

## Low Power Digital Spectrometer For Portable Applications

### OVERVIEW

The XIA  $\mu$ DXP card is a complete, low power digital spectrometer the size of a credit card. It includes both spectroscopy amplifier and MCA functions and is intended for both handheld and embedded table-top applications. Digital filtering is shared between a field programmable gate array (FPGA) and a digital signal processor (DSP) that also provides MCA functions. RS232 serial communication is via a PIC processor. Additional  $\mu$ DXP I/O paths include: a direct connection to a high speed synchronous serial port on the DSP; an optional 16-bit wide high throughput parallel bus; and several general-purpose digital I/O lines, including I<sup>2</sup>C capability, through which the  $\mu$ DXP can control external instrumentation. All operating firmware is stored in non-volatile memory and is factory preloaded but can also be upgraded in the field. To minimize OEM costs, many card features are optional: only those that are actually required for an application need be purchased. XIA would be pleased to discuss developing custom  $\mu$ DXP spectroscopy, process or control code on an NRE basis.

### POSSIBLE APPLICATIONS

While developed for x-ray applications, the  $\mu$ DXP's design is flexible enough to address other applications with appropriate firmware modifications. Please call XIA to discuss the details.

**X-ray spectroscopy:** The  $\mu$ DXP is well suited to handheld, table-top, and embedded process control applications.

**Gamma-ray spectroscopy:** Combining the  $\mu$ DXP's high quality ADC, 8K spectrum, and XIA's proprietary ballistic deficit correction firmware results in a high quality gamma-ray spectrometer for portable or dedicated applications.

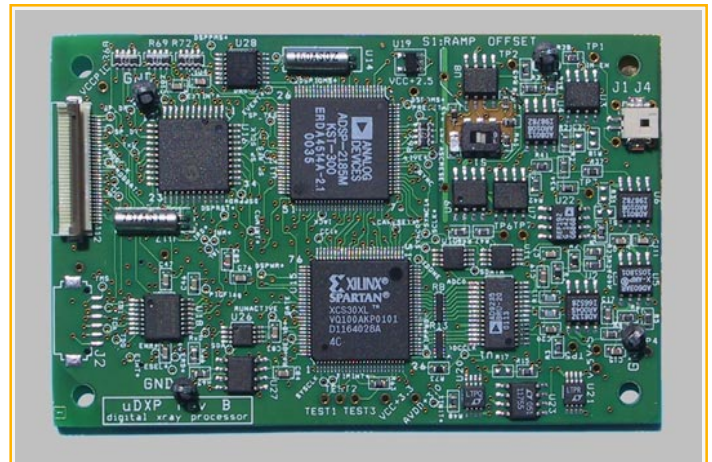
**Array detectors:** The low cost  $\mu$ DXP offers an economic approach to providing full spectroscopic support for arrays of detectors, including those where coincidence timing information is important.

**Scintillation detectors:** The  $\mu$ DXP supports both direct and preamplifier connection to scintillator/photodiode and scintillator/photomultiplier combinations.

**Neutron/gamma discrimination:** using firmware migrated from our high performance Polaris spectrometer, the  $\mu$ DXP can implement particle ID with CsI or other detectors.

### EVALUATION KIT

The  $\mu$ DXP RS232 evaluation kit is available to get spectrometry applications up and running quickly. All communications cabling, power supply and a micro-COM interface motherboard are included.



ACTUAL SIZE

### GENERAL SPECIFICATIONS

#### DETECTORS/PREAMPLIFIERS SUPPORTED

**Preamplifiers:** the  $\mu$ DXP supports both reset and feedback preamplifiers of almost any gain, of either polarity, and up to  $\pm 5V$  voltage range or even higher on request.

**Solid state detectors:** Si(Li), HPGe, PIN diode, SDD (Silicon Drift Detector), and CdTe are readily supported.

**Other detectors:** as a general purpose spectrometer, the  $\mu$ DXP can also be adapted to such diverse detectors as proportional counters and scintillator/photomultiplier tube combinations, as well as to CZT, surface barrier, and liquid Xenon detectors where pulse shape processing can significantly enhance results.

#### POWER CONSUMPTION

Power consumption depends upon both the clock speed and on what other options are selected. The table below shows basic design values. Various sleep modes with sub-second wake up times are available, controlled by the  $\mu$ DXP or its host.

Mode	Digitizing Rate	Power	Max. Throughput
Low	4 MSPS	500 mW	>50 kcps
Medium	8 MSPS	630 mW	>100 kcps
High	16 MSPS	750 mW	>200 kcps

#### POWER REQUIREMENTS

Digital: +3.3V, 300 mA

Analog: There are two voltage supply options:

Option 1:  $\pm 5.0V$ , 50 mA each, clean, regulated voltages.

Option 2:  $\pm 5.25V$ , 50 mA each, to supply  $\pm 5V$  on board linear regulators. This option allows a deep sleep mode (<50 mW) under  $\mu$ DXP control by shutting down the regulators.

## COMMUNICATIONS

Primary: RS232 (serial port) at 115 kBaud (11 Kbytes/sec – 270 ms to transfer a 1K spectrum at 3 bytes per channel). Slower rates on request. A PIC microcontroller handles RS232 communications, and offers a simple command interface.

Secondary: 1) a DSP serial port connection provides high-speed synchronous serial communication (up to 16 Mbps).

2) An optional 16-bit wide parallel connection is available, offering peak throughputs of up to 10 MB/sec.

Auxiliary I/O: the  $\mu$ DXP has 4 general-purpose I/O lines to communicate with the FPGA and an input gate to indicate valid data taking conditions. Three additional lines connect to the PIC microcontroller: two are configured as an industry standard I<sup>2</sup>C interface that allows the  $\mu$ DXP to control off-board peripherals; the third line can be used to interrupt the PIC controller, or for general purpose I/O.

## FIRMWARE

All firmware is stored in onboard non-volatile memory and normally ships with the part; no downloads from the host are needed. New configurations or upgrades can be downloaded in the field without removing parts from the board – the DSP and FPGA firmware through the serial port, while other parts need special tools for reconfiguration.

## SPECTROMETER SPECIFICATIONS

### OVERVIEW

The spectrometer is implemented using an analog signal conditioning section, an ADC, an FPGA and a DSP. The FPGA runs firmware (“Decimation N FiPPI”) that first decimates the input signal by producing sums of  $2^N$  consecutive samples and then operates on them using a set of digital filter functions (called a “FiPPI” for *F*ilter *P*eak and *P*ileup *I*nspection), including a fast channel x-ray detection filter, a slower shaping energy filter, peak capture, pileup inspection, and baseline correction. These functions operate at the ADC sampling speed. Values captured in the FiPPI are passed to the DSP which builds a spectrum and performs various secondary functions to improve energy resolution. In adapting the  $\mu$ DXP to a specific application, the following quantities can be specified: analog gain, ADC/FiPPI clock speed, peaking times, and MCA functions.

### GAIN

Two analog gain options are available:

Option 1: Hard-wired gain is factory set to match a selected detector design using precision, Low TempCo resistors.

Option 2: Variable gain, using a variable gain op-amp that is set from the host via a 16-bit DAC. This option adds 125 mW to the power draw estimates presented above.

### CLOCK SPEED

The  $\mu$ DXP’s primary speed characteristic and its basic power consumption are set by its ADC clock speed. It can have one fixed or two different clock speeds, selected by the host. There are three available options:

Standard Low/Medium Power Option: the  $\mu$ DXP card is factory set to a single clock speed: either 4 or 8 MHz.

Enhanced Clock Option: extends the standard option to allow switching between 4 and 8 MHz under host control, which extends the range of available peaking times.

High Speed Clock Option: allows switching between 8 MHz and 16 MHz clock speeds. This option also includes the Enhanced Peaking Time Option (below) to produce a selection of 6 overlapping peaking time ranges.

Higher digitizing rates: Consult XIA.

### PEAKING TIMES

The three standard Decimation N FiPPIs (N = 0, 2, & 4) combine with the three available clock speeds (4, 8, & 16 MHz) to create 9 peaking time ranges with values from 0.375  $\mu$ s to 96  $\mu$ s. Each peaking time range is a set of 5 peaking times whose values have the ratios 1, 1.5, 2, 3, and 4 relative to the first or “base” value. For example, a base value of 6  $\mu$ s results in a range of 6, 9, 12, 18, and 24  $\mu$ s. The 9 base values are shown in the table below. Only 7 values are unique.

Clock Rate	N=0	N=2	N=4
4 MHz	1.5 $\mu$ s	6.0 $\mu$ s	24 $\mu$ s
8 MHz	0.75 $\mu$ s	3.0 $\mu$ s	12 $\mu$ s
16 MHz	0.375 $\mu$ s	1.5 $\mu$ s	6.0 $\mu$ s

### Base peaking time versus clock rate and decimation

The shortest peaking time range on the  $\mu$ DXP card is for N = 0 and 16 MHz, and has the values 0.375, 0.563, 0.750, 1.125, and 1.500  $\mu$ s. The longest range is for N = 4 and 4 MHz, and has the values 24, 36, 48, 72, and 96  $\mu$ s. Non-standard Decimation N values are not difficult for XIA to create on an NRE basis for special applications. Two peaking time options are available:

Standard Peaking Time Option: The  $\mu$ DXP card comes with a single preloaded Decimation N FiPPI, where N may be 0, 2, or 4, giving base peaking times shown in the table below.

Enhanced Peaking Time Option: The DXP card comes with three preloaded Decimation N FiPPI’s, where N is typically 0, 2, and 4. A desired FiPPI may be selected by the host at any time during operation.

### MCA

MCA functions are implemented in the on-card DSP.

Spectrum size: Up to 8K channels, 24 bits deep.

Regions of interest: Using optional firmware, up to 16 ROIs may be defined and their summed counts read out.

Counting time: counting can be for either fixed counting time or fixed live time. The MCA can report total input counts detected, output counts to the spectrum, and spectrometer on-line time so that accurate dead time corrections can be made.

### SPECIALIZED FUNCTIONS ON NRE BASIS

A major  $\mu$ DXP capability is its onboard DSP’s ability to make spectral calculations in real time and control external equipment based on the results. These functions may be simple (sound an alarm if the ratio of two peaks falls outside of an allowed range); complex (estimate the weight % gold in a sample); high speed (separate copper from ferrous scraps with 25 ms sampling times or output a deadtime-corrected TTL pulse stream representing ROI counts in real time), or power saving (various sleep modes after specific times). XIA will be pleased to quote NRE costs for developing such special purpose  $\mu$ DXP code.

### BOARD SIZE

The  $\mu$ DXP measures 2.125 x 3.375 inches (credit card size). Larger sizes or other geometries available on an NRE basis.

## X-ray Instrumentation Associates

8450 Central Ave., Newark, CA 94560 USA

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510.494.9020 (tel)

510.494.9040 (fax)

www.xia.com

Email inquiries: microDXP@xia.com