time</b>	None
<b>Presets</b>	Time, total counts, counts in an ROI, counts in a channel.
<b>MCS Timebase</b>	10 ms/channel to 300 s/channel
<b>External MCA Controls - Gate Input</b>	Pulses accepted only when gated on by external logic. Input can be active high or active low.
<b>Counters</b>	Slow channel events accepted by MCA. Incoming counts (fast channel counts above threshold), event rejected by selection logic, and external event counter.

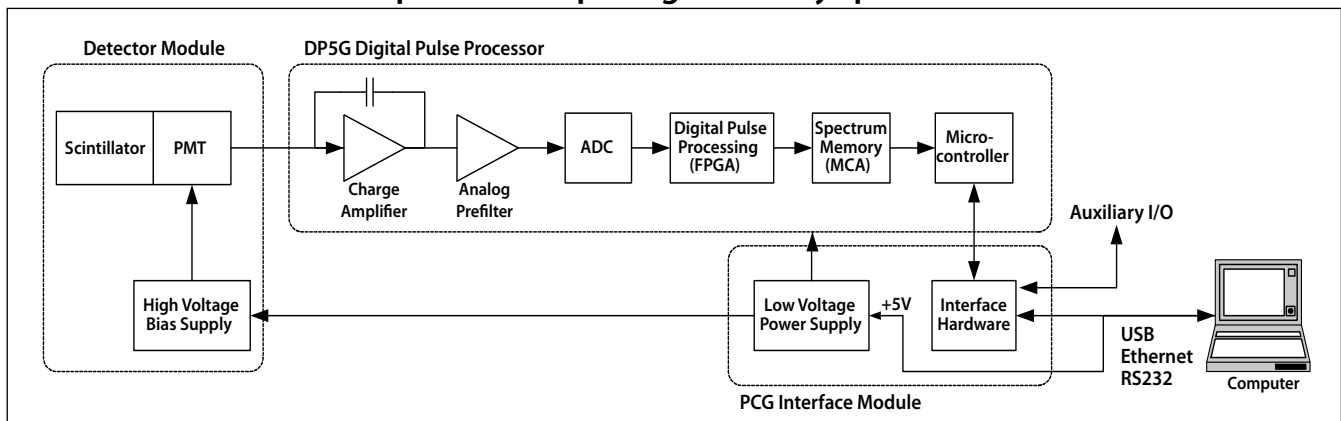
Hardware	
<b>Microprocessor</b>	Silicon Labs 8051F340 8051-compatible core.
<b>External Memory</b>	512 kb low-power SRAM
<b>Firmware</b>	Signal processing is programmed via firmware, can be upgraded in the field.

Communications	
<b>RS-232</b>	Standard serial interface @ 115 Kbaud.
<b>USB</b>	Standard 2.0 full speed (12 Mbps).
<b>Ethernet</b>	Standard 10base-T. (UDP)

Connections	
<b>Analog Input</b>	The output from a PMT, the anode, is connected to the analog input of the DP5G. The first stage of the DP5G is a charge amplifier with a conversion gain of 0.15 mV/pC (CF=6.8 nF). The input connector is a MMCX jack.
<b>Power</b>	+3.3 VDC.
<b>DAC Output</b>	Used in oscilloscope mode to view the shaped pulse and other diagnostic signals. Range: 0 to 1 V.

Power	
<b>+3.3 V</b>	20 MHz clock: 180 mA typical 80 MHz clock: 240 mA typical
<b>Input Range</b>	$3.3 \pm 0.1$ V

### Example of a complete gamma-ray spectrometer.



## Specifications (con't)

Physical	
Size	2.0" x 1.75"
Weight	13 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	
These signals are not required for the primary use of the DP5G: acquiring spectra and transmitting them over the serial interface. These are generally "low level" logic signals associated with each pulse processed by the DP5G. They are primarily used for synchronizing the DP5G data acquisition to external hardware and for direct counter/timer outputs from the DP5G. The signals are described below.	
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.

## Architecture

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 DP5G 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 DP5G 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 DP5G. 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 DP5G 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 available.

## PC5 and Interface

The DP5G includes only the core signal processing functions. The DP5G does not include the interface connectors or low voltage power supplies which are found on the DP5. To use the DP5G, a user can either (1) purchase a PCG interface board from Amptek or (2) implement a custom interface solution.

These functions were removed from the DP5G to make it as small as possible. OEM customers integrating the DP5G into their complete system usually have a power supply and connectors. Including them on the DP5G was duplicative and would make the board larger than necessary.

Amptek offers an interface board, the PCG, which includes these functions. The DP5G and PCG together offer essentially the same electrical functionality as the DP5 configured for scintillators. The figure below illustrates a complete gamma-ray spectrometer solution. Amptek also offers a complete spectrometer solution, the GammaRad.

DP5G (top) mated with the PCG (bottom)



## Software

There are two distinct software packages that are needed for the DP5G: embedded software that runs on the microcontroller on the DP5G (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

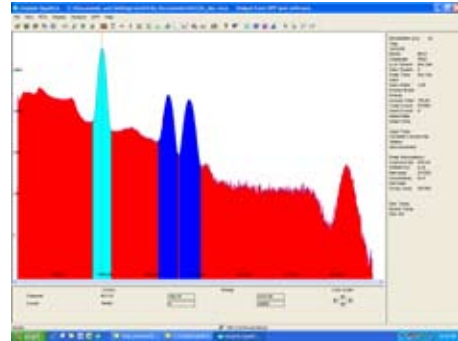
The embedded software is responsible for controlling the pulse processing, controlling the MCA, carrying out some data processing, and interfacing with the personal computer. This software is fixed and cannot be modified by the user. Firmware updates will be released by Amptek and can be uploaded in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

## Software (con't)

### Interface Software

**DPPMCA Software** The DP5G can be controlled by the Amptek DPPMCA display and acquisition software. This software can be used for control and display of the DP5G and supports regions of interest (ROI), calibrations, peak searching, and so on. The DPPMCA software includes a seamless interface to the XRF-FP quantitative X-ray analysis software package.

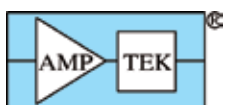
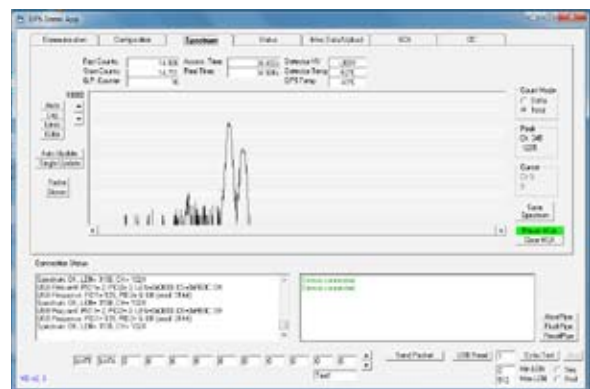
**Example of DPPMCA display and acquisition software.**



**DPP SDK** The DP5G comes with SDK: C++ classes. The user can use this library to easily write custom code to control the DP5G 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 DP5G 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 DP5G through either the USB, ethernet, or RS-232 interface without the DPP SDK.

**Example of demonstration software supplied with the DP5G for data acquisition (source code provided).**



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