User Manual

PhotoniQ Series

IQSP584
128 Channel Data Acquisition System

Vertilon Corporation, 66 Tadmuck Road, Westford, MA 01886 / Tel: (978) 692-7070 / Fax: (978) 692-7010 / www.vertilon.com

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General Safety Precautions

Warning – High Voltages

The PhotoniQ Model IQSP584 interfaces to sensor interface boards (SIBs) through high voltage cable assemblies. The PhotoniQ, SIB, and SIB power cable are energized with potentially harmful high voltages (up to 2000 Volts) during operation.

Use Proper Power Source

The PhotoniQ Model IQSP584 is supplied with a +5V desktop power source. Use with any power source other than the one supplied may result in damage to the product.

Operate Inputs within Specified Range

To avoid electric shock, fire hazard, or damage to the product, do not apply a voltage to any input outside of its specified range.

Electrostatic Discharge Sensitive

Electrostatic discharges may result in damage to the PhotoniQ and SIB board set. Follow typical ESD precautions.

Do Not Operate in Wet or Damp Conditions

To avoid electric shock or damage to the product, do not operate in wet or damp conditions.

Do Not Operate in Explosive Atmosphere

To avoid injury or fire hazard, do not operate in an explosive atmosphere.

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Product Overview

The PhotoniQ Model IQSP584 is designed to offer scientists, engineers, and developers an off-the-shelf solution for their multi-channel electro-optic sensor needs. Implemented as a stand-alone laboratory instrument with a PC interface, the PhotoniQ is used for charge integration and data acquisition (DAQ) from photomultiplier tubes, photodiodes, silicon photomultipliers, and other multi-element charge-based sensors. It is a precision, high speed, multi-channel parallel system capable of providing real-time DSP-based signal processing on input events. Flexible intelligent triggering allows the unit to reliably capture event data using one of several sophisticated triggering techniques. Two data acquisition modes enable data collection of random events such as those found in particle analysis applications, or continuous events from scanned imaging applications. Optional accessories such as dual on-board high voltage supplies are available for applications requiring high voltage biasing. Through the PC, the PhotoniQ is fully configurable via its USB 2.0 port using an included graphical user interface. Continuous high speed data transfers to the PC are also handled through this interface. Additionally, a LabVIEW™ generated DLL is provided for users who wish to write their own applications that interface directly to the unit.

Features

- 128 gated integrator / data acquisition channels
- 14-bit dynamic range
- Event pair resolution of 6.5 usec for 128 channels, 3.9 usec for 64 channels, and 2.5 usec for 32 channels
- Maximum trigger rate of 140KHz for 128 channels, 250 KHz for 64 channels, and 385 KHz for 32 channels
- Graphical User Interface (GUI) for menu driven data acquisition and configuration
- GUI supports real time display of acquired data in linear and two dimensional graphs
- Two data acquisition modes optimized for particle analysis and scanned imaging applications
- Intelligent triggering firmware module supports standard edge, internal, level, and boxcar modes
- Advanced triggering capability supports pre-triggering, input threshold, and cross bank
- Flexible control of integration parameters such as delay, period, or external boxcar
- Highly parallel, high speed hardware processor unit performs real-time data discrimination, channel gain normalization and background subtraction
- Programmable data filtering function for real time detection of predefined energy patterns or spectrums
- General purpose digital output linked to filter function
- Event trigger stamping and time stamping with 100 nsec resolution
- USB 2.0 interface supports high data transfer rates
- LabVIEW™ generated DLLs for interface to user custom applications
- Available with up to two negative 1000V, negative 1500V, or negative 100V high voltage bias supplies

Applications

Applications	Compatible Sensors[1]
▪ Bioaerosol Detection and Discrimination ▪ PET and SPECT ▪ Fluorescence Spectroscopy ▪ Spatial Radiation Detection ▪ Confocal Microscopy ▪ Piezoelectric Sensor Array Readout ▪ Flow Cytometry ▪ Particle Physics ▪ DNA Sequencing ▪ Arrays of Individual Sensors ▪ Gamma Cameras ▪ Silicon Photomultipliers (SPM) ▪ Multi-Pixel Photon Counters(MPPC)	▪ Hamamatsu 32 Element Multianode PMT P/N H7260 ▪ Hamamatsu 16 Element Multianode PMT P/N H8711 ▪ Hamamatsu 16 Element Multianode PMT P/N R5900U-L16 ▪ Hamamatsu 64 Element Multianode PMT P/N H8500D ▪ Hamamatsu 64 Element Multianode PMT P/N H7546B ▪ Photonis 64 Element Multianode MCP-PMT P/N XP85013 ▪ SensL 16 Element Silicon Photomultiplier Array P/N ArraySL-4 ▪ Hamamatsu 16 Element Multi-Pixel Photon Counter P/N S11064 ▪ Pacific Silicon Sensor 16 Channel APD Array P/N AD-LA-16-9-DIL18

[1] Sensor Interface Boards available for specific sensors. Other sensor arrays can be accommodated. Contact Vertilon for additional information.

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Hardware

The two photos below show the front and rear views of the PhotoniQ IQSP584



Figure 1: Model IQSP584 Front View



Figure 2: Model IQSP584 Rear View
(Shown with optional DIO100 digital I/O port)

Software

The screen shot below shows the main window of the Graphical User Interface (GUI) software included with the PhotoniQ. All control, status, and acquisition functions are executed through this interface.

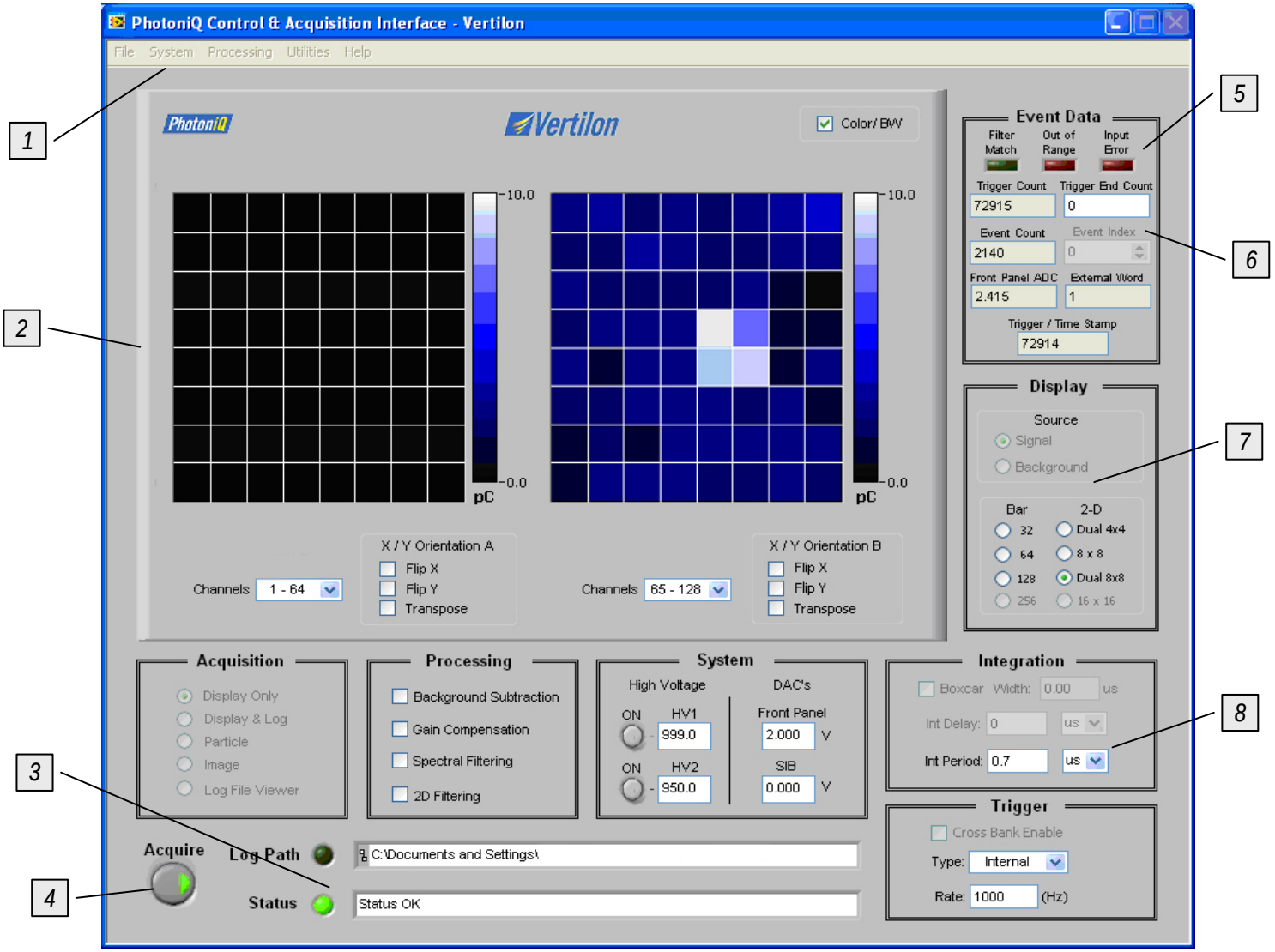


Figure 3: PhotoniQ Control and Acquisition Software Front Panel

1. Pull Down Menus
2. Main Display Area
3. Status Bars
4. Acquire Button
5. Status Indicators
6. Counters & Event Data
7. Display Type
8. Control Section

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Included Components and Software

The PhotoniQ comes enclosed in a rugged, EMI-shielded, laboratory instrument case and is shipped with the following standard components and software:

- PhotoniQ Control and Acquisition Interface Software CD-ROM
- DC power supply (+5V, 2A) with power cord
- USB 2.0 cable

Ordering Information

The PhotoniQ IQSP584 can be ordered with the following options pre-installed.

Option Number	Option Description	Notes
HVPS001	Negative 1000V on-board high voltage bias supply, includes 90 cm high voltage cable (HVC090)	Up to two may be added in any combination
HVPS002	Negative 1500V on-board high voltage bias supply, includes 90 cm high voltage cable (HVC090)	
HVPS701	Negative 100V on-board high voltage bias supply, includes 90 cm high voltage cable (HVC090)	
MEM064	Memory upgrade, 250,000 event image buffer when configured for 128 channels	500,000 events when configured for 64 channels 1,000,000 events when configured for 32 channels
MEM032	Memory upgrade, 125,000 event image buffer when configured for 128 channels	250,000 events when configured for 64 channels 500,000 events when configured for 32 channels
DIO100	External digital data interface	Allows external digital data to be acquired in parallel with the signal data

Table 1: Ordering Information (Configuration Options)

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Hardware Accessories

The following items are hardware accessories for the PhotoniQ IQSP584 that can be separately ordered. Typical accessories include sensor interface boards and sensor interface board cables.

- Sensor interface board for Hamamatsu S11064 16 element silicon photomultiplier (SIB416)
- Sensor interface board for Hamamatsu R5900U-L16 PMT (SIB016)
- Sensor interface board for Hamamatsu H8711 PMT (SIB116)
- Sensor interface board for Hamamatsu H7260 series PMT (SIB232)
- Sensor interface board for Hamamatsu H7260 series PMT, long integration times (SIB232D)
- Sensor interface board for Hamamatsu H8500D series PMT (SIB064A)
- Sensor interface board for Hamamatsu H7546B series PMT (SIB164A)
- Sensor interface board for Photonis XP85013 series MCP-PMT (SIB264)
- Sensor interface board for SensL ArraySL-4 16 element silicon photomultiplier (SIB1256)
- Sensor interface board for PSS[1] AD-LA-16-9-DIL avalanche photodiode array (SIB216)
- 32 channel SMB distribution system (SDS232)
- Sensor interface board cable, 30 cm, 60 cm, and 90 cm (SBC030, SBC060, SBC090)
- Custom sensor interface board[2]

[1] Pacific Silicon Sensor, Inc.
[2] Contact Vertilon for custom SIB design for sensors not listed.

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Specifications

(Typical specifications at room temperature)

System Specifications

Item	Value	Test Conditions
Resolution	14 bits	
Dynamic Range	84 dB	
Equivalent Input Noise Charge	100 fC RMS typ.	Edge triggered mode. Other modes slightly higher or lower.
Maximum Input Signal	877 pC	
Channel-to-Channel Crosstalk	-84 dB typical, -80 dB max.	For integration periods greater than 300 nsec.
Input Bias Current	±40 pA typical, ±150 pA max.	
Input Offset Voltage	±1.5 mV max.	Offset relative to input bias voltage which is 0.250V.
Power Consumption	10.0 Watts typ., 12.0 Watts max.	Assumes no optional high voltage bias supplies. Add 0.7W for each bias supply at max voltage and max load.
High Voltage Bias Supply Range (HVPS001)	-50 V to -925 V	At a load of 370 uA. Voltage range divided by three at SIB (-17V to -308V) when using SIB216.
High Voltage Bias Supply Range (HVPS002)	-100 V to -1390 V	At a load of 250 uA.
High Voltage Bias Supply Range (HVPS701)	-5.0 V to -92.5 V	At a load of 1 mA.

Table 2: System Specifications

General Timing Specifications

Item	Configured Channels				Test Conditions
	128	96	64	32	
Maximum Trigger Rate (MTR)	140 KHz	180 KHz	250 KHz	385 KHz	MEM064 event buffer option installed and image mode enabled. Integration period of 100 nsec.
Minimum Event Pair Resolution (MEPR) Edge Trigger, Integration Time = 100 nsec	6.5 usec	5.1 usec	3.9 usec	2.5 usec	Assumes 95% acquisition success with five consecutive triggers spaced apart by MEPR time.
Minimum Event Pair Resolution (MEPR) Pre Trigger, Integration Time = 1 x T_S	7.5 usec	5.8 usec	4.1 usec	2.8 usec	
Minimum Event Pair Resolution (MEPR) Pre Trigger, Integration Time = 2 x T_S	9.2 usec	8.3 usec	5.8 usec	3.5 usec	
Sustained Average Event Rate (SAER)	22,000	30,000	45,000	75,000	Events per second. Specification assumes PC and USB port capable of handling continuous data transfers at ~16MB/sec and all log file reporting functions disabled.
MEM064 Event Buffer Size (EBS)	250K	333K	500K	1M	Measured in events consisting of all configured channels. The standard unit does not include an event buffer.
MEM032 Event Buffer Size (EBS)	125K	167K	250K	500K	

Table 3: General Timing Specifications

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Trigger and Integration Specifications[1]

Description	Sym	Trigger/Mode	Minimum	Maximum
Trigger to Integration Delay[2]	t_{td}	Edge	0 nsec	1 msec
Trigger to Integration Jitter	t_{td}	Edge		± 5 nsec
Pre-Trigger Delay[3]	t_{ptd}	Pre-trigger	$-10T_S$	$+1000T_S$
Pre-Trigger Uncertainty	t_{ptu}	Pre-trigger		T_S
Integration Start Delay	t_{bcd1}	Boxcar	15 nsec	25 nsec
Integration Start Jitter		Boxcar		± 5 nsec
Integration End Delay	t_{bcd2}	Boxcar	15 nsec	25 nsec
Boxcar Width Resolution	t_{bcw}	Boxcar		10 nsec
Integration Period	t_{int}	Edge	50 nsec	1000 msec
		Internal	50 nsec	1000 msec
		Level	50 nsec	1000 msec
		Boxcar	50 nsec	1000 msec
		Input	T_S	$1000T_S$
		Pre-trigger	T_S	$1000T_S$
Integration Period Error	t_{int}	All		±500 psec
Internal Trigger Rate	f_{trig}	Internal	10 Hz	200 KHz
		Level	10 Hz	200 KHz
Trigger Threshold Range		Input	59.5 fC	487 pC
Sample Period	T_S		1.67 usec. for 128 channels 1.27 usec. for 96 channels 0.87 usec. for 64 channels 0.47 usec. for 32 channels	1.67 usec. for 128 channels 1.27 usec. for 96 channels 0.87 usec. for 64 channels 0.47 usec. for 32 channels

Table 4: Trigger and Integration Specifications

[1] Typical specifications at room temperature.
[2] A fixed delay of approximately 15 nsec is in addition to the delay setting.
[3] Relative to system sample period, T_S. A negative value for the delay corresponds to a pre-trigger condition.

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Miscellaneous Specifications

Description	Sym	Minimum	Maximum
General Purpose ADC Input Range	ADC	0 V	+3.0 V
General Purpose DAC Output Range	DAC	0 V	+3.0 V
General Purpose SIB DAC Input Range	SIB DAC	0 V	+3.0 V
Trigger Input Voltage Range	TRIG IN	0 V	+3.3V, +5.0 V max.
Trigger Input Logic Low Threshold	TRIG IN		+0.8 V
Trigger Input Logic High Threshold	TRIG IN	+4.2 V	
Trigger Input, Input Impedance	TRIG IN	1 Mohm	
Trigger Input, Rise Time	TRIG IN		20 nsec
Trigger Input, Positive Pulse Width	TRIG IN	100 nsec	
Trigger Input, Negative Pulse Width	TRIG IN	100 nsec	
Trigger Output Voltage Range	TRIG OUT	0 V	+3.3V
General Purpose Output Voltage Range	AUX OUT	0 V	+3.3V
General Purpose Output Delay	AUX OUT	100 nsec	2 msec
General Purpose Output Period	AUX OUT	100 nsec	2 msec
Trigger Stamp Counter Range		0	2^{32}-1
Time Stamp Counter Range		0	2^{32}-1
Time Stamp Resolution (Decade Steps)		100 nsec	1 msec
Time Stamp Maximum (Decade Steps)		429.4967 sec	49.71026 days
Event Counter Range		0	10^8
Trigger to External Word DR High	t_{dr}		1 usec
External Word SCK to SDO Valid	t_{dv}		10 nsec
External Word SCK period	t_{sck}	50 nsec	100 nsec

Table 5: Miscellaneous Specifications

Mechanical Specifications

Description	Specification
Width	9.843 in. (250 mm)
Height	3.346 in. (85 mm)
Depth	10.236 in. (260 mm)

Table 6: Mechanical Specifications

PC System Requirements

- Microsoft Windows XP operating system
- Intel USB 2.0 high-speed host controller with 82801Dx chipset (low speed is not supported)
- Run-time engine for LabVIEW™ version 9.0 for use with DLL

Typical PET Setup

A typical setup for a PET scanner application using a Vertilon PhotoniQ IQSP584, two Vertilon SIB064's, and two Hamamatsu H8500D 8 x 8 multianode photomultiplier tubes is shown below. The 64 element MAPMTs are each connected to a SIB064 and positioned to detect incoming light from a scintillator crystal or optical assembly. The four sensor interface board cables (SIB cables) connect the 64 detector outputs from each SIB064 to the PhotoniQ 128 channel data acquisition system. High voltage bias to the MAPMTs is controlled by connecting the high voltage output on the PhotoniQ front panel to the detector bias input on the SIB064. This arrangement allows the user to have a convenient means to control the photomultiplier tube gain through the PhotoniQ GUI. In the example below, the two high voltage bias outputs from the PhotoniQ are used so that the user has independent control over each MAPMT. The *Pulse Detect* outputs from the SIB064s fire when an event exceeding a user-programmed energy threshold is detected. The external coincidence detector measures the time between events and generates a trigger signal to the PhotoniQ if the events occur within a predefined time interval. Digitized output data from the PhotoniQ is then sent to a PC over a USB 2.0 connection for display, logging, or real time processing.

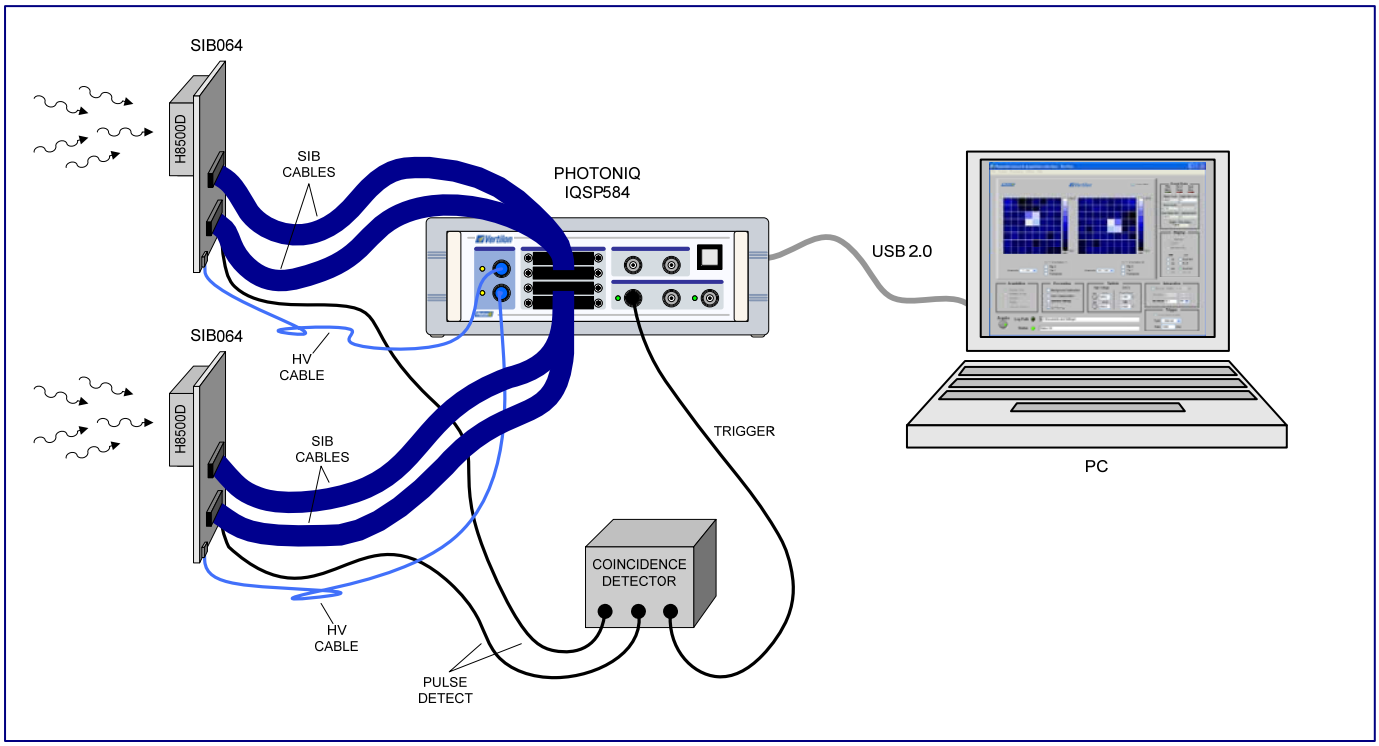


Figure 4: Typical Setup for PET Scanner

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In a PET application, the PhotoniQ is configured in pre-trigger mode whereby the unit can capture the charge data from the detectors that occurred prior to the trigger signal. This powerful triggering mode allows the data acquisition unit to be timed to the pulse peaks or to high energy thresholds yet still collect all of the charge from the particle event — including the charge that preceded the trigger. Timing for this mode is shown below.

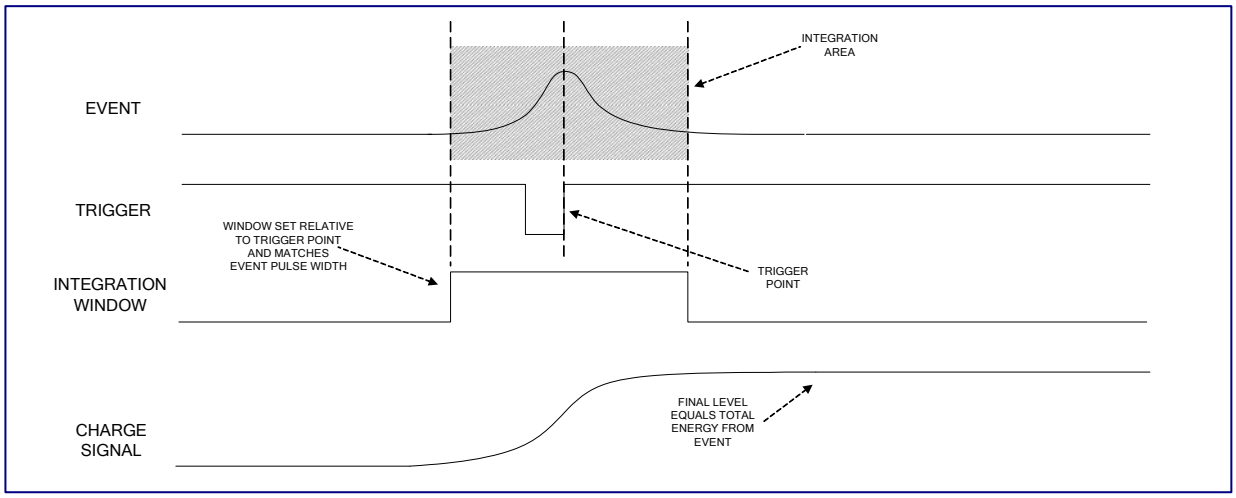


Figure 5: PhotoniQ Pre-Trigger Timing

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Theory of Operation

The IQSP584 data acquisition system is made up of four independent banks of 32 charge collection and data acquisition circuits for a total of 128 simultaneous integrating and sampling channels. Each bank is independently configured and triggered and generates eight parallel streams of digital data as shown in the figure below. The intelligent trigger/ acquisition module configures the triggering and acquisition parameters for each bank such that any one of multiple triggering modes can be used to initiate the data acquisition process. A total of thirty-two parallel digital data channels are output to the Pipelined Parallel Processor (P3) where it performs data channel offset and uniformity correction. Time multiplexing the signals from the sampling channels allows the P3 to process the data in four time slices (Channel Blocks 1 through 4) so that all 128 channels are operated on. The resulting data from the P3 is sent to the DSP where it is packetized and sent to the USB output port. Additional reserved DSP processing power can be used to implement user defined filter, trigger, and data discrimination functions.

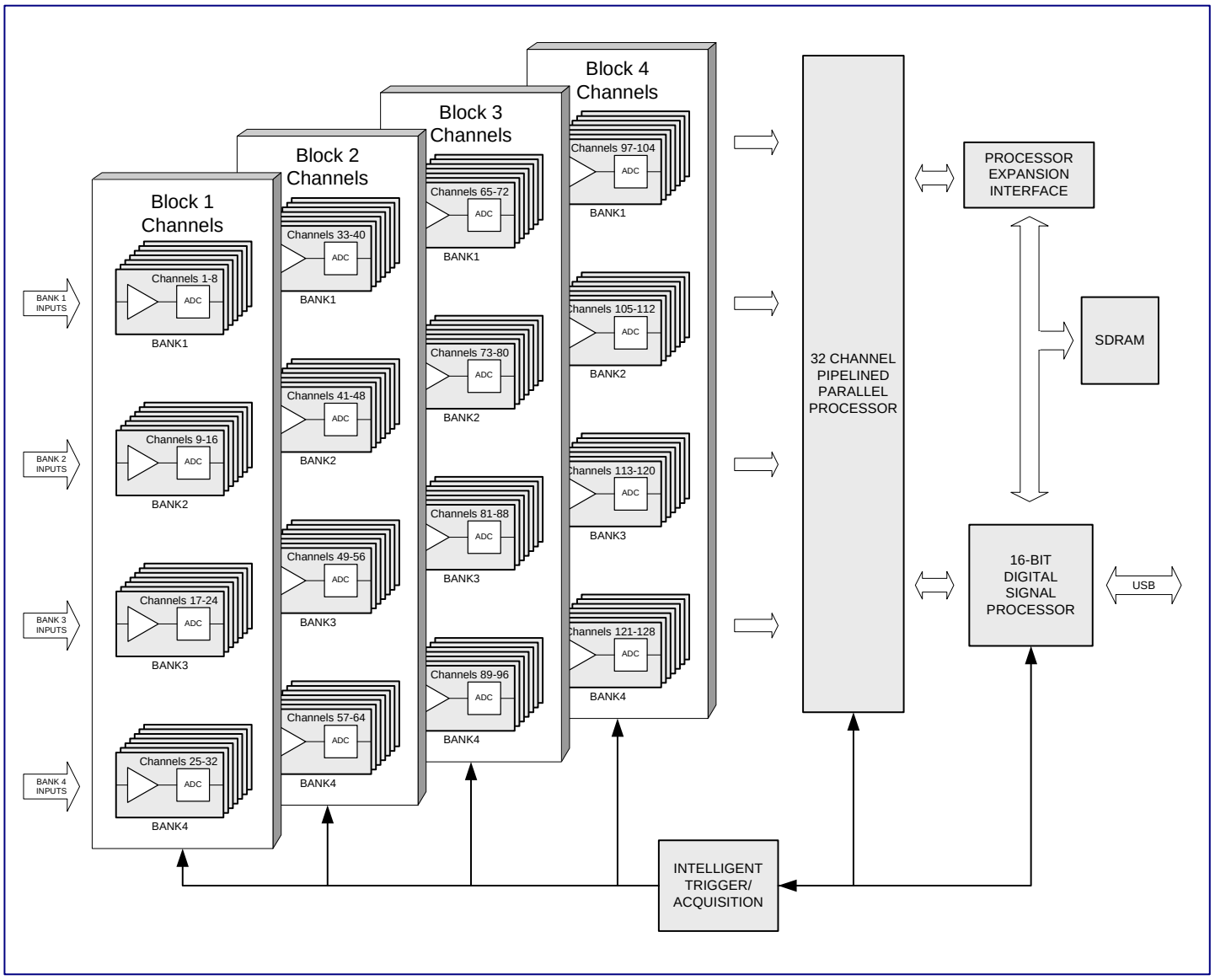


Figure 6: PhotoniQ IQSP584 Functional Block Diagram

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Charge Collection & Data Acquisition Channels

Data acquisition is initiated by a trigger signal detected by the PhotoniQ's intelligent trigger module. Each trigger starts the collection and digitization of charge signals from the PMT, silicon photomultiplier, or photodiode sensors across all channels. This functionality, which is shown in the previous figure as an amplifier followed by an ADC, is implemented primarily as precision analog circuit elements that integrate, amplify, and digitize charge. The parallel architecture of this circuitry allows charge integration and digitization to take place simultaneously across all channels thus achieving very high data acquisition speeds. Additionally, the proprietary design of the front end preamp permits very narrow charge pulses to be reliably captured with single photon sensitivity at very high repetition rates.

Configurable Preamp Cell

The front end preamp is designed for use in demanding low noise, high speed, and high background applications. Consisting of a gated boxcar integrator, an independent reset function, and other proprietary functionality not shown in the figure, the front end is dynamically controlled and reconfigured to support any one of several advanced triggering and data acquisition modes. When coupled to a typical single or multi-anode PMT, this circuit achieves single photon sensitivity at microsecond-level pulse-pair resolution.

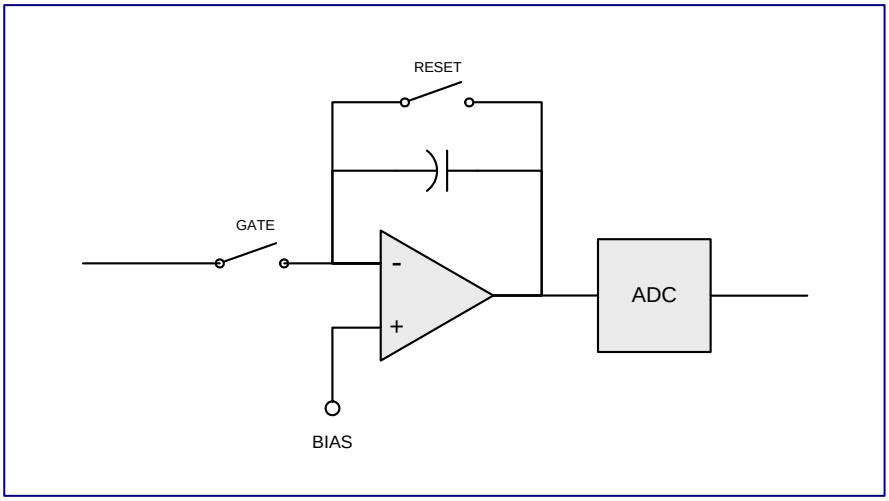


Figure 7: Front End Preamp Cell

In gated applications where the integration period is precisely timed relative to a trigger signal, the *gate* switch is used to selectively connect the PMT, SiPM, or photodiode to the integrator during the desired time interval. Special cancellation circuitry and processing algorithms ensure that the charge injection from the switch remains below the noise level and does not contribute appreciably to the measurement of the signal. This gating technique is used for the *edge*, *internal*, and *level* trigger modes. A different gating scheme is used for the *input* and *pre-triggering* modes where the *gate* switch remains closed for all time, and the integration period is set using digital techniques. Under these conditions the system is at risk of saturation because of constant optical background signals and electrical bias currents applied to the integrator. A proprietary algorithm in conjunction with specialized circuitry ensures that the integrator remains well within its linear region thus maintaining virtually all of its dynamic range.

Pipelined Parallel Processor

The P3 Pipelined Parallel Processor shown on the next page is a dedicated high speed hardware processing unit that executes 32 parallel channels of computations on the 32 data streams from the front-end digitizing blocks. Each channel processor performs real-time data discrimination, buffering, and channel uniformity correction. Time division multiplexing of the inputs to the P3 allows it to operate on all 128 channels of data in four time slices. The outputs from the 32 channel processors are sent to the frame post processor where additional frame-formatted data manipulation is performed. The frame post processor output is sent to the Parallel Peripheral Interface (PPI) where it is formatted and transferred to the DSP for further processing.

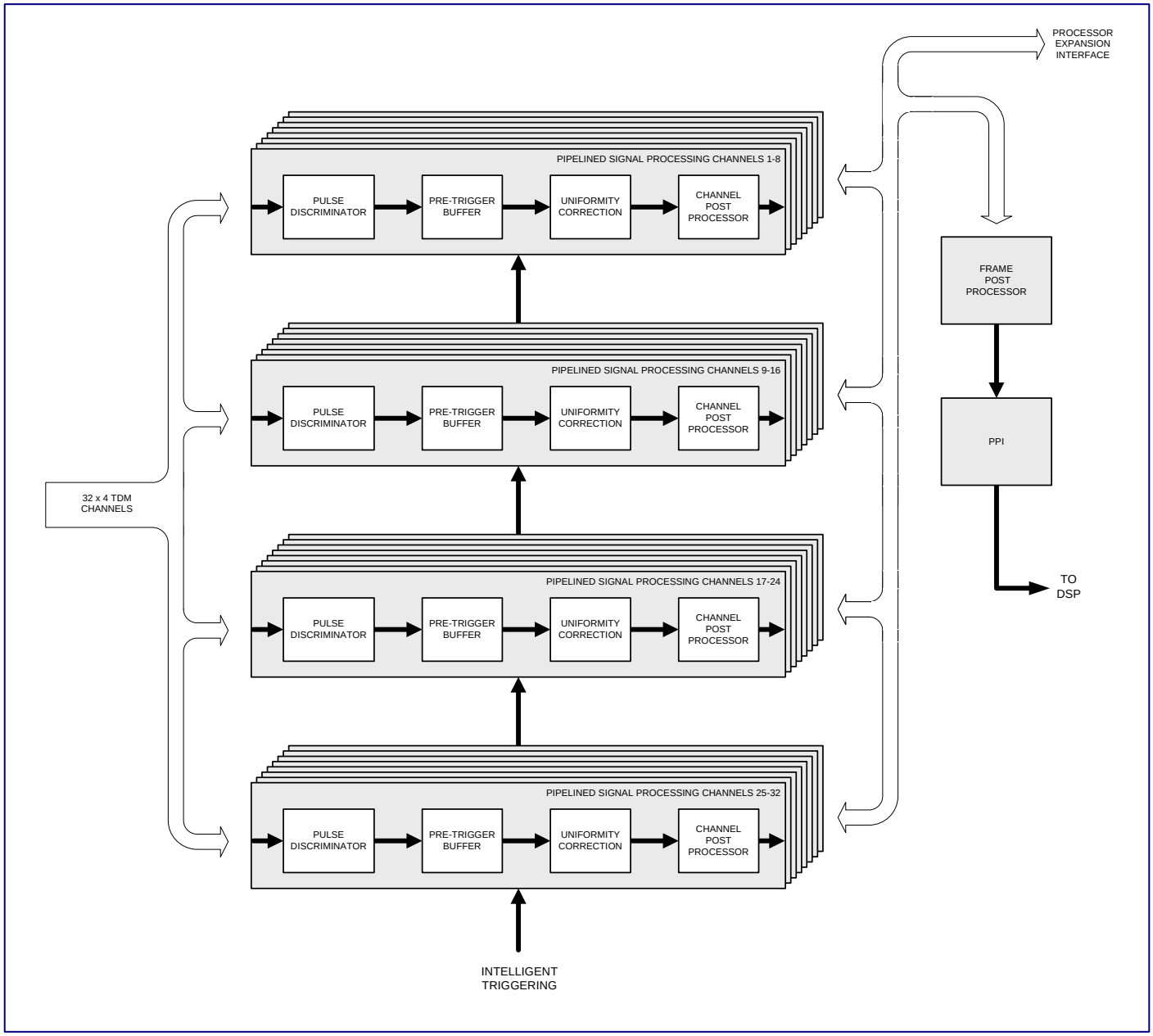


Figure 8: 32-Channel Pipelined Parallel Processor

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Digital Signal Processor

The 16 bit fixed point digital signal processor performs the high level data manipulation and system control in the PhotoniQ. Channel data received from the P3 on the PPI is routed through the DSP and buffered using the on-board SDRAM. This architecture allows the PhotoniQ to capture very large frames of data, such as the kind typically found in imaging applications, without the loss of any data. Once the data is stored, it is packetized by the USB packet generator and sent out to the PC through the USB 2.0 port. Extra computational power is reserved in the DSP so that user-defined algorithms can be executed on the data prior to transmission. This has the benefit that routines that were previously performed off-line by the PC can instead be handled in real-time. The net effect is that the downstream data load to the PC is reduced so that throughput can be increased by orders of magnitude. In addition to user-defined filtering and triggering functions, the DSP can be used to process commands from the PC and drive external actuators and devices.

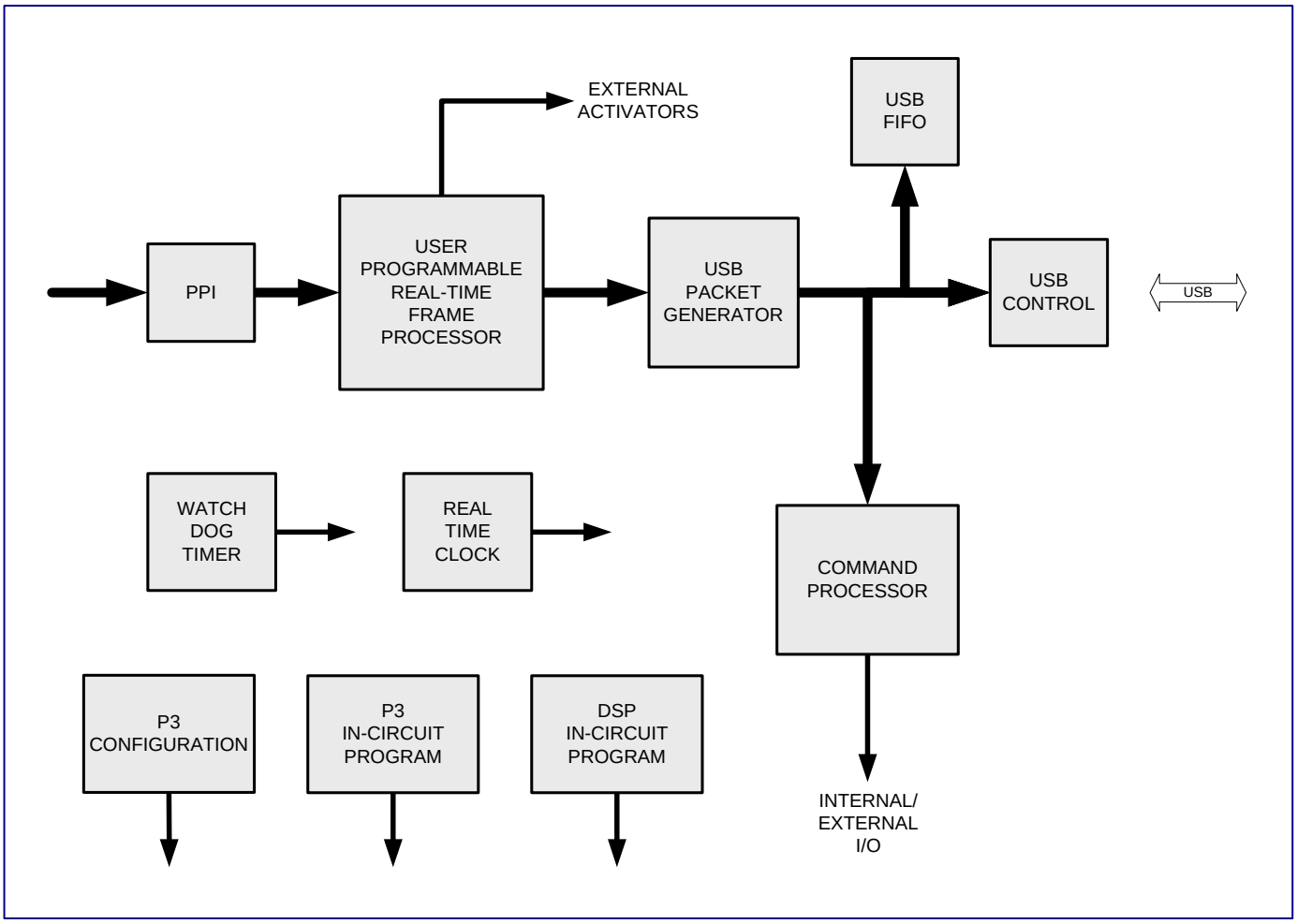


Figure 9: DSP Functional Block Diagram

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Control and Acquisition Interface Software

The PhotoniQ is programmed and monitored by the Control and Acquisition Interface Software. This software, which is resident on the PC, provides a convenient GUI to configure and monitor the operation of the unit. Configuration data used to control various functions and variables within the PhotoniQ such as trigger and acquisition modes, integration time, processing functions, etc. is input through this interface. For custom user applications, the GUI is bypassed and control and acquisition is handled by the user's software that calls the DLLs supplied with the PhotoniQ. As configuration data is modified, the PhotoniQ's local, volatile RAM memory is updated with new configuration data. The hardware operates based upon the configuration data stored in its local RAM memory. If power is removed from the PhotoniQ, the configuration data must be reprogrammed through the GUI. However, a configuration can be saved within the non-volatile flash memory of the PhotoniQ. At power-up, the hardware loads configuration data from its flash memory into its volatile RAM memory. Alternatively, the RAM memory can be configured from a file on the user's PC.

Intelligent Triggering and Integration

One of the most powerful features of the PhotoniQ is the wide variety of ways the data acquisition process can be triggered. The unit consists of an intelligent trigger module with the capability to trigger the input channels in conventional external or internal post trigger modes. Additionally, advanced on-board signal processing techniques permit more sophisticated triggering modes such as pre-trigger, which captures events that occur prior to the trigger signal, and input trigger, which captures events based on a threshold criteria for the event. The PhotoniQ also has a cross bank triggering mode that permits certain trigger parameters for each bank to be independently configured and operated. The descriptions below illustrate some of the advanced trigger and integration capabilities of the PhotoniQ.

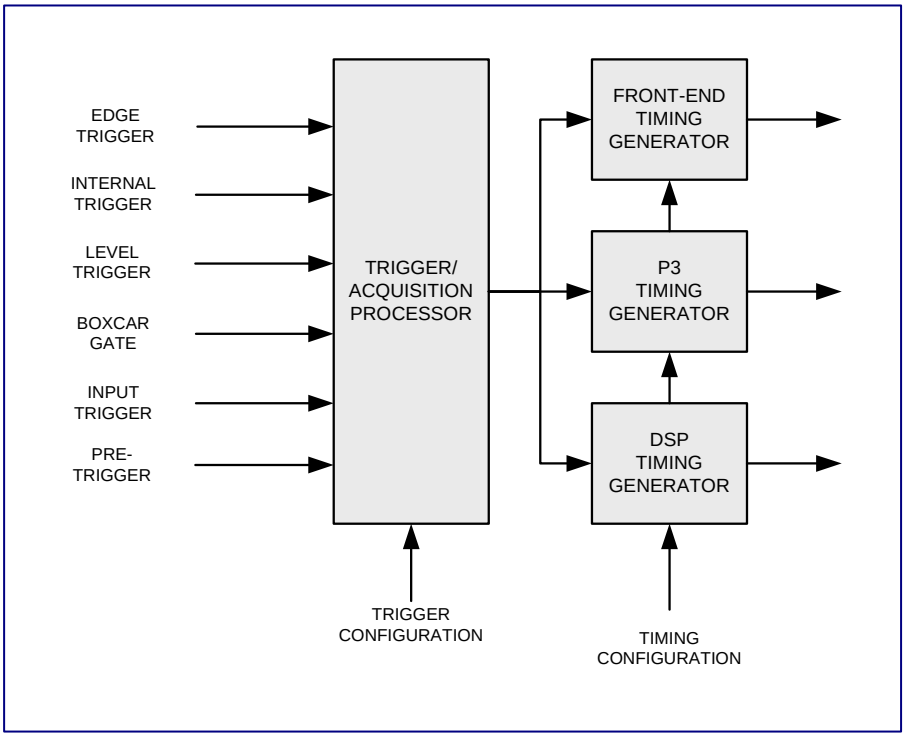
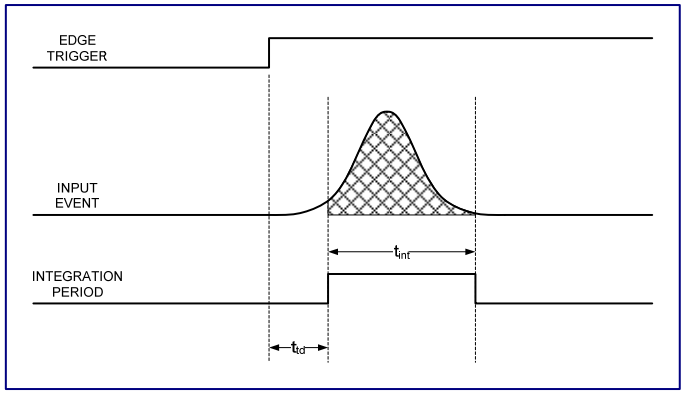


Figure 10: Intelligent Trigger Module

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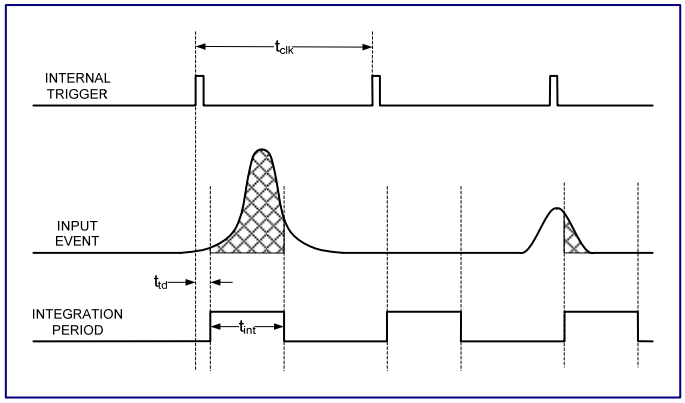
Edge Trigger

Edge trigger is a simple trigger mode whereby an externally-supplied positive signal edge to the intelligent trigger module starts the event acquisition process. As shown in the figure at right, the rising edge of the trigger initiates the start of the integration. The integration parameters of integration delay (t_{td}) and integration period (t_{int}) are programmable over a large range of values with very fine resolution.



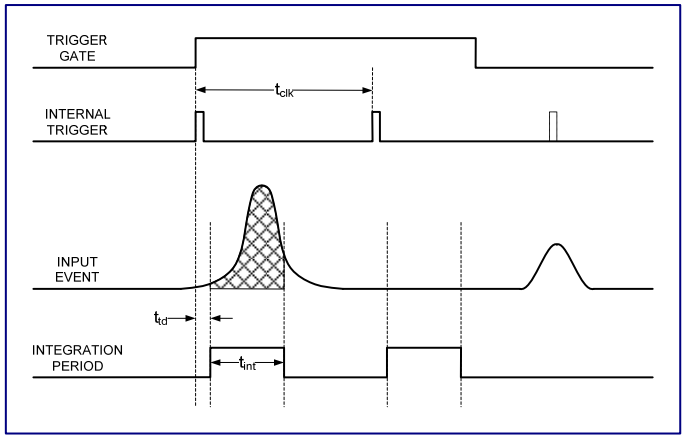
Internal Trigger

Continuous data acquisition is possible by operation of the unit in internal triggering mode. Here a programmable internal free running clock (t_{clk}) replaces the external trigger signal. Data is continuously acquired on each edge of the clock signal. This mode is particularly useful when large blocks of event data are needed for collection and analysis, but no trigger signal is available.



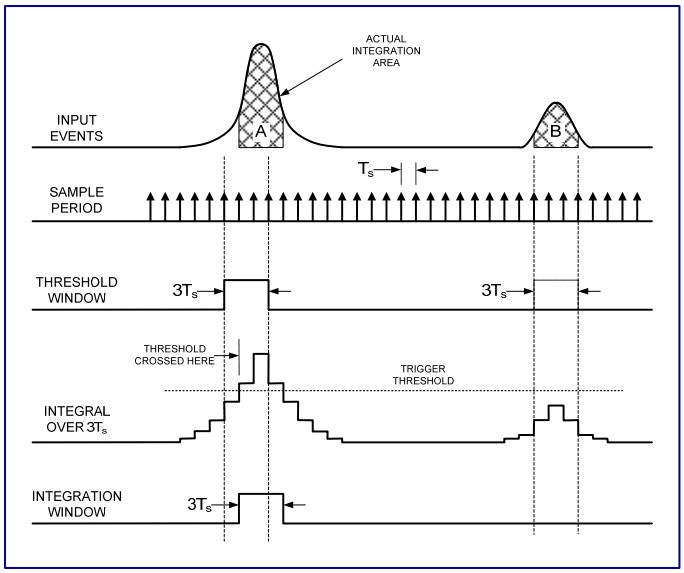
Level Trigger

This trigger mode is similar to internal triggering except that an externally provided positive level-sensitive trigger gate controls the acquisition of events. The actual trigger signal is internally generated but synchronized and gated by the external trigger gate. A logic high enables the acquisition of events by allowing the internal trigger to generate the pre-programmed integration period. A logic low on the trigger gate blocks the internal trigger from generating the integration period so that no further events are acquired.



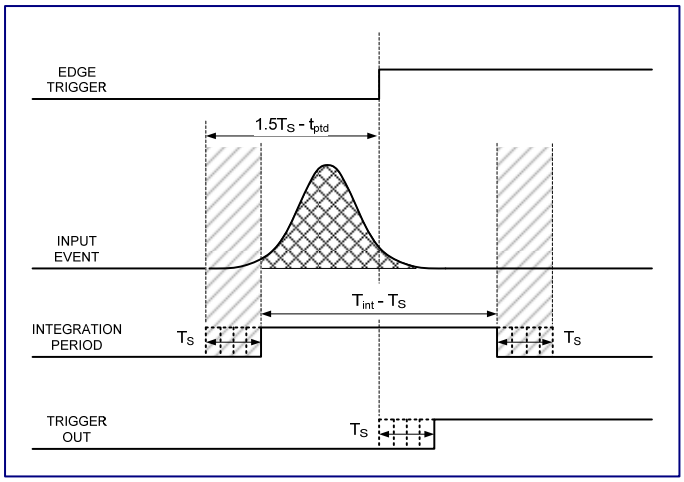
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Input Trigger



Input trigger is used to trigger the acquisition process when incoming data on a specific channel exceeds a user defined threshold. No external trigger signal is required. The integration period determines the time over which the input signal is integrated and is typically set to closely match the expected pulse width. The figure shows a timing diagram for input triggering. When using this mode, the integration period must always be a multiple of the sample period, T_S. The charge integrated during the integration time is compared to the trigger threshold level. In the example, tint equals $3T_S$ and event 'A' exceeds the threshold and event 'B' does not. The crossing of the threshold triggers the PhotoniQ to acquire data across all channels. To better position the integration window around the detected pulse, the actual window can be shifted by an integer number of T_S intervals (positive delay only) relative to when the threshold was crossed. In the example below, the integration window shift is one T_S interval.

Pre-Trigger



In pre-trigger mode, an external positive edge sensitive trigger signal is used to acquire event data that occurred prior to the trigger's arrival. As shown below, the programmable pre-trigger delay (t_{ptd}) is used to set the start of the programmable integration period (T_{int}) at a time prior to the trigger edge. The pre-trigger uncertainty time (t_{ptu}), shown as the dashed area in the figure, is equal to sampling period of the system, T_S. While the start of the integration period is uncertain by time T_S, the actual duration of the integration period itself is quite accurate. Both the pre-trigger delay and the integration period are constrained to be multiples of the system's sampling period. The trigger output signal is a reference signal that can be used to setup the system. Regardless of the pre-trigger delay time, the leading edge of the trigger out always occurs between 0 and T_S from the leading edge of the trigger input signal. The period of the trigger out is precisely equal to the integration time. When the pre-trigger delay is set to one (positive) T_S, the start of the integration period precedes the rising edge of the trigger output by one half of sample period, T_S. For other pre-trigger delay times (either positive or negative), the actual integration window is shifted accordingly.

Although pre-triggering mode is mostly used in applications where the integration window precedes the trigger edge (i.e. when the pre-trigger delay is negative), positive pre-trigger delays are also permissible. This positive delay mode has slightly lower noise than the edge trigger mode and can be used when precise control over the start (and end) of the integration period is not necessary.

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Cross Bank Triggering

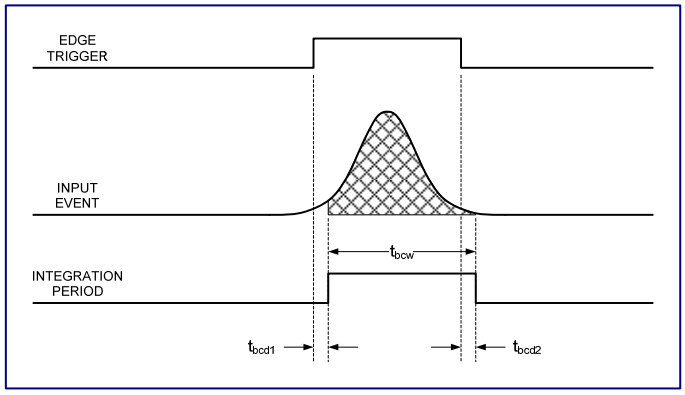
The flexibility of the PhotoniQ allows one or more channel banks to be triggered with one set of parameters which in turn trigger other banks using a different set of parameters. In a typical example, a bank is set up as an input trigger type with a particular integration period. The other banks are set up with different delays and integration periods. When an input event crosses the specified threshold on the first bank, the other banks can then be triggered. Data acquisition on these banks occurs with their respective specified delays and integration periods. The figure at right illustrates this example. Bank 1 is the main trigger bank and is setup as an input trigger type with an integration period of T_{int1} and integration delay of zero. Trigger timing for Bank 2 and Bank 3 is setup independently from Bank1. The integration delay for these banks is T_{d2} and T_{d3}, respectively, and the integration period is T_{int2} and T_{int3}, respectively. For simplicity, Bank 4 is not shown. The main trigger point occurs when the signal on Bank 1 crosses the defined input threshold. From that point, Bank 2 and Bank 3 trigger after their defined integration delay time has elapsed. Each independently integrates over its defined integration period.

Integration Delay and Period

The integration delay is the parameter that sets the start of the integration period relative to the rising edge of the trigger. Only for pre-triggering can this value be negative. The integration period is the time duration over which the input signal is accumulated in the charge sensitive preamp. Both integration parameters are adjustable.

Boxcar Mode

Boxcar mode utilizes the input trigger signal to set the two integration parameters. The preset values are ignored. As shown in the figure, the trigger signal is used to define the period over which the input is to be integrated. Aside from a small amount of fixed positive delay (times t_{bcd1} and t_{bcd2}), the boxcar formed by the trigger signal is the integration period (t_{bcw}) and any unwanted background signals that occur when the boxcar is inactive are not integrated and effectively masked out.



Boxcar Width

The PhotoniQ has the ability to determine the width of the boxcar input signal. For each triggering event, the system measures the width of the boxcar and appends it to the event data in the log file if enabled. This feature is particularly useful for particle sizing where the boxcar is generated from threshold crossings on an external scatter channel. The sizing information (boxcar width) could then be used to normalize the spectral data.

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Hardware Interface

The photos below show the front and rear panel interface connectors on the IQSP584.

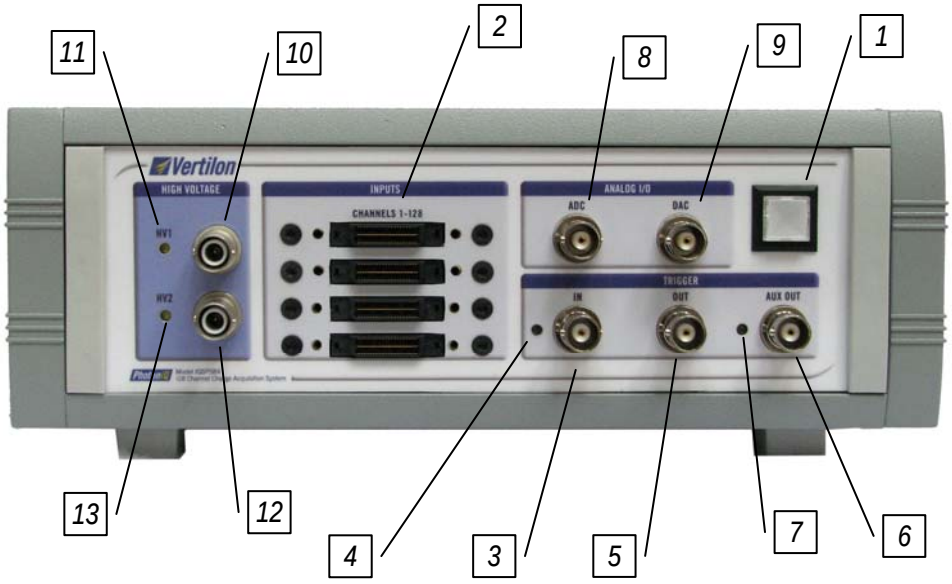


Figure 11: IQSP584 Front Panel

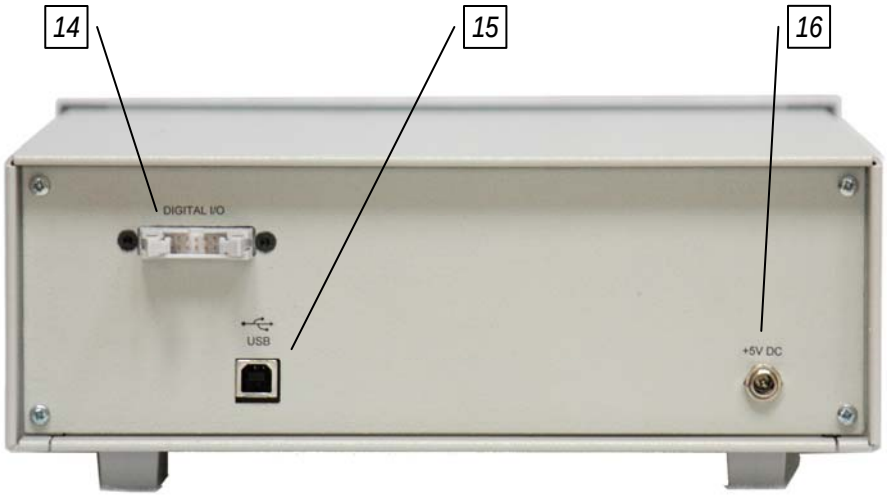


Figure 12: IQSP584 Rear Panel

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1. Main Power Switch: PhotoniQ main power switch.

2. Sensor Interface Board Connectors (SIB Connectors): Connectors to SIB cables for connection to a sensor interface board or signal distribution system. Each connector and cable carries 32 input channels over individual coaxial lines. Additional control and monitor lines are also carried.

3. Trigger Input (BNC): Main trigger input to the PhotoniQ. This input is positive edge sensitive.

4. Trigger Indicator (Green LED): Indicates when a trigger is supplied to the PhotoniQ on the Trigger Input connector.

5. Trigger Output (BNC): Main trigger output from the PhotoniQ. When in edge or internal trigger mode, the output from this connector is the integration window used by the PhotoniQ to integrate the signal. If cross bank triggering is enabled, this output is the integration window from the main trigger bank(s). There are no trigger outputs associated with the secondary bank(s). In input trigger and pre-trigger modes, the trigger output indicates the trigger point shifted by the programmable delay time.

6. Auxiliary Output (BNC): Configurable general purpose output.

7. Acquisition Indicator (Green LED): Indicates when an event is acquired by the PhotoniQ.

8. ADC Input (BNC): Input to the internal analog to digital converter.

9. DAC Output (BNC): Output from the internal digital to analog converter.

10. High Voltage Bias Supply #1 Output (SHV): Cable connector for the optional high voltage bias supply #1 (HV1).

11. High Voltage Bias Supply #1 Indicator (Yellow LED): Indicates when the optional high voltage bias supply #1 (HV1) is energized.

12. High Voltage Bias Supply #2 Output (SHV): Cable connector for the optional high voltage bias supply #2 (HV2).

13. High Voltage Bias Supply #2 Indicator (Yellow LED): Indicates when the optional high voltage bias supply #1 (HV2) is energized.

14. External Word Interface (10-Pin IDC): Optional digital I/O interface for external word.

15. USB Cable Input (USB B Type): USB cable connection to PC.

16. Main Power Input (2mm Barrel): +5V input from external power supply.

Control and Acquisition Interface Software

Running *Control & Acquisition Interface.exe* will open the main window (front panel) of the Control and Acquisition Interface Software. The front panel is generally for display and control of the data acquisition process and reporting of the system's operational status. Various pull-down menus are used for setting the configuration of the PhotoniQ and for performing diagnostic routines. The figures on the following pages show different display modes for the acquired data.

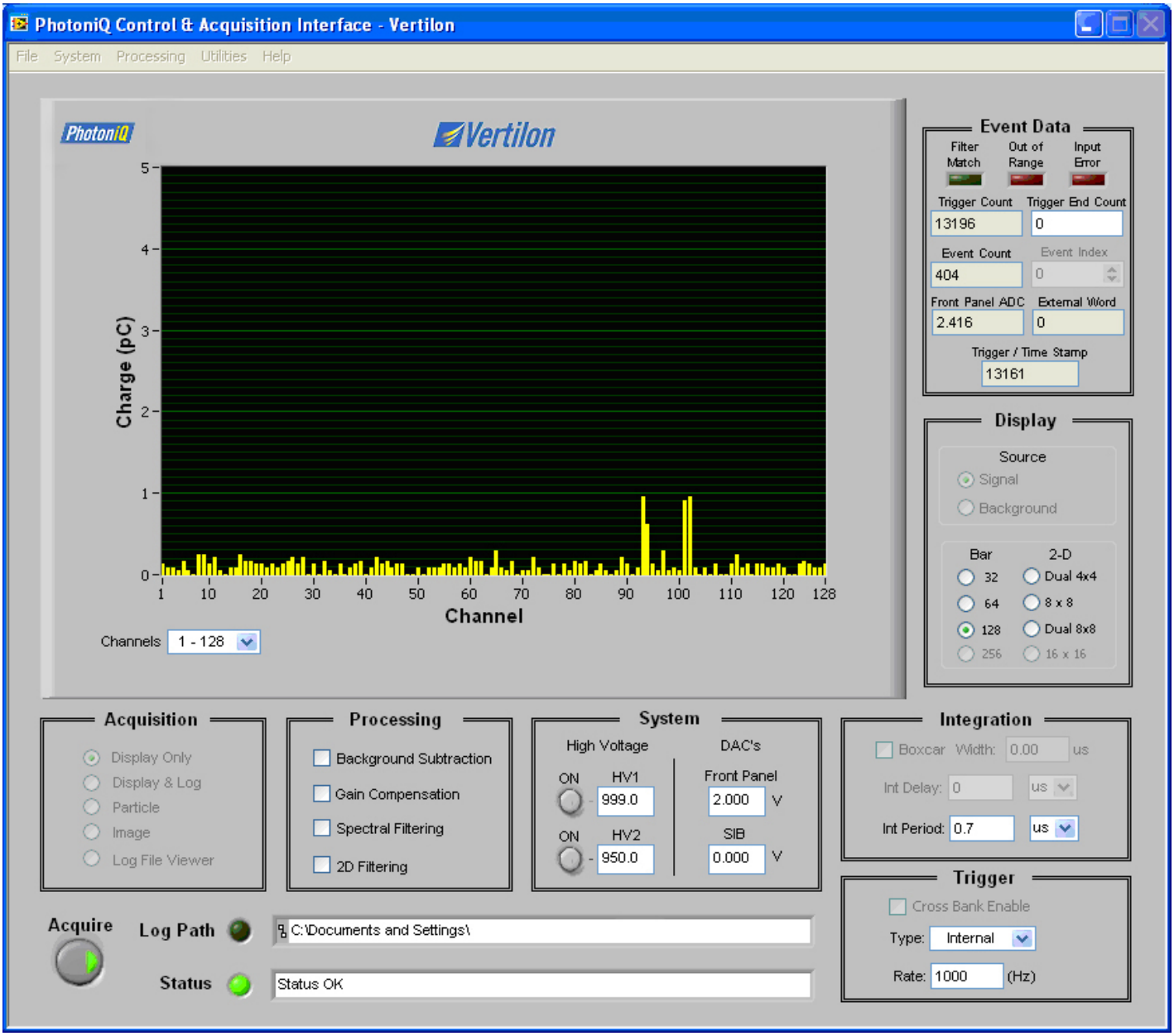


Figure 13: Front Panel (Bar Graph Display)

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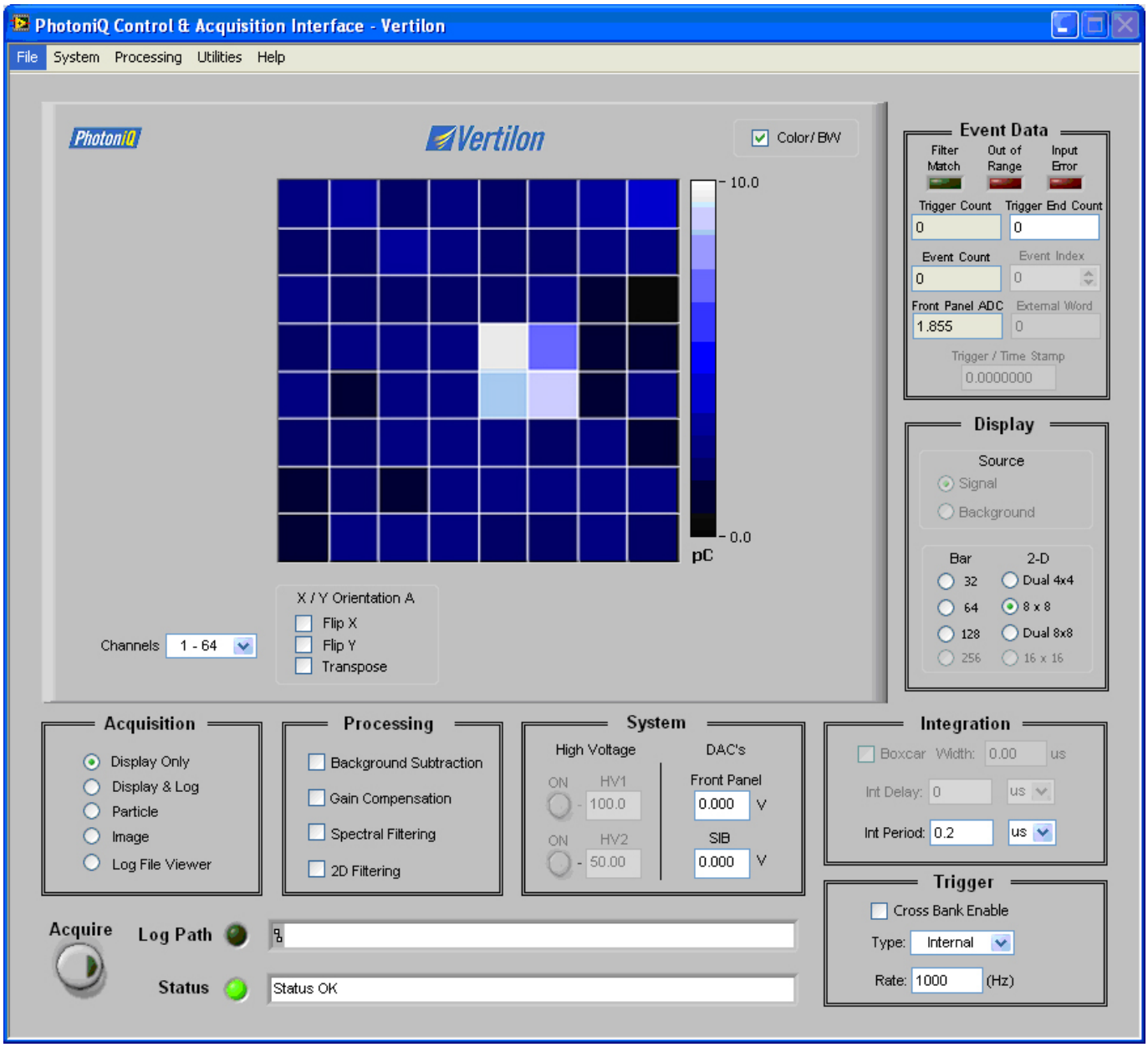


Figure 14: Front Panel (2D Single 8 x 8 Display)

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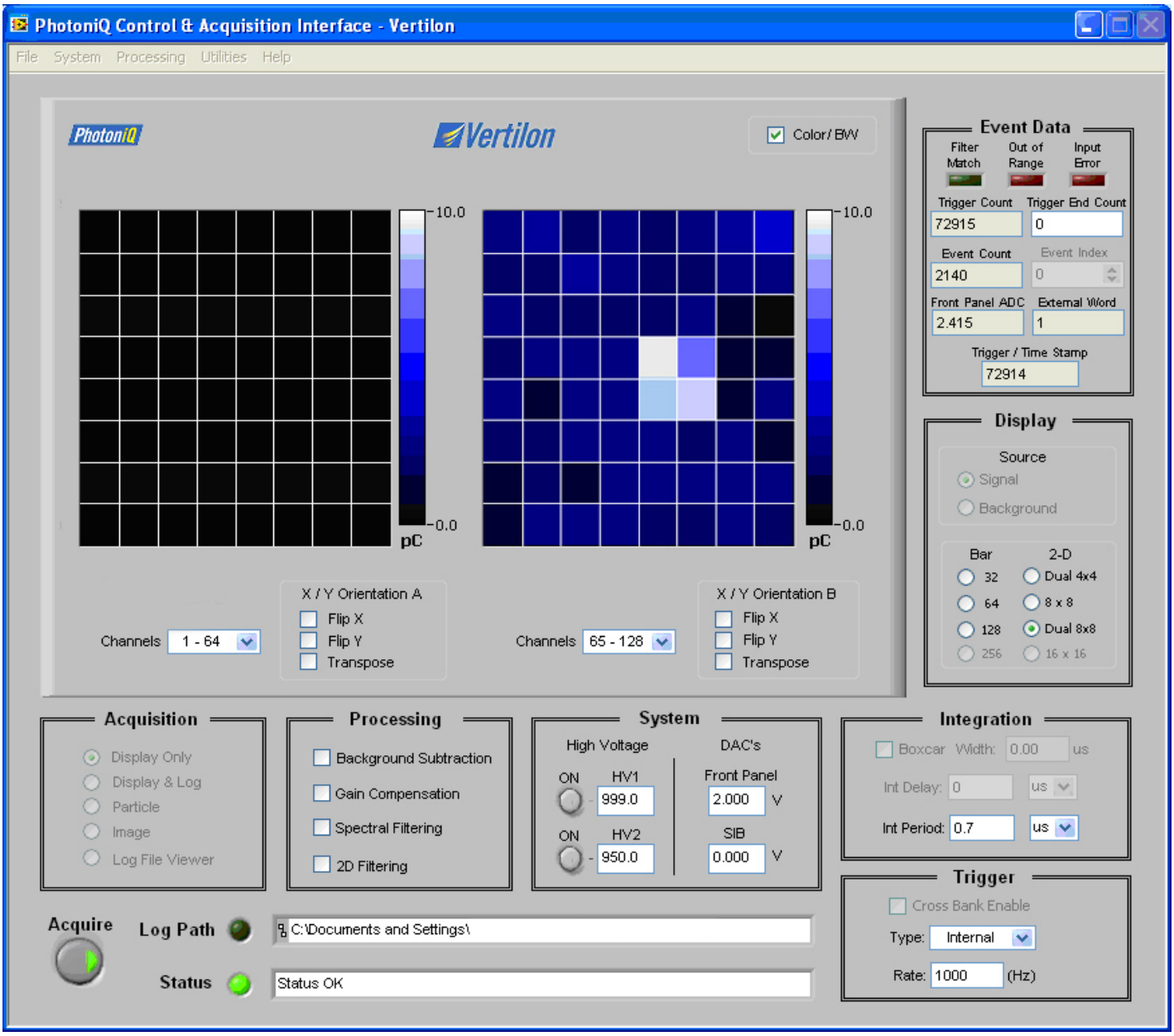


Figure 15: Front Panel (2D Dual 8 x 8 Display)

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Control Area

This area allows the user to define the acquisition, triggering, and integration parameters and control system settings.

Acquisition

The Control and Acquisition Interface Software supports four types of acquisition modes for real time display and/or logging of event data from the PhotoniQ hardware. A fifth acquisition mode allows the user to view a logged file in the display area.

Display Only
This mode is intended for use in setting up the user's system when the real time impact of modifications is needed, such as during optical alignment or detector bias adjustment. Most of the front panel functions are accessible. Data is collected from the PhotoniQ one event at a time and displayed in the display area in the GUI. Additional trigger events are ignored until the display is completely updated. The processing overhead necessary to display the data greatly reduces the maximum event capture rate.

Display & Log
Similar to the *Display Only* mode except that the user is able to log the viewed events. The display overhead severely reduces the maximum event rate that can be logged without a loss of data. Most of the front panel functions are disabled in this mode.

Particle
In this mode data from the PhotoniQ is logged directly to a file. With the exception of the *Event* and *Trigger* counters, the display and front panel functions are disabled so that the maximum achievable logging rate can be attained. Data acquisition is optimized for the collection of stochastic events. Triggers to the PhotoniQ are not accepted if the system is busy processing an event that was previously acquired. The uniform acquisition process makes this mode well suited for particle analysis applications. The maximum data acquisition rate will vary depending upon the user's computer system.

Image
Data acquisition is optimized for the rapid collection of events over a predefined period of time. Generally used in scanned imaging applications, this mode allows the PhotoniQ to be triggered at the highest rate possible. Data is stored in an image buffer where it is then logged at a slower speed to the PC. In a typical application, the PhotoniQ is triggered at the pixel clock rate and the image size, buffer size, and timing is configured such that the system can capture and store a full scan of the subject image before logging the data to the PC.

Log File View
Allows the user to select a previously logged file for viewing in the display area. Events are stepped-through using the event index box.

Acquire (Select File) Button
Toggles between *Acquire* and *Standby* for display and logging acquisition modes. Once a configuration has been set, the user starts acquiring data by toggling this switch to *Acquire*. When the *Log File View* acquisition mode is selected, this button allows the user to select the log file for viewing. Pushing the button opens a dialog box through which a data file can be selected for manual playback.

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Log Path
Indicates the location of the data file that has been selected for logging or viewing.

Status Line
Status information and error messages regarding the PhotoniQ's operation are displayed in this box. The LED is green under normal conditions and turns red when there is an error condition.

Processing

Allows the user to select which processing functions, if any, are applied to the data. The parameters for the individual processing functions are entered in their respective dialog boxes which can be found under the *Processing* pull-down menu.

Background Subtraction
Enables subtraction of a pre-calculated background signal from the total signal.

Gain Compensation
Enables gain compensation of channel to channel non-uniformities.

Spectral Filtering
Enables the spectral filtering processor.

2D Filtering
Enables the two dimensional filtering processor.

System

Used to set and monitor the PhotoniQ hardware peripherals. The high voltage functions are available only if the high voltage bias supply options are installed and activated in the *High Voltage Supply* dialog box found under the *System* pull down menu.

HV1 On
Enables high voltage bias supply #1. This function is available only if high voltage bias supply #1 is enabled under the *High Voltage Supply* dialog box.

HV1 Set Point
Sets the output voltage of high voltage bias supply #1. Cannot exceed upper limit set under *High Voltage Supply* dialog box.

HV2 On
Enables high voltage bias supply #2. This function is available only if high voltage bias supply #2 is enabled under the *High Voltage Supply* dialog box.

HV2 Set Point
Sets the output voltage of high voltage bias supply #2. Cannot exceed upper limit set under *High Voltage Supply* dialog box.

Front Panel DAC
Sets the output voltage of the front panel general purpose digital to analog converter.

SIB DAC
Sets the output voltage of the digital to analog converter on the sensor interface board connector. This function is typically used to control precision discriminator threshold signals on specialized sensor interface boards.

Integration

Sets the signal integration parameters for the acquisition process.

Integration Delay

Used with *Edge, Input,* and *Pre-trigger* types, this parameter sets the delay from the trigger source to the start of the integration period. Negative values are permitted if *Pre-trigger* is selected as the trigger type. This parameter is ignored when *Boxcar* mode is enabled.

Integration Period

Used with all trigger types, this parameter sets the duration of the integration period. For *Input* and *Pre-trigger*, the period minimum is equal to the PhotoniQ sample period – a parameter that is dependent on the speed configuration of the PhotoniQ. When using *Input* or *Pre-trigger*, only integer multiples of the PhotoniQ sample period can be used as the *Integration Period*. This parameter is ignored when *Boxcar* mode is enabled.

Boxcar

Available only with *Edge* trigger type, *Boxcar* mode uses the externally supplied trigger signal to set the integration delay and integration period. The preset integration parameters are ignored. The integration period starts immediately after the rising edge of the user supplied boxcar trigger signal. The integration period equals the width of the boxcar signal.

Boxcar Width

Displays the width of the boxcar input. To enable this feature, *Boxcar* mode must be selected in the front panel and the *Boxcar Width* box must be checked in the *Data Configuration* menu.

Trigger

Sets the trigger parameters for the acquisition process.

Type

Used to select the trigger type of *Edge, Internal*, *Level*, *Input*, *or Pre-trigger*. For *Edge, Level* and *Pre-trigger* types, the user supplies the trigger signal (positive edge/level) to the trigger input BNC connector on the PhotoniQ. For *Internal* trigger type, the PhotoniQ supplies the internal trigger and therefore no external input is required. *Input* triggering does not require a trigger signal but does require setting a threshold level.

Rate

Used in conjunction with *Internal* and *Level* trigger types. This parameter sets the rate of the internally generated trigger signal.

Threshold

Sets the charge threshold level for *Input* triggering.

Channel

Sets the channel number used for *Input* triggering.

Cross Bank Enable

When cross bank triggering is disabled, the front panel's trigger and integration parameters are applied identically to all four banks of channels. In this configuration, the PhotoniQ is triggered once and data is collected across all channels simultaneously using the front panel settings for the integration delay and period. When cross bank triggering is enabled, different integration delays and integration periods are applied to each bank of channels. In this configuration, the front panel trigger parameters are applied to the main trigger bank(s). The settings for the secondary banks are configured under the *Cross Bank Trigger* configuration menu.

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Event Data

Displays real time event specific data.

Filter Match

This function is active when the data filter processing is enabled. It indicates when a particular event matches the filter criteria.

Out of Range

Indicates when one or more channels in a displayed event are out of range.

Input Error

Indicates when an input error has been detected on one or more channels in a displayed event. Certain types of input overloads can cause an input error condition.

Trigger Count

This indicator keeps count of the absolute number of triggers seen by the system since the beginning of the *Acquire* period. The counter is reset at the start of the *Acquire* period and effectively counts all triggers (regardless of whether a trigger was accepted or rejected) until the *Acquire* period ends. In *Image* acquisition mode, the *Trigger Count* is used as a system status indicator that shows the current number of pixels counted by the PhotoniQ. It also serves as a diagnostic tool to ensure that the maximum trigger rate to the PhotoniQ is not exceeded. If the *Trigger Count* equals the *Event Count* after the acquired data has been transferred to the PC, then no pixels were missed. The *Trigger Count* is also valuable in *Particle* acquisition mode where it can be compared to the *Event Count* to determine the percentage of events acquired by the PhotoniQ. Note that if the event rate is exceptionally high, the displayed *Trigger Count* will slightly lag the actual trigger count measured by the system. It is also important to note that unlike *Particle* and *Image* mode where the displayed *Trigger Count* will be equal to the *Trigger End Count* at the end of the acquisition period, this will usually not be the case when using the *Display* and *Display & Log* modes. Although the system in these modes will accurately count the triggers and stop when the *Trigger End Count* is reached, the final displayed *Trigger Count* will only indicate the number of triggers counted when the last event was acquired. The additional triggers are counted to reach the *Trigger End Count* but not displayed because none of them resulted in the acquisition of an event.

Trigger End Count

A user programmable value that specifies the *Trigger Count* value that terminates the *Acquire* period. This is normally used in *Image* acquisition mode where it is set equal to the total number of pixels in the scanned image. In this way, the PhotoniQ acquires a complete image in its event buffer, ends its acquisition period, and transfers the buffered data to the PC. A value of zero for the *Trigger End Count* corresponds to an infinite acquisition period.

Event Count

Indicates the running total of the number of events accepted by the PhotoniQ and transferred to the PC. The counter is cleared when an acquisition period is restarted and will roll over if the maximum event total is reached. This counter is also used as an indicator of the total number of events in a log file when in *Log File View* mode. The *Event Count* and *Trigger Count* are the only two indicators active when in *Particle* or *Image* acquisition mode. Note, when the PhotoniQ is in the *Display Only* or *Display & Log* acquisition modes, the *Event Count* will usually be much less than the *Trigger Count* because the overhead from the real time data display significantly slows the event acquisition rate. The *Particle* and *Image* acquisition modes, on the other hand, are high speed data acquisition modes that are able to keep up with the trigger rate provided it is within

the specified limits. Under these conditions, the *Event Count* will usually equal *Trigger Count* after the acquisition period ends and all events are transferred to the PC. However, even in these two high speed modes it is possible for the *Event Count* to be less than the *Trigger Count*. This can occur if the trigger specification is exceeded—even momentarily—or if the *Acquire* button is pressed while active triggers are input to the system. To avoid the latter situation, the *Acquire* button should be pressed before any triggers are applied to the system.

Event Index
Available only in *Log File View* mode, this box allows the user to scroll through events or to enter a specific event number for viewing from the log file. The maximum event index is equal to the event total.

Front Panel ADC
Displays the value in volts measured on the PhotoniQ front panel general purpose ADC input. The input is sampled each time the unit is triggered. Sampling occurs coincident with the rising edge of the trigger input signal and is independent of the integration and delay time parameters. Data will be displayed in this area even if the *Front Panel ADC* is left unchecked in the *Data Configuration* menu because the system will update the value even if no trigger is applied. Enabling the *Front Panel ADC* in the *Data Configuration* menu will insert the ADC sample associated with each trigger in the *event* packet in the log file. When used, this input should be driven by a low impedance device.

External Word
When enabled in the *Data Configuration* menu this field displays the 16-bit value (in decimal) of the externally generated data word. The *external word* is transferred to the PhotoniQ through the digital interface connector located on the rear of the unit. The interface is designed to serially shift-in a 16-bit digital word immediately after an external trigger is applied to the system. If the trigger signal is accepted by the PhotoniQ and an event created, the *external word* corresponding to the accepted trigger signal is displayed on the front panel if in *Display* or *Display & Log* Mode. It is also appended to the event data packet.

Trigger/Time Stamp
Shows the trigger or time stamp for the event currently displayed in the display window. The trigger stamp is the running total of all triggers seen by the system since the start of the *Acquire* period. Time stamps are taken in fixed resolution steps as determined in the *Data File Configuration* pull-down menu and are also referenced to the start of the *Acquire* period. The *Trigger/Time Stamp* counter rolls over after the maximum value is reached. To enable this feature the *Trigger/Time Stamp* must be selected in the *Data Configuration* menu.

Display

Configures the real time display area.

Source
Selects the type of data plotted on the display. The logged data and processing functions are unaffected by this selection.

Signal
The input signal is plotted on the real time display. If *Background Subtraction* is enabled, the raw input signal minus the background is displayed.

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Background
Only the pre-calculated background signal is plotted on the real time display. Select this display function when initially configuring the system to minimize the background optical signal. This function is only available if *Background Subtraction* processing is enabled.

Display Type
The display type for the input channels is selected using this feature. Different sized bar and two dimensional intensity graphs can be used to display the input signal data.

Bar
Displays a single linear bar graph with the signal channels on the x-axis and their corresponding signal amplitude in picocoulombs on the y-axis. The number of channels for display can be 32, 64, or 128 channels. The channel mapping for the graph is selected directly beneath the graph in a separate dropdown selection box.

2-D
Displays a two dimensional (x-y) intensity graph of the signal channels with the signal amplitude in picocoulombs displayed as intensity. The graph choices consist of a dual 4 x 4 display, single 8 x 8, or dual 8 x 8. The channel mapping for the graphs is selected directly beneath them in separate dropdown selection box(es).

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Real Time Display Area

The display area is used to give a graphical view of the data collected while in the *Display Only* and *Display & Log* acquire modes. For these modes the displayed data is obtained directly from the PhotoniQ in real time. Data is also shown in the display area when viewing a previously logged file in *Log File View* mode. The display area and its associated control functions are disabled when either *Particle* or *Image* is selected as the acquisition mode.

Display

Displays the real time signal in picocoulombs (pC) from each of the input channels. Data is also shown on the display when viewing a previously logged file in *Log File View* mode. The signal data can be displayed as a single bar graph, single two-dimensional intensity map, or dual two-dimensional intensity map.

Display Limit Adjust

Clicking the upper or lower vertical scale value allows the display limits to be adjusted.

Channels

Selects the channel range for display.

Flip X

Inverts the x-axis for 2D displays.

Flip Y

Inverts the y-axis for 2D displays.

Transpose

Swaps the x-axis and y-axis for 2D displays.

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Pull Down Menus

The pull down menus are available at the top of the graphical user interface window.

File

File operations generally consist of storing and retrieving PhotoniQ configurations between the PC and the PhotoniQ's volatile and non-volatile (flash) memory. Configuration information stored in volatile memory will be lost when power to the PhotoniQ is removed. The default configuration will be loaded on power up. Configuration information stored in flash memory will be retained even when power to the PhotoniQ is removed.

New
Loads the PhotoniQ with the default configuration.

Open
Loads the PhotoniQ with a stored configuration from a file on the PC.

Save
Saves the current configuration of the PhotoniQ to a file on the PC.

Save As
Saves the current configuration of the PhotoniQ to a new file on the PC.

Read from Flash
Loads the PhotoniQ with the configuration stored in the PhotoniQ's flash memory.

Write to Flash
Writes the current configuration of the PhotoniQ to its flash memory

Print Window
Prints the current window.

Exit
Closes the executable.

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System

The PhotoniQ is configured through this pull down menu.

Data Configuration

Opens the dialog box shown below where the PhotoniQ log file settings are configured. The log file will increase in size when any of these items are selected. See section on Log Files for the specifics on the log file sizes and format.

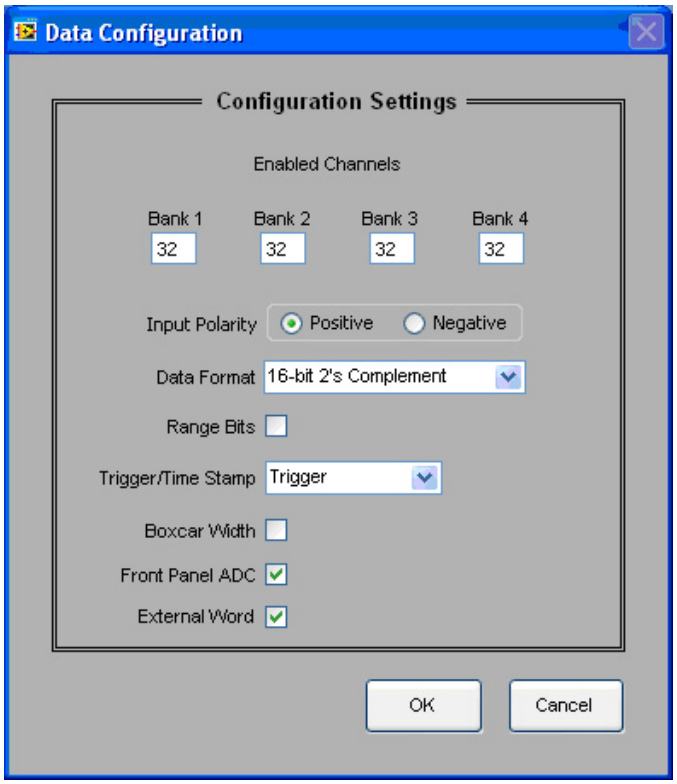


Figure 16: Data Configuration Dialog Box

Enabled Channels

Configures the number of input channels used by the system which in-turn determines the size of the output data packets. Channels are arranged by banks with 32 channels per bank. The number of channels per bank also determines the operating speed of the unit. If any bank is configured with 25 or more channels, the IQSP584 timing operates like a 128 channel system — regardless of the configuration of the other banks. Similarly, if the maximum number of channels in any bank is between 17 and 24, then the unit's timing behaves like a 96 channel unit. If all banks are configured with 8 or less channels, then the PhotoniQ speed is maximized and operates like a 32 channel unit.

Input Polarity

Changes the polarity of the input preamplifiers on the PhotoniQ. Normally set to positive, this configuration switch is used to match the preamplifier's polarity to the direction of the current from the sensor attached to the sensor interface board connector. The PhotoniQ should be recalibrated if this switch is changed. See the sensor interface board's user manual for more details.

Data Format

The data format for the signal data in the log file can be configured in either of two ways; *17-bit Sign-Magnitude* or *16-bit Two's Complement*. The 17-bit option inserts the magnitude of the channel data into 16-bit words and "bit-packs" the sign bits for each channel into additional *sign* words. For a 128 channel configuration this format adds 16 extra words to the event packet. While in most applications it is possible to ignore the sign bit and assume the data is always positive, there are occasions when the sign bit is important such as in system noise characterization. The 16-bit format does not append additional *sign* words to the events in the log file. Signal data is simply inserted into 16-bit words in a standard two's complement representation.

Range Bits

Inserts out of range (OOR) and input error (ERR) data for each channel into the log file. The range data is reported for each event. Out of range occurs when the input signals are too large (negative or positive) for the electronics. An input error is reported when a fault other than an out of range is detected. Regardless of whether this option is selected, the header for each event contains data to indicate if at least one of the channels in the event packet is out of range or has an input error.

Trigger / Time Stamp

Inserts a two word trigger or time stamp for each event into the log file. The selection choices are *Trigger, Time (100nsec), Time (1 usec), Time (10 usec), Time (100 usec), Time (1 msec), and Off*. No trigger or time stamp is inserted into the log file if *Off* is selected.

The *Trigger* option inserts the absolute count of the number of triggers seen by the system for each event that is acquired. The trigger stamp is reset to zero at the start of *Acquire* mode. Ideally, in a scanned imaging application, the trigger stamp will increment by exactly one for each event (pixel). An increment of greater than one indicates that one or more triggers were missed. This usually indicates that the trigger rate exceeded the maximum trigger rate for the system. In a particle application, the trigger stamp can be used as a measure of the percentage of particles missed by the system.

The five *Time* options are used to insert a time stamp with a programmable resolution from 100 nsec to 1 msec. Like the trigger stamp, the time stamp is reset to zero at the start of *Acquire* mode. To obtain absolute time, an absolute time stamp — taken when the PhotoniQ first enters *Acquire* mode and inserted into the header at the top of each log file — can be added to the relative time stamps appended to each event. Time stamping is most useful in particle analysis applications where particle interarrival times can be measured. Although not as useful in imaging applications, the time stamp can function as a good diagnostic tool if trigger frequency or scan time needs to be measured.

Boxcar Width

Inserts the measured width of the external boxcar signal for each event into the log file.

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Front Panel ADC
Inserts the measured voltage value of the ADC input on the front panel of the unit. A new sample is taken on each trigger.

External Word
Enable the external data word interface on the rear of the unit and inserts the data into the event packet. Enabling the *external word* also enables the *front panel ADC*. Available only if option DIO100 installed.

High Voltage Supplies
Opens the dialog box shown below where the optional high voltage bias supplies are configured.

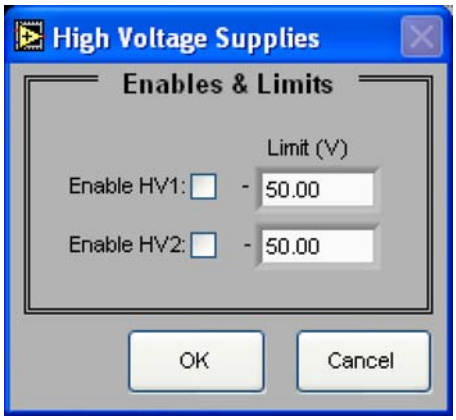


Figure 17: High Voltage Supply Dialog Box

Enable HV1
Allows optional high voltage bias supply #1 to be controlled from the front panel. If this box is unchecked, the supply is turned off and the front panel controls are disabled. Supply HV1 is typically used in conjunction with the first 64 channels on the PhotoniQ.

Enable HV2
Allows optional high voltage bias supply #2 to be controlled from the front panel. If this box is unchecked, the supply is turned off and the front panel controls are disabled. Supply HV2 is typically used in conjunction with the second 64 channels on the PhotoniQ.

HV1 Limit
Sets the voltage limit for high voltage bias supply #1 so that the user cannot select a set point above this level from the front panel.

HV2 Limit
Sets the voltage limit for high voltage bias supply #2 so that the user cannot select a set point above this level from the front panel.

General Purpose Output

The *General Purpose Output* (AUX OUT) is located on a BNC connector on the front panel. It is mainly used in real-time particle sorting where it can enable an actuator based on a spectral filter match. This selection opens the dialog box shown below where the user sets the delay, pulse width, and enable condition for the *General Purpose Output*.

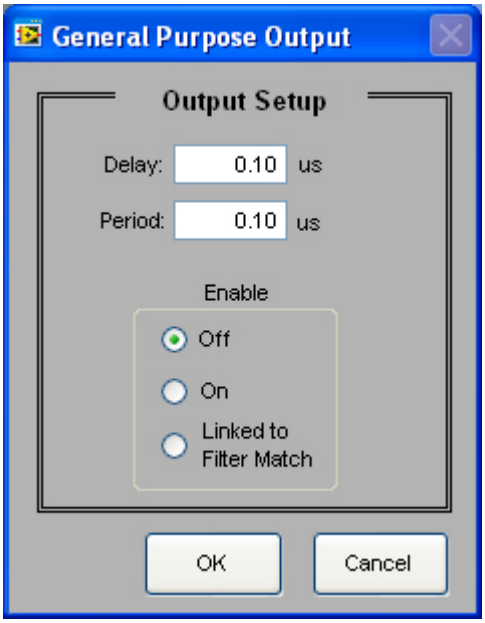


Figure 18: General Purpose Output Dialog Box

Delay

Sets the delay time from trigger of the general purpose output signal.

Period

Sets the period (positive pulse width) of the general purpose output signal.

Enable

Forces the general purpose output signal to be either always off, always on, or linked to an event filter match. When set to *On*, a pulse output is generated every time a trigger occurs. When set to *Linked to Filter Match*, a pulse output occurs only when *Spectral Filtering* is enabled and an event meets the filter criteria. If *Spectral Filtering* is disabled, the pulse output will be generated for every trigger. Note that the *Spectral Filtering* operation takes a non-zero amount of time that is dependent on the *Spectral Filtering* configuration. This limits the minimum delay that can be selected for the *General Purpose Output.* The user needs to determine this empirically for a given *Spectral Filtering* configuration.

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Cross Bank Triggering

This selection opens the dialog box shown below that allows the user to configure the cross bank triggering parameters. Triggering of the secondary banks occurs after the triggering of the main bank(s). Secondary banks are always triggered as *Edge* type where the trigger edge is derived from the trigger output from the main bank(s). The *Cross Bank Enable* box on the front panel must be checked for the cross bank parameters to be applied.

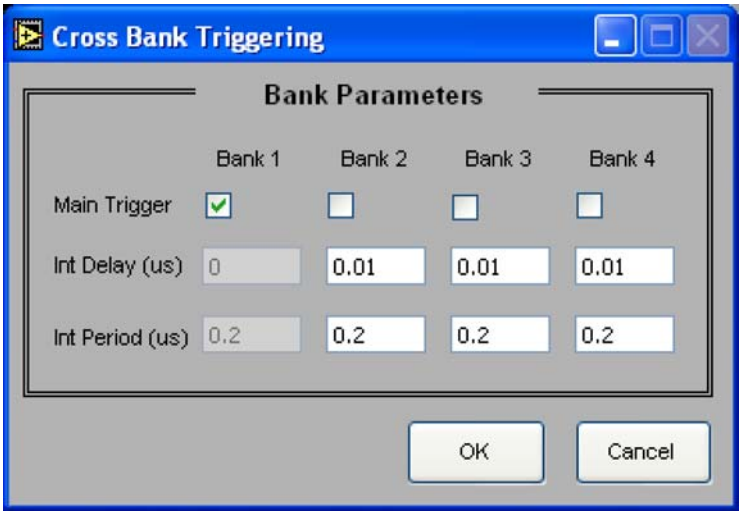


Figure 19: Cross Bank Triggering Dialog Box

Main Trigger

Selects the bank(s) for the main trigger. Each selected bank is configured with the triggering parameters from the front panel.

Int Delay

Sets the integration delay for each of the secondary bank(s).

Int Period

Sets the integration period for each of the secondary bank(s).

Processing

The PhotoniQ processing functions are configured through this pull down menu.

Background Subtraction

The PhotoniQ includes a processing function that continuously subtracts a pre-calculated background level from the raw signal from each of the input channels. This function is useful when the raw input signal is dominated by a stable DC background level. By enabling the *Background Subtraction* processing, a DC background signal is removed from each channel for each event so that only the actual desired signal can be displayed or logged. Pressing the *Apply* button performs the background level computation on each channel. The computed values are then used for the *Background Subtraction* processing if enabled. Calculation of the background level should be initiated anytime the user changes the system parameters. Note that *Background Subtraction* does not increase the dynamic range of the system nor does it remove the shot noise associated with the background. Its main use is to improve the display of the data and simplify the post processing of the logged data. It is also useful for optical system setup diagnostics.

Gain Compensation

Gain compensation processing allows the user to normalize the outputs from the individual channels of a particular sensor. This is helpful when compensating for channel-to-channel responsivity differences in multi-anode PMTs and photodiode arrays. The gain compensation dialog box shown in Figure 20 lets the user adjust each channel by a positive or negative percentage. For example, a positive 2% adjustment into a specific channel will effectively multiply the raw data for that channel by 1.02. A negative 2% adjustment would multiply the raw data by 0.98. The compensation coefficient range is -100% to +100%. The coefficients default to 0 % when gain compensation is disabled.

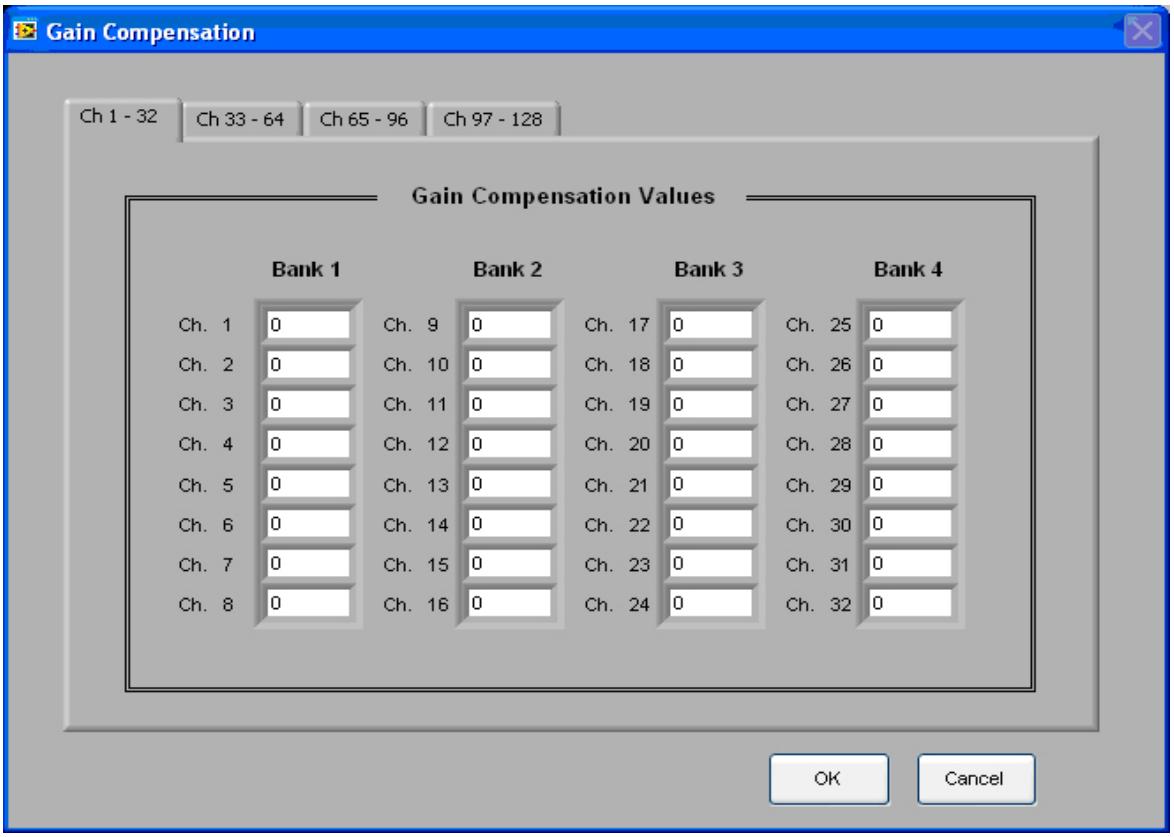


Figure 20: Gain Compensation Dialog Box

Spectral Filtering

Spectral Filtering is used to selectively display, log, or tag events that meet a specific user defined matching criteria. It is typically used in fluorescence detection or other applications where the acquired event data represents spectral or wavelength information. Spectral filtering is described in more detail in the Data Filtering section.

2D Filtering

2D Filtering is used to selectively display, log, or tag events that meet a specific user defined matching criteria. It is most appropriate for applications such as PET and particle physics that use position sensitive detectors. 2D filtering is described in more detail in the Data Filtering section.

Utilities

Generate Diagnostic Report

Automatically runs diagnostic routines and generates a diagnostic report using the current system configuration. A trigger must be supplied (internal or external) before this routine is run.

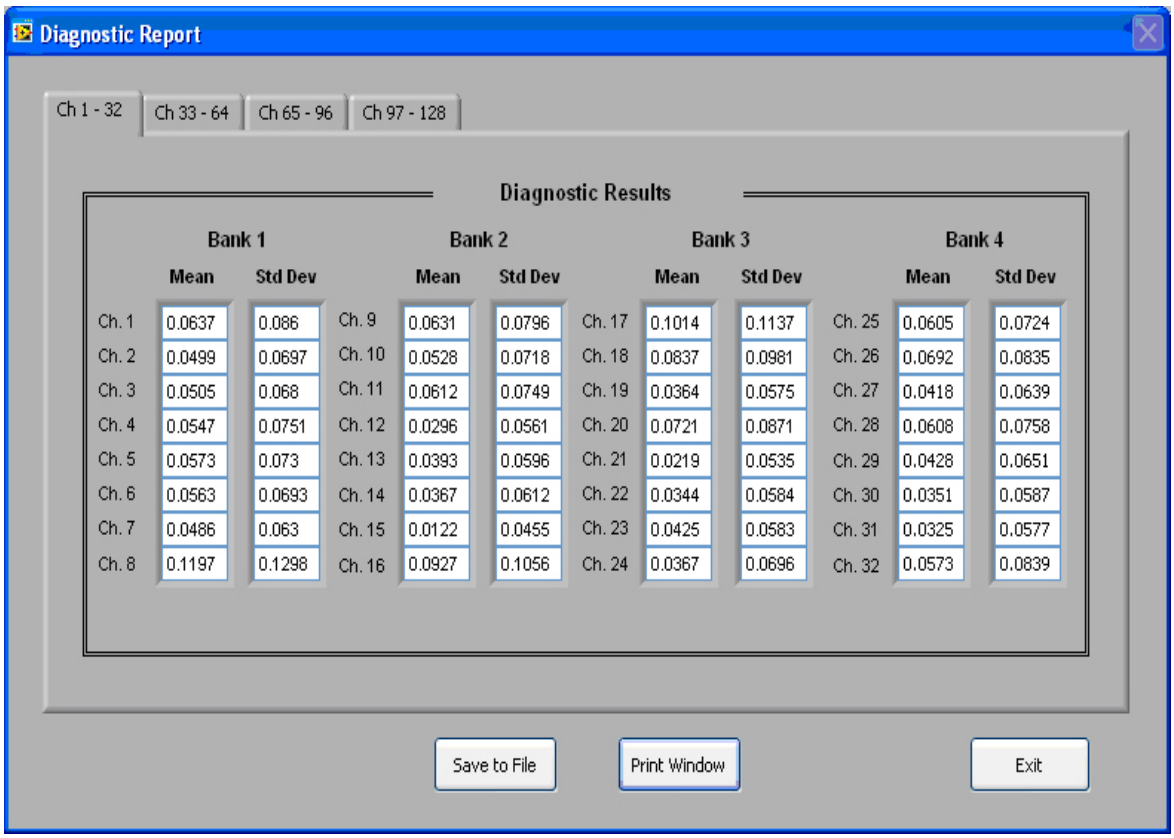


Figure 21: Diagnostic Report Dialog Box

Calibrate

Calibrates the PhotoniQ hardware. This function is generally not intended for the user and should only be initiated at the factory. However, if the SIB cable is replaced, modified, or not used, a calibration should be performed to compensate for any small differences in the cables. To initiate a calibration, configure the PhotoniQ and confirm that the SIB is not connected to the other end of the cable. Press the *Apply* button to calibrate the unit.

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Log File Converter

This utility converts the binary files (.log) created during logging into tab delimited text files (.txt). The readable text files can be used as is or imported into a database program for further processing. For details on the data format of binary and text log files, the Log Files section of this manual should be consulted.

When the *Log File Converter* utility is selected, the dialog box shown in Figure 22 opens. Here the user selects the source binary file (.log) that is to be converted into a text file (.txt) by pressing the *Select File* button. This in turn opens the dialog box shown in Figure 23 where the user then browses to the source file. The target file is the name of the text file that results from the conversion of the source binary file. Similar in behavior to the source file select button, a dialog box opens where the user browses to the target directory and names the target file. Once both the source and target files are selected, the converter is initiated by pressing the *Convert* button. The progress of the log file conversion process is monitored by observing the *Progress* bar at the top of the dialog box.

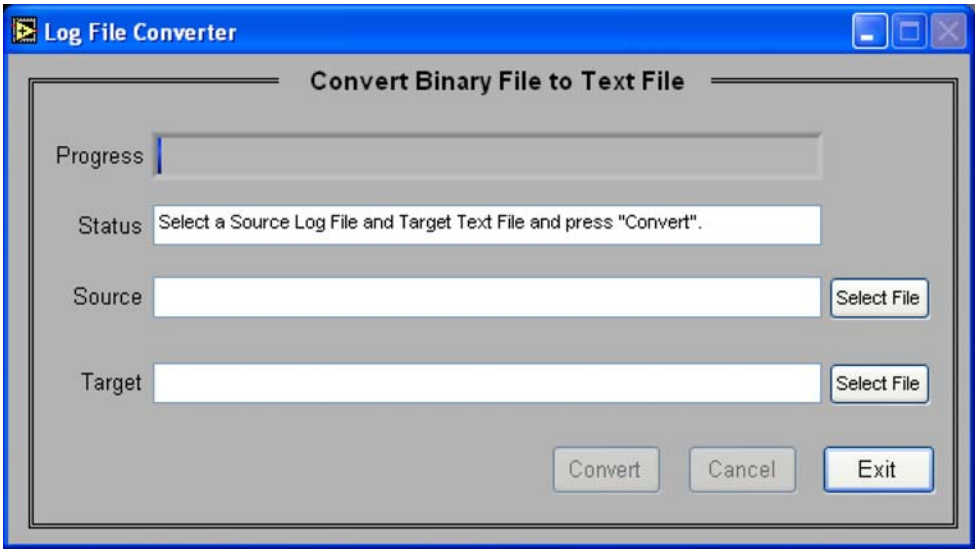


Figure 22: Log File Converter Dialog Box

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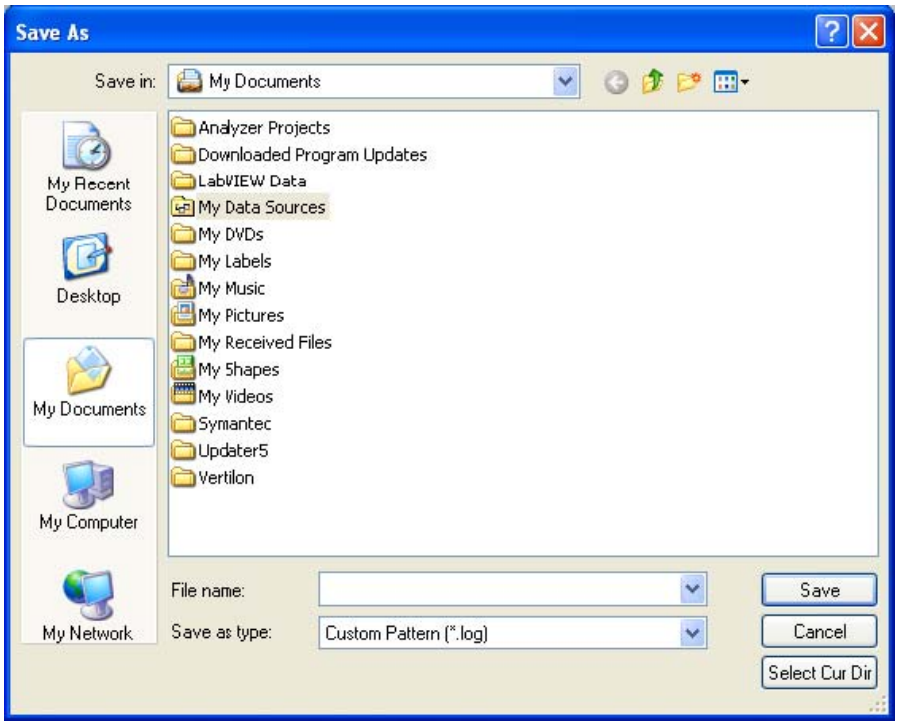


Figure 23: Select File Dialog Box

The *Log File Converter* can also process binary files in a batch mode to save time when multiple binary files are to be converted. Instead of browsing for a source file when the *Select File* button is pressed, the user selects an entire directory by pressing the *Select Cur Dir* button as shown in the dialog box above. This effectively selects all binary files (i.e. all files ending in .log) in the source directory for conversion to text files. The target *Select File* button opens up a similar dialog box where the user selects the destination directory for the text files with the *Select Cur Dir* button. Pressing the *Convert* button converts all files with the .log extension in the source directory, and places the resulting text files into the destination directory. The target file names are identical to the source names except the file extension is changed from .log to .txt. Note that since the batch mode of the *Log File Converter* attempts to convert all files ending in .log into text files, care should be taken to ensure that all .log files in the source directory are valid binary log files. If the converter encounters an invalid binary file, the conversion process will abort and no files, valid or invalid, will be converted.

Data Filtering

When either the *Spectral Filtering* or *2D Filtering* processing function is enabled, an output marker can be generated for each event that meets a predefined filter criteria. If the result is true, a positive going digital pulse is output on the *General Purpose Output* connector (AUX OUT) on the front panel of the PhotoniQ. The timing for this pulse is configured under the *General Purpose Output* pull down menu. In addition to the marker pulse, events in the log file are tagged so that those that meet the filter criteria can be identified when subsequently displayed or analyzed. To minimize the data processing load to the host processor, a *Block Data Transmission* configuration switch is available to block events that do not meet the filter criteria from being logged or displayed. When this switch is set, only data that generates a true response to the filter criteria is transmitted. Note, since spectral and 2D filtering are real-time embedded DSP functions in the PhotoniQ, a reduction in the maximum data acquisition rate can be expected when either of these functions are enabled.

Spectral Filtering

Spectral filtering is most useful in applications where the acquired data represents wavelength or frequency information. It is also possible to use it in one dimensional, linear positional applications. Typically the spectral filter is configured to accept or reject events that meet a predefined criteria or discriminant. For instance, the filter can be setup to acquire events that match a particular fluorescence spectral pattern and reject all others. Parameters for the filter are entered in three tabbed panes in the dialog box under the *Spectral Filtering* option in the *Processing* menu. The data filtering processor operates on spectral bands defined by the user in the *Band Definition* pane according to a Boolean expression defined in the *Flag Definition* and *Discriminant Definition* panes.

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Band Definition

The *Band Definition* pane allows the user to create a set of up to eight frequency or position bands that are used to compare spectral or location regions, respectively. A band is defined as a continuous sequence of channels. For example, in the figure below Band 1 is defined as channels 3 through 5 and Band 2 as channels 6 through 7. Bands 3 through 8 are not defined. It is not necessary to define all bands. However, care should be taken to not include unused channels in a band definition or unused bands in the *Flag Definition* described on the next page.

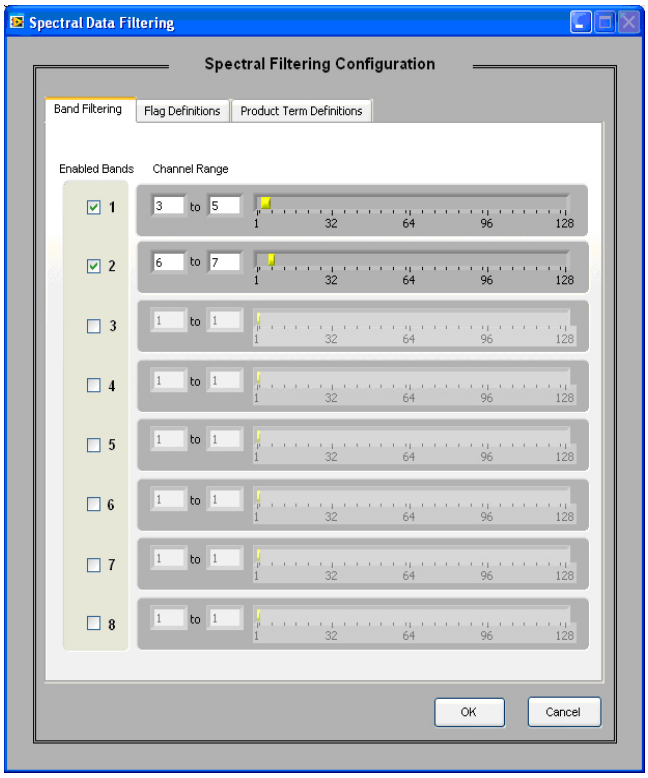


Figure 24: Band Definition Pane

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Flag Definition

Up to eight flags can be defined by the user in the *Flag Definition* pane. The result of a flag computation on the spectral or position data is either true or false. All eight flags have the same structure in which the operand on the left is tested for being greater than the operand on the right. Within each operand, the user selects a multiplier and either a constant (equal to the weight of one LSB) or the average of one of the bands defined in the *Band Definition* pane. This allows the data filter processor to compare a band to a constant or compare two independently scaled bands to each other. Referring to the example below, two flags (Flag 1 and Flag 2) are defined in the *Flag Definition* pane. Flag 1 is true if one times the average of Band 1 is greater than 60 times 0.0595 pC (the LSB weight for an IQSP584) and Flag 2 is true if one times the average of Band 2 is less than 70 times 0.0595 pC. The data discriminator operates on these two flags with a user defined function to determine if a filter match occurred. Note the user should only use bands in the flag definitions that have been enabled and defined in the *Band Definition* pane.

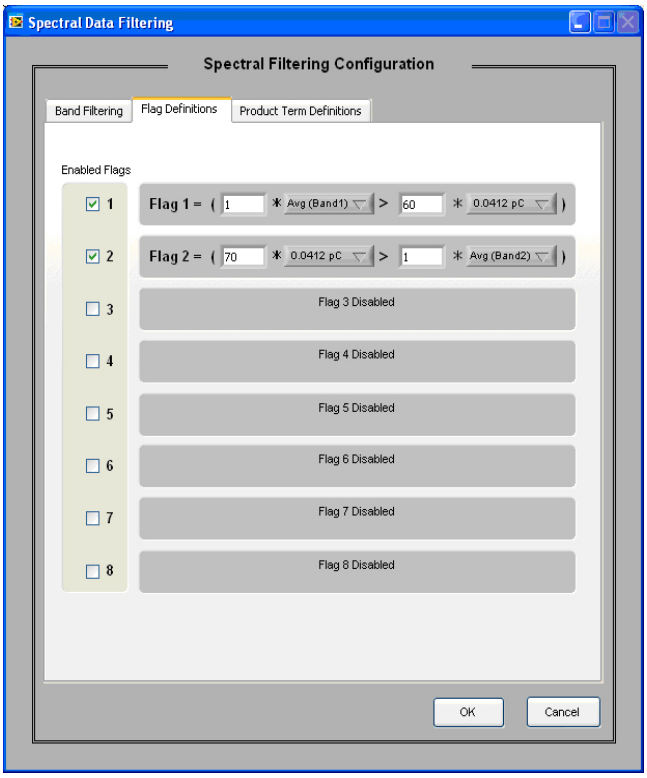


Figure 25: Flag Definition Pane

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Discriminant Definition

The data filter match function is programmed in the *Discriminant Definition* pane as a logical combination of the previously defined flags utilizing a sum of products format. Each row in the table is a grouping of flags that are logically AND'd together. The rows are then logically OR'd to produce the filter result. The *Filter Criteria* line shows the resulting equation with "*" representing a logical AND and "+" representing a logical OR. Each event can thus generate only a true or false condition. The user should only use flags in the discriminant definition that have been defined and enabled in the *Flag Definition* pane. Checking the *Block Data Transmission* box in the *Discriminant Definition* pane forces event data that generates a false response to the filter criteria to be blocked from being logged or displayed. The output marker pulse is unaffected by the setting of this configuration switch.

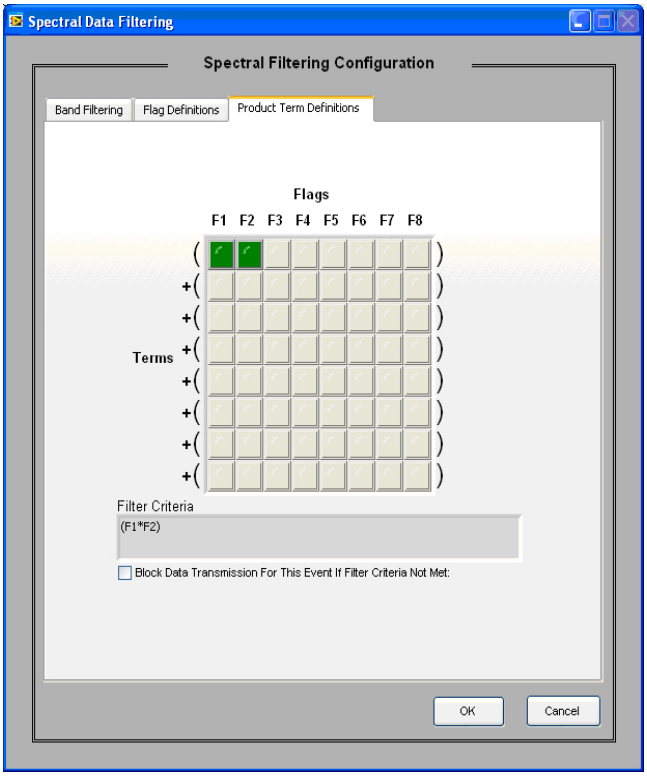


Figure 26: Discriminant Definition Pane

With the product term definition shown above, the data filter function will generate a match only if the average of channels 3, 4, and 5 is greater than 3.57 pC and the average of channels 6 and 7 is less than 4.17 pC. The events that meet this criterion will have their corresponding *data filter match* bit set in the log file. However, because the *Block Data Transmission* box is not checked, all events will be logged, regardless of the match condition.

2D Filtering

Filtering of two dimensional data from position sensitive devices is performed using the *2D filtering* function. The 2D filter is most effective in applications where single particles are detected based on their locations in the detector array. In particle physics applications the detection criteria would be based on the energy level of the particle. The 2D filtering parameters are entered in a single dialog box under the *2D Filtering* option in the *Processing* menu. The data filtering processor operates on a subsection of the detector array by comparing the particle's energy level to a predefined threshold or to another coincident particle's energy level.

2D Filtering Definition

The 2D filter works by defining either one or two small filter areas in the detector array for comparison. Selection areas are defined by first selecting the display mode as either a *dual 4 x 4* or *dual 8 x 8* matrix. The *Channels* dropdown menu below each array is used to select which channels are assigned to each matrix. This defines the *Matrix A* and *Matrix B* selection areas. Within these areas, the user clicks on the location of the filter areas, which depending on the *Filter Matrix* size, can be either 1 x 1 or 2 x 2 pixels. Under the *Enabled Flags A* location, the comparison condition flag is configured for *Matrix A*. For a 1 x 1 *Filter Matrix*, this condition is applied to the single pixel defined in the display matrix. For a 2 x 2 *Filter Matrix*, the condition is independently applied to each of the four pixels defined in the display area and, depending on the *A Product Terms* selection, the conditions are either AND'd or OR'd together to produce a single Boolean result. The flag for *Matrix B* is similarly configured under the *Enabled Flags B* location. The final filter criteria is determined by combining (by ANDing or ORing) the *Matrix A* and *Matrix B* conditions using the *A/B Product Term*.

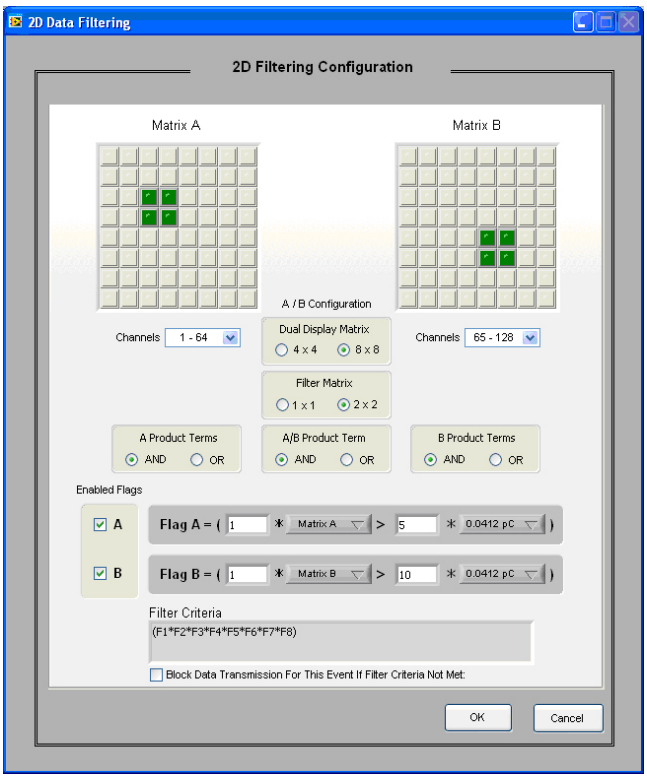


Figure 27: 2D Filtering Definition Pane

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Log Files

The Control and Acquisition Interface Software produces binary log files during data collection that can be viewed using the GUI display or processed off-line for more thorough data analysis. The GUI display function is accessed using the *Log File View* on the front panel. This acquisition mode allows the user to step through and view individual events in the binary log file. More advanced data processing functions such as sorting and pattern detection can be applied by operating directly on the binary log files or by using spreadsheet-based routines on text log files. If text file format is desired, a function included with the Control and Acquisition Interface Software is used to convert the binary log files to text log files.

Binary Log File Format

Binary log files are used to minimize the time required to transfer the data from the PhotoniQ to a hard disk on a PC. To reduce processing overhead and storage requirements, it is recommended that any off-line data manipulations operate on this type of file. The contents of the binary log files written by the Control and Acquisition Interface Software can be broken into three main sections; the identification text header, the configuration table, and the data block. The *ID Text Header* defined in Table 7 below is a simple header that identifies the PhotoniQ model number, date, time (24 hour format), and version information. It is organized along 8-bit byte boundaries.

Offset (Bytes)	Description	Length (Bytes)	Contents
0	Product ID	17	"Vertilon xxxxxx[CR][LF]"
17	Date/Time String	19	"MM/DD/YY HH:MM xx[CR][LF]"
36	Software UI Version	28	"LabVIEW UI Version xxxxxxx[CR][LF]"

Table 7: Binary Log File (ID Text Header Section)

The *Config Table* section shown in Table 8 contains configuration information relating to the PhotoniQ hardware and firmware. Unlike the *ID Text Header* section, the *Config Table* section is organized as 16-bit words instead of 8-bit bytes. The configuration data is partitioned into three tables; *user*, *custom*, and *factory*. The *user* table contains the configuration of the PhotoniQ set by the user through the user interface. Any custom configuration data is stored in the *custom* table. Factory-programmed, read-only configuration data is found in the *factory* table.

Offset (Words)	Description	Length (Words)	Contents
32	Config Table Revision	1	1st 8 bits = Major Rev, 2nd 8 bits = Minor Rev
33	User Config Table	1000	User Configuration Binary Data
1033	Custom Config Table	250	Custom Configuration Binary Data
1283	Factory Config Table	750	Factory Configuration Binary Data

Table 8: Binary Log File (Config Table Section)

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The *Data Block* section defined in Table 9 below is made up of packets that contain event data. An *event* packet contains the data for each channel and is created for each event that is acquired while logging. The length (L) of the *event* packets is dependent on the configuration settings selected in the user interface. Packet data is partitioned along 16-bit word boundaries.

Offset (Words)	Description	Length (Words)	Contents
2033	Data Packet # 1	L	First Event Packet
2033 +L	Data Packet # 2	L	Second Event Packet
…	…	L	…
2033 +(n+0)*L	Data Packet # n+1	L	nth+1 Event Packet
2033 +(n+1)*L	Data Packet # n+2	L	nth+2 Event Packet
2033 +(n+2)*L	Data Packet # n+3	L	nth+3 Event Packet
…	…	…	…

Table 9: Binary Log File (Data Block Section)

Event Packet Description

Format

Each event processed by the PhotoniQ IQSP584 generates an *event* packet of length, L, where L is in 16-bit words. The packet consists of a single word *header* followed by *signal data* words containing the signal information for each channel in the unit. Depending on the system configuration, there may be additional *footer* words following the *signal data* that hold the trigger/time stamp, boxcar width, general purpose ADC sample, and external data word.

When configured for 128 channels the IQSP584 produces 160 *signal data* words (128 words with *sign* and *range* reporting off). Other channel configurations produce less *signal data* words as shown in the table below.

# of Configured Channels	# of Signal Data Words (Sign & Range Words On)	# of Signal Data Words (Sign & Range Words Off)
128	160	128
96	120	96
64	80	64
32	40	32

Table 10: Event Packet Signal Data Word Totals

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The figure below shows a generic example of an *event* packet for a system configured with 17-bit data format (*sign* words on) and reporting for *Range Bits* (R), *Trigger/Time Stamp* (TS), *Boxcar Width* (BW), *Front Panel ADC* (ADC), and *External Word* (EW) enabled. The numbers in parentheses in the figure indicate the number of words for each data type in the packet.

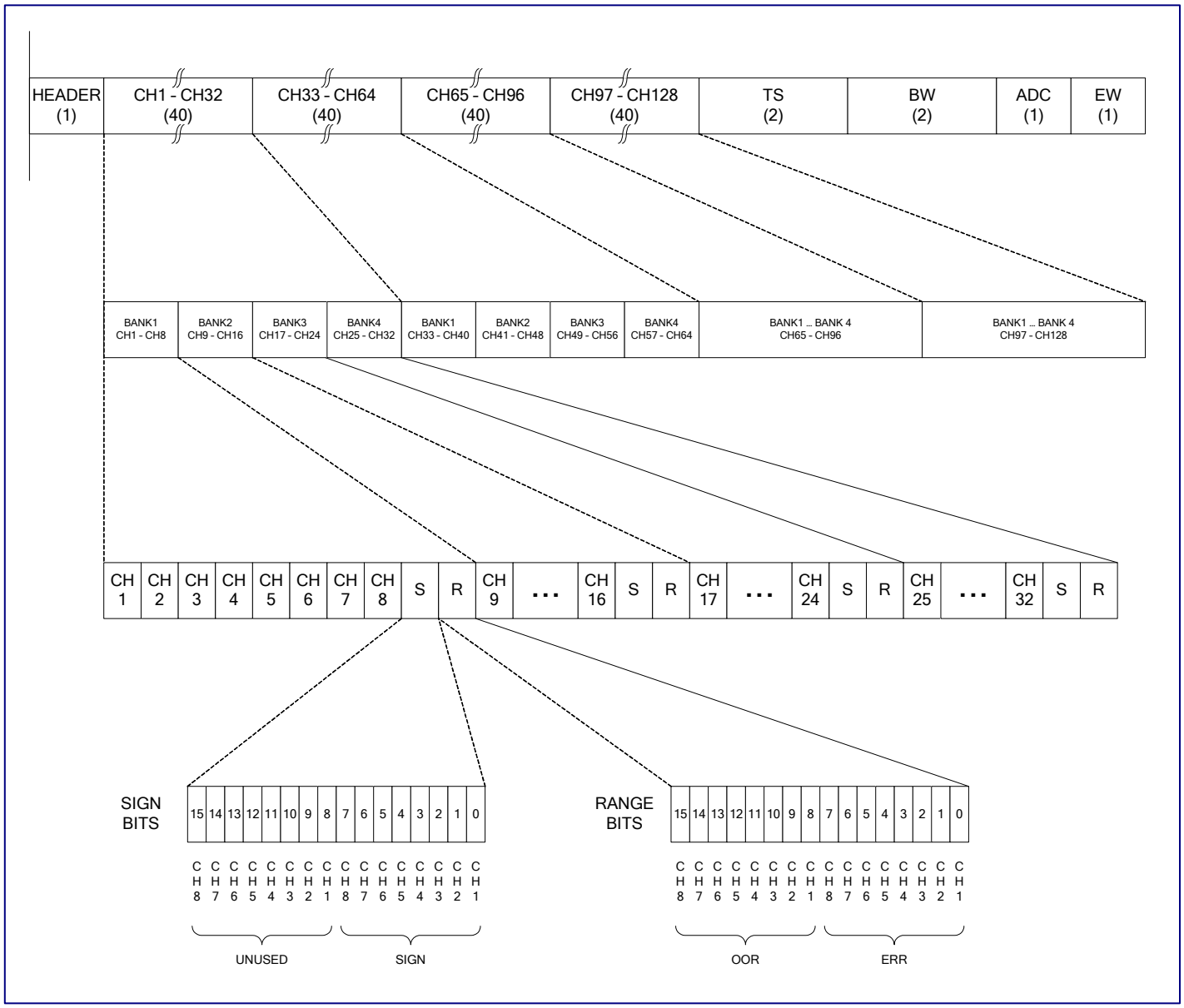


Figure 28: Event Packet Format

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Header Word

The contents of the *event* packet header word are detailed in the table below.

Bit	Function	Description
15-13	Packet Type	'100' = Event Packet
12	Out of Range Fault	'0' = No Faults Detected in Packet '1' = At Least 1 Fault Detected in Packet
11	Input Error Fault	'0' = No Faults Detected in Packet '1' = At Least 1 Fault Detected in Packet
10-6	Reserved	Reserved for Future Use
5	Filter Match	'0' = Filter Condition Not Met for Event or Filtering Not Enabled '1' = Filter Condition Met for Event
4-0	Filter Match Library Number	Library Number of Filter Match Don't Care if No Filter Match (currently unsupported)

Table 11: Event Packet Header Word

Signal Data

Signal data is organized sequentially starting with the data from the first channel followed by the data from the second channel and so on. Individual channels are included in the *event* packet only if they are enabled under the *Data Configuration* menu. Depending on the data format selected under this menu, signal channels are formatted as either 17-bit sign-magnitude words or 16-bit two's complement words; with the LSB for each word located in bit 0. For the 17-bit data format only, the signal data also includes a *sign* word — "bit-packed" as shown in the figure above — which holds the sign bits for the signal channels. Similarly "bit-packed" are the range words that if enabled, hold the range reporting bits. Disabling the range bit reporting under the *Data Configuration* menu removes the range words from the event packet. Sign and range bits for unused channels should be ignored. Programs manipulating the signal data words should use the bit weight of 41.20 femtocoulombs (fC) per bit.

Data Format	Dec Data Range	Hex Data Range	LSB Wgt	Full Scale Range
17-bit Sign-Magnitude	+16,383 to -16,383	0 3FFF to 1 3FFF	59.51 fC	877 pC
16-bit Two's Complement (Full Scale)	+16,383 to -16,384	3FFF to C000	59.51 fC	877 pC

Table 12: Log File Data Formats

Trigger / Time Stamp

The trigger/time stamp is encoded as a two word (32-bit) value. The least significant word follows the most significant word in the *event* packet. For time stamp reporting, the event time relative to the start of the acquisition (the time in the *ID Text Header*) is computed by multiplying the time stamp by the time stamp resolution selected in the *Data Configuration* menu. Disabling the reporting enable for this field removes that data from the packet.

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Boxcar Width

The boxcar width is reported using two words. It is computed by multiplying the two-word, 32-bit boxcar value by 10 nanoseconds. Disabling the reporting enable for this field in the *Data Configuration* menu removes that data from the packet.

Front Panel ADC

A single 16-bit word is used to report the measured value from the front panel, 12-bit analog-to-digital converter. To convert the integer value found in the *event* packet into a voltage, the value is multiplied by 5 volts and divided by 4096. Disabling the *Front Panel ADC* in the *Data Configuration* menu removes the data from the *event* packet.

External Word

The external data word taken from the digital interface on the rear panel of the PhotoniQ is reported in this field as a single 16-bit word. Disabling the *External Word* in the *Data Configuration* menu removes it from the *event* packet. The DIO100 option is required for this function.

Packet Length

The length (L) in words of each packet is given by the generic equation:

$$L = 1 + (NC_1+NC_2+NC_3+NC_4) + (K_1+K_2+K_3+K_4)\cdot(F+R) + 2\cdot TS + 2\cdot BW + ADC + EW$$

The settings include the *Number of Channels* in each bank ($NC_1$to NC_4) and the *Data Format* (F) which indicates whether *sign* words are used or not. The 17-bit data format uses *sign* words (F=1), the 16-bit format does not (F=0). Packet length is also dependent on the settings for the reporting enables for the *Range Bits* (R), *Trigger/Time Stamp* (TS), *Boxcar Width* (BW), *Front Panel ADC* (ADC), and *External Word* (EW). The reporting enables are set in the *Data Configuration* menu and can be either '1' or a '0'. The value (K_m) in the length formula is an integer that is computed from the *Number of Channels* in bank m (NC_m) by the equation:

$$K_m = \mathrm{INT}\left(\frac{NC_m + 7}{8}\right)$$

Minimum Packet Length

In certain applications it is desirable to minimize the size of the event packet so that the highest throughput to the PC can be attained. Additionally, a reduced event packet size allows the PhotoniQ's event buffer to hold more events before the possibility of overflow. In a scanned imaging application this means that larger image sizes or higher scan rates can be accommodated. The minimum event packet size is achieved by disabling all reporting functions and selecting the 16-bit data format. Since the header word cannot be disabled, the resulting event packet size is 33 words (66 bytes) for a 32 channel configuration, 65 words (130 bytes) for 64 channels, 97 words (194 bytes) for 96 channels, and 129 words (258 bytes) for 128 channels.

Converting a Binary Log File to Text

Text log files should be used if a user wishes to import logged event data into a spreadsheet for further processing. A built in routine is included in the GUI for the purpose of converting a binary log file (.log extension) into a text file (.txt extension). The output of this conversion is a file containing a time and date stamp header and the logged event data organized by row where each row represents a successive event. The *event* rows are stored as tab-delimited numbers where the columns represent from left to right, *Packet Number* (#), *Packet Type* (PT), *Out of Range* (OR), *Input Error* (IE), *Filter Match* (FM), and channels 1 through N in picocoulombs. Only configured channels appear in the log file — unused channels are left out. If enabled, the *Trigger/Time Stamp* (TS), *Boxcar Width* (BW), *Front Panel ADC Value* (ADC) and *External Data Word* (EW) are stored in the last four columns, respectively. A '4' in the *Packet Type* column indicates an *event* row — other packet types are currently unsupported. An out of range condition on any of the N data channels is identified in the *Out of Range* column by a '1'. Input errors are similarly reported in the *Input Error* column. If range bit reporting was enabled during logging, the individual channel data columns will contain the value "MAX" or "MIN" depending on whether the signal was out of range high or low, respectively. An input error on a particular channel is identified by the value "ERR" in its respective column in the table. The *Filter Match* column contains a '1' when the event met the filter criteria or a '0' when it did not. If filter processing is not enabled this column is filled with '0'. Due to conversion speed limitations, the log file converter should be used on files containing less than 20,000 events. Larger files will take a noticeable time to process.

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Configuration Tables

The hardware and software configuration of the PhotoniQ is stored in three separate tables; *user*, *custom*, and *factory* configuration tables. The sections that follow summarize the contents of the three tables. Some configuration parameters are not used in certain PhotoniQ products. Additionally, parameter limits may differ depending on PhotoniQ model number.

User Configuration Table

The *user* table contains the configuration of the PhotoniQ set by the user through the user interface. It is 1000 words long and is described in the table below.

Index	Parameter Name	Type	Description	Parameter Limits
0	SystemMode	16 SHORT	Indicates current system mode, acquire or standby mode	0 = Standby Mode 1 = Acquire Mode
1	HVLimit0	16 SHORT	Maximum allowed voltage on HV supply 1	Range = 100 – 13900 (10 – 1390V)
2	HVLimit1	16 SHORT	Maximum allowed voltage on HV supply 2	Range = 100 – 13900 (10 – 1390V)
3	NumChannelsB0	16 SHORT	Number of channels enabled bank 1	Range = 0 – 64
4	NumChannelsB1	16 SHORT	Number of channels enabled bank 2	Range = 0 – 64
5	NumChannelsB2	16 SHORT	Number of channels enabled bank 3	Range = 0 – 64
6	NumChannelsB3	16 SHORT	Number of channels enabled bank 4	Range = 0 – 64
7	HVEnabled	16 SHORT	Enables for high voltage supplies	Bit 0 = HV Supply 1 Enable/Disable Bit 1 = HV Supply 2 Enable/Disable
8	HVSetpoint0	16 SHORT	Current setpoint HV supply 1 (DAC 6)	Range = 100 – 13900 (10 – 1390V)
9	HVSetpoint1	16 SHORT	Current setpoint HV supply 2 (DAC 7)	Range = 100 – 13900 (10 – 1390V)
10	UserConfigID	16 SHORT	Unused	N/A (0 – 65535)
11	DCRD_AOut_0	16 SHORT	Daughtercard analog out control (DAC 8)	0-4095 (3.0V full scale)
12	BandEnables	16 SHORT	Spectral filtering band enables	Range = 0 – 255 (each bit position corresponds to 1 of 8 band enables)
13	Band0StartIndex	16 SHORT	Start index for spectral filtering band 1	Range = 0 – 255 (1 channel per bit)
14	Band0EndIndex	16 SHORT	End index for spectral filtering band 1	Range = 0 – 255 (1 channel per bit)
15-28	Band Indices for Remaining Bands	16 SHORT	Start index for spectral filtering band 2 - 8 End index for spectral filtering band 2 - 8	Range = 0 – 255 (1 channel per bit)
29	FlagEnables	16 SHORT	Spectral filtering flag enables	Range = 0 – 255 (each bit position corresponds to a flag enable)
30-33	Flag0Operand0-Flag0Operand3	16 SHORT	Spectral filtering operands for flag 1 configuration	Flag0Operand0,2 Range = 0 – 32767 Flag0Operand1,3 Range = 0 – 7 or 65535 (1 channel per bit or LSB wgt, 65535)
34-37	Flag1Operand0-Flag1Operand3	16 SHORT	Spectral filtering operands for flag 2 configuration	Same as Above
38-41	Flag2Operand0-Flag2Operand3	16 SHORT	Spectral filtering operands for flag 3 configuration	Same as Above

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Index	Parameter Name	Type	Description	Parameter Limits
42-45	Flag3Operand0-Flag3Operand3	16 SHORT	Spectral filtering operands for flag 4 configuration	Same as Above
46-49	Flag4Operand0-Flag4Operand3	16 SHORT	Spectral filtering operands for flag 5 configuration	Same as Above
50-53	Flag5Operand0-Flag5Operand3	16 SHORT	Spectral filtering operands for flag 6 configuration	Same as Above
54-57	Flag6Operand0-Flag6Operand3	16 SHORT	Spectral filtering operands for flag 7 configuration	Same as Above
58-61	Flag7Operand0-Flag7Operand3	16 SHORT	Spectral filtering operands for flag 8 configuration	Same as Above
62-69	PTerm0-PTerm7	16 SHORT	Spectral filtering product terms	Range = 0 – 255 (each bit position corresponds to a flag)
70	DataFilterEnable	16 SHORT	Spectral filtering data filter blocks data output if there is no spectral filter match	0 = Disabled 1 = Enabled
71	ProcessingEnables	16 SHORT	Enables for various signal processing options	Bit 0 = Spectral Filtering Enable Bit 1 = Gain Enable Bit 2 = Background Subtraction Enable
72	TimestampEnable	16 SHORT	Enables/Disables timestamp output	0 = Disabled 1 = Enabled
73	DAC_Spare	16 SHORT	SIB analog out control (DAC 5)	0-4095 (3.0V full scale)
74-75	TimestampInterval	32 LONG	Timestamp interval configuration	Range = 10 – 100000 (10ns per bit)
76	CustomWordsEnable	16 SHORT	Enables/Disable custom words output	0 = Disabled 1 = Enabled
77	EventCustomCount	16 SHORT	Number of custom words	Range = 0 – 64 (1 word per bit)
78	RESERVED	16 SHORT	Unused	N/A (0 – 65535)
79	ImageAcqMode	16 SHORT	Image Acquisition Mode Enable	0 = Particle 1 = Image
80	InputTrigThresh	16 SHORT	Input trigger threshold	Range = 1 – 8191
81	InputTrigChannel	16 SHORT	Input trigger current channel	Range = 0 – 256 (1 channel per bit)
82	RangeErrorEnable	16 SHORT	Enables/Disables range and error output	0 = Disabled 1 = Enabled
83	CrossBankConfig	16 SHORT	Current cross-bank configuration	Bit 0 = Cross Bank Enable Bit 1 = Bank 1 Main Trigger Bit 2 = Bank 2 Main Trigger Bit 3 = Bank 3 Main Trigger Bit 4 = Bank 4 Main Trigger
84	ReportPackingMode	16 SHORT	Indicates high speed or real-time acquisition	0 = Real-Time Acquisition (no packing) 1 = High Speed Acquisition
85	GPOutputEnable	16 SHORT	Enables/Disables general purpose output	0 = GP Output Disabled 1 = GP Output Always On 2 = GP Output Linked to Spectral Filter Match
86-87	GPOutputDelay	32 LONG	General purpose output delay	Range = 10 – 200000 (0.1 – 2000us)

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Index	Parameter Name	Type	Description	Parameter Limits
88-89	GPOutputPeriod	32 LONG	Period of general purpose output	Range = 10 – 200000 (0.1 – 2000us)
90	IntBoxcarEnable	16 SHORT	Enables/Disables boxcar mode	0 = Disabled 1 = Enabled
91	BoxcarWidthEnable	16 SHORT	Enables/Disables boxcar width output	0 = Disabled 1 = Enabled
92-99	ResetDelay0- ResetDelay3	32 LONG	Unused (reset delays 1 through 4)	N/A (0 – 65535)
100- 103	TrigSource0- TrigSource3	16 SHORT	Trigger source bank 1 to 4	0 = External Edge Trigger 1 = Internal Trigger 2 = Level Trigger 3 = Input Trigger 4 = DSP Trigger (Cross bank use only) 5 = Pre-trigger
104- 111	TrigPeriod0- TrigPeriod3	32 LONG	Trigger period bank 1 to 4	Range = 500 – 10000000 (200kHz – 10Hz)
112- 119	IntegPeriod0- IntegPeriod3	32 LONG	Integration period bank 1 to 4	Range = 5 – 10000000 (0.05 – 100000us)
120- 127	IntegDelay0- IntegDelay3	32 LONG	Integration delay bank 1 to 4	Range = -400000 – 10000000 (-4000us – 100000us)
128	SibSel0	16 SHORT	Hamamatsu R5900U-L16	Range = 0 – 0xFFFF
129	SibSel1	16 SHORT	Hamamatsu H8711	Range = 0 – 0xFFFF
130	SibSel2	16 SHORT	Pacific Silicon Sensor AD-LA-16-9-DIL18	Range = 0 – 0xFFFF
131	SibSel3	16 SHORT	Hamamatsu H7260	Range = 0 – 0xFFFF
132	SibSel4	16 SHORT	Undefined	Range = 0 – 0xFFFF
133- 135	SibSel5- SibSel7	16 SHORT	Reserved for SIB expansion	Range = 0 – 0xFFFF
136- 137	TriggerEndCount	32 LONG	Number of Triggers allowed in Acquire mode	Range = 0 – 0xFFFFFFFF
138	TrigStampSelect	16 SHORT	Triggerstamp Enable	0 = Disabled 1 = Enabled
139- 142	DataFormat0- DataFormat3	16 SHORT	Bank 1 to 4 data format	0: 17-bit Sign-Magnitude 1: 16-bit 2's Comp w/ shift (FS) 2: 16-bit 2's Comp no shift (HS)
143- 149	RESERVED		Reserved for expansion	
150- 405	Ch0GainComp- Ch255GainComp	16 SHORT	Gain compensation values for each channel	0 – 0xFFFF
406- 661	Ch0TrigThresh- Ch255TrigThresh	16 SHORT	Input triggering threshold values for each channel	0 – 0xFFFF
662- 677	Ch0TrigEnb- Ch255TrigEnb	16 SHORT	Input triggering enables bit packed for each channel	0 = Disabled One bit per channel
678	MBandEnables	16 SHORT	Matrix filtering band enables	Range = 0 – 255 (each bit position corresponds to 1 of 8 band enables)

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Index	Parameter Name	Type	Description	Parameter Limits
679	MBand0StartIndex	16 SHORT	Start index for matrix filtering band 1	Range = 0 – 255 (1 channel per bit)
680	MBand0EndIndex	16 SHORT	End index for matrix filtering band 1	Range = 0 – 255 (1 channel per bit)
681-694	MBand Indices for Remaining MBands	16 SHORT	Start index for matrix filtering band 2 - 8 End index for matrix filtering band 2 - 8	Range = 0 – 255 (1 channel per bit)
695	MFlagEnables	16 SHORT	Matrix filtering flag enables	Range = 0 – 255 (each bit position corresponds to a flag enable)
696-699	MFlag0Operand0-MFlag0Operand3	16 SHORT	Matrix filtering operands for flag 1 configuration	Flag0Operand0,2 Range = 0 – 32767 Flag0Operand1,3 Range = 0 – 7 or 65535 (1 channel per bit or LSB wgt, 65535)
700-703	MFlag1Operand0-MFlag1Operand3	16 SHORT	Matrix filtering operands for flag 2 configuration	Same as Above
704-707	MFlag2Operand0-MFlag2Operand3	16 SHORT	Matrix filtering operands for flag 3 configuration	Same as Above
708-711	MFlag3Operand0-MFlag3Operand3	16 SHORT	Matrix filtering operands for flag 4 configuration	Same as Above
712-715	MFlag4Operand0-MFlag4Operand3	16 SHORT	Matrix filtering operands for flag 5 configuration	Same as Above
716-719	MFlag5Operand0-MFlag5Operand3	16 SHORT	Matrix filtering operands for flag 6 configuration	Same as Above
720-723	MFlag6Operand0-MFlag6Operand3	16 SHORT	Matrix filtering operands for flag 7 configuration	Same as Above
724-727	MFlag7Operand0-MFlag7Operand3	16 SHORT	Matrix filtering operands for flag 8 configuration	Same as Above
728-735	MPTerm0-MPTerm7	16 SHORT	Matrix filtering product terms	Range = 0 – 255 (each bit position corresponds to a flag)
736	MDataFilterEnable	16 SHORT	Matrix filtering data filter blocks data output if there is no matrix filter match	0 = Disabled 1 = Enabled
737	MDataFilterConfig	16 SHORT	Matrix A/B combine parameters	
738	MDataFilterAChannels	16 SHORT	Matrix A channel span in GUI	
739	MDataFilterBChannels	16 SHORT	Matrix B channel span in GUI	
740	MDataFilterA	16 SHORT	Matrix A parameters in row/column format	
741	MDataFilterB	16 SHORT	Matrix B parameters in row/column format	
742	DisplaySetting	16 SHORT	Display mode for GUI graphs	Bit 0 = Bar 32 Bit 1 = Bar 64 Bit 2 = Bar 128 Bit 3 = Bar 256 Bit 4 = Dual 4 x 4 Bit 5 = 8 x 8 Bit 6 = Dual 8 x 8 Bit 7 = 16 x 16
743	Bar32Channels	16 SHORT	Channels for Bar 32 graph	

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Index	Parameter Name	Type	Description	Parameter Limits
744	Bar64Channels	16 SHORT	Channels for Bar 64 graph	
745	Bar128Channels	16 SHORT	Channels for Bar 128 graph	
746	Bar256Channels	16 SHORT	Channels for Bar 256 graph	
747	S8x8Channels	16 SHORT	Channels for single 8 x 8 graph	
748	D4x4ChannelsA	16 SHORT	Channels dual 4 x 4 graph A	
749	D4x4ChannelsB	16 SHORT	Channels dual 4 x 4 graph B	
750	D8x8ChannelsA	16 SHORT	Channels dual 8 x 8 graph A	
751	D8x8ChannelsB	16 SHORT	Channels dual 8 x 8 graph B	
752	S16x16Channels	16 SHORT	Channels single 16 x16 graph	
753	Bar32Attributes	16 SHORT	Attributes for Bar 32 graph	
754	Bar64Attributes	16 SHORT	Attributes for Bar 64 graph	
755	Bar128Attributes	16 SHORT	Attributes for Bar 128 graph	
756	Bar256Attributes	16 SHORT	Attributes for Bar 256 graph	
757	S8x8Attributes	16 SHORT	Attributes for single 8 x 8 graph	Bit 0 = Graph x flip Bit 1 = Graph y flip Bit 2 = Graph transpose Bit 6 = Graph color/BW
758	D4x4Attributes	16 SHORT	Attributes dual 4 x 4 graphs	Bit 0 = Graph A x flip Bit 1 = Graph A y flip Bit 2 = Graph A transpose Bit 3 = Graph B x flip Bit 4 = Graph B y flip Bit 5 = Graph B transpose Bit 6 = Graph color/BW
759	D8x8Attributes	16 SHORT	Attributes dual 8 x 8 graphs	Bit 0 = Graph A x flip Bit 1 = Graph A y flip Bit 2 = Graph A transpose Bit 3 = Graph B x flip Bit 4 = Graph B y flip Bit 5 = Graph B transpose Bit 6 = Graph color/BW
760	S16x16Attributes	16 SHORT	Attributes single 16 x16 graph	Bit 0 = Graph x flip Bit 1 = Graph y flip Bit 2 = Graph transpose Bit 6 = Graph color/BW

Table 13: User Configuration Table

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Custom Configuration Table

The *custom* table is a reserved space of 250 words that is used by applications programmers to store custom configuration data.

Index	Parameter Name	Type	Description	Parameter Limits
1000-1249	CustomElement0-CustomElement249	16 SHORT	Reserved location for custom configuration parameters	N/A (0 – 65535)

Table 14: Custom Configuration Table

Factory Configuration Table

Factory-programmed, read-only configuration data is found in the *factory* table. This table is 750 words long and is described below.

Index	Parameter Name	Type	Description	Parameter Limits
1250-1251	DSPRevCode	32 LONG	DSP Revision Code	None (0 – 0xFFFFFFFF)
1252-1253	FPGARevCode	32 LONG	FPGA Revision Code	None (0 – 0xFFFFFFFF)
1254-1509	Ch0BckgndOffset-Ch255BckgndOffset	16 SHORT	DSP calculated background for each channel	0 - 0xFFFF
1510-1765	Ch0ElecOffset-Ch255ElecOffset	16 SHORT	DSP calculated electrical offsets for each channel	0 – 0xFFFF
1766-1767	SiteSerNum	32 LONG	Unused	None (0 – 0xFFFFFFFF)
1768-1769	BoardSerNum	32 LONG	Board Serial Number	None (0 – 0xFFFFFFFF)
1770	SIBSpareControl	16 SHORT	Unused	Unused
1771	SpeedDyRange	16 SHORT	Speed Dynamic Range for each bank, nibble based	For each nibble (4 bits) 0 = Standard 1 = 16 Bit 2 = 14 Bit
1772	HVPopulated0	16 SHORT	High voltage supply 1 populated	0 = Unpopulated 1 = Populated
1773	HVPopulated1	16 SHORT	High voltage supply 2 populated	0 = Unpopulated 1 = Populated
1774	BiasVoltage	16 SHORT	Bias Voltage Control (DAC 1)	0-4095 (3.0V full scale)
1775	DREVoltage0	16 SHORT	Can be configured for an alternative front-end configuration (DAC4)	0-4095 (3.0V full scale)
1776	RESERVED	16 SHORT	Reserved for expansion	
1777-1780	ResetLowThresh0-ResetLowThresh3	16 SHORT	Reset low threshold for bank 1 to bank 4	0 - 0xFFFF
1781-1784	ResetHighThresh0-ResetHighThresh3	16 SHORT	Reset high threshold for bank 1 to bank 4	0 - 0xFFFF

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Index	Parameter Name	Type	Description	Parameter Limits
1785-1788	OORLowThresh0-OORLowThresh3	16 SHORT	Out of range low threshold for bank 1 to bank 4	0 - 0xFFFF
1789-1792	OORHighThresh0-OORHighThresh3	16 SHORT	Out of range high threshold for bank 1 to bank 4	0 - 0xFFFF
1793-1794	VBTest0- VBTest1	16 SHORT	Test voltages (DAC2 and DAC3)	0-4095 (3.0V full scale)
1795-1798	ChProcessingEnables0 ChProcessingEnables3	16 SHORT	Channel processing enables for bank 1 to bank 4	Bit 0 = Deserializer Enable Bit 1 = Reset Threshold Enable Bit 2 = Buffer Enable Bit 3 = Differencer Raw or Subtract Bit 4 = Offset Enable Bit 5 = Gain Enable Bit 6 = Range Adjust Enable Bit 7 = Data Trigger Enable 0 = Disabled, Raw 1 = Enabled, Subtract
1799-1802	NumChPopulated0-NumChPopulated3	16 SHORT	Number of channels populated for bank 1 to bank 4	0- 0xFFFF (Should never exceed 64 channels per bank, 256 total channels)
1803	SignalPolarity	16 SHORT	Signal polarity	Nibble-based (4-bits/nibble) per bank signal polarity select. 0 = Sign Magnitude 1 = Magnitude
1804	TestVoltageEnable	16 SHORT	Test voltage enables bank 1 to bank 4	0 = TV1 Disabled, TV2 Disabled 1 = TV1 Enabled, TV2 Disabled 2 = TV1 Disabled, TV2 Enabled 3 = TV1 Enabled, TV2 Enabled
1805-1806	HV0Parameter0-HV0Parameter1	16 SHORT	High voltage supply 1 normalization parameters	Factory calculated values. Floating-point calculation results * 100 are entered into table.
1807-1808	HV1Parameter0-HV1Parameter1	16 SHORT	High voltage supply 2 normalization parameters	Same As Above
1809	AssemblyRevisionPCRev	16 SHORT	PCB Revision Number	None (0 – 0xFFFF)
1810	AssemblyRevisionLetter	16 SHORT	Assembly Revision Letter	None (Only letters are A-F)
1811	RESERVED	16 SHORT	Reserved for expansion	
1812	X1	16 SHORT	Trigger Indicator LED On Period	1 – 0x32
1813	Y1	16 SHORT	Trigger Indicator LED Off Period	1 – 0x32
1814	X2	16 SHORT	Acquisition Indicator LED On Period	1 – 0x32
1815	Y2	16 SHORT	Acquisition Indicator LED Off Period	1 – 0x32
1816	CPLDRevCode	16 SHORT	CPLD Revision Code	0 – 0xFF
1817 - 1832	ModelNumber	16 SHORT	Model Number String	None (ASCII Codes)
1833	SDRAMPopulated	16 SHORT	SDRAM Type Populated	0: None 1: 32 MByte

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Index	Parameter Name	Type	Description	Parameter Limits
				2: 64 MByte
1834	SDRAMEnabled	16 SHORT	SDRAM Type Enabled	0: None 1: 32 MByte 2: 64 MByte
1836-1837	ProgScaling0	32 SINGLE	Bank 1 floating-point programmable bit scale factor, units of Coulombs	None
1838-1839	ProgScaling1	32 SINGLE	Bank 2 floating-point programmable bit scale factor, units of Coulombs	None
1840-1841	ProgScaling2	32 SINGLE	Bank 3 floating-point programmable bit scale factor, units of Coulombs	None
1842-1843	ProgScaling3	32 SINGLE	Bank 4 floating-point programmable bit scale factor, units of Coulombs	None
1844 - 1999	RESERVED		Reserved for expansion	

Table 15: Factory Configuration Table

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DLL Function Prototypes

To accommodate custom application development, the low-level control and communication functions for the PhotoniQ have been provided in both a dynamic link library (PhotoniQ.dll) and an import library (PhotoniQ.lib). The provided header file (PhotoniQ.h) contains the required function prototypes, typedefs, and other definitions (contained in extcode.h, which is included in PhotoniQ.h and is also provided).

Function Prototypes

The DLL prototype functions use the standard C calling convention and require the run-time engine for LabVIEW™ version 9.0. The five functions provided in the file PhotoniQ.dll are described below. The Windows XP API is leveraged by each of these functions. Typedefs for non-standard types can be found in the header files (PhotoniQ.h and extcode.h).

Initialize:

void __cdecl **Initialize** (long BufferSize, TD1 *errorInNoError, unsigned long *Version, TD1 *errorOut);

Opens and initializes an interface to a PhotoniQ. Sets the amount of buffering used in USB communications with the PhotoniQ, and returns the USB firmware version number from the PhotoniQ.

BufferSize	-	Sets the amount of buffering used in USB communications with the PhotoniQ. Valid range is 8-200. Larger numbers use more buffering, which helps keep the throughput of the interface maximized.
errorInNoError	-	Accepts a standard LabVIEW error cluster. Initialization is not performed if an error is present.
Version	-	Indicates the USB firmware version number.
errorOut	-	Points to error information from the function in a standard LabVIEW error cluster.

Close:

void __cdecl **Close** (TD1 *errorInNoError, TD1 *errorOut);

Closes the interface to a previously initialized PhotoniQ.

errorInNoError	-	Accepts a pointer to a standard LabVIEW error cluster.
errorOut	-	Duplicate error in cluster output.

ControlInterface:

void __cdecl **ControlInterface** (unsigned short Opcode, unsigned short Arguments[], long len, long TimeoutMs, TD1 *errorInNoError, unsigned short *NumRetArguments, unsigned short ReturnedArguments[], long len2, TD1 *errorOut);

Executes a control operation to a previously initialized PhotoniQ. The Opcode input specifies the operation to be executed, and any additional information should be entered using the Arguments input. Any returned information is available in the Returned Arguments output.

Opcode	-	Selects the control operation to be performed.
Arguments	-	Input for any additional information required by the selected control operation.
len	-	Length of Arguments[] array.
TimeoutMs	-	Specifies the time to wait for a response from the PhotoniQ. Value entered in milliseconds.
errorInNoError	-	Accepts a standard LabVIEW error cluster. Control operation is not performed if an error is present.
NumRetArguments	-	Indicates the number of returned arguments.
ReturnedArguments	-	Output for any returned information from the control operation.
len2	-	Length of ReturnedArguments[] array.
errorOut	-	Points to error information from the function in a standard LabVIEW error cluster.

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DataInterface:

void __cdecl DataInterface (LVRefNum *fileRefnum, LVRefNum *BoolRefnum, LVRefNum *DigNumRefnum, LVRefNum *TrigCountRefnum, unsigned long NumEvents, double TimeoutS, double TimeToCollect, LVBoolean *HighSpeedMode, TD1 *errorInNoError, LVBoolean *MessagingEnabled, long MessagingArray[], long len, long *NumEventsRead, LVRefNum *dupFileRefnum, LVBoolean *NumEventsReached, LVBoolean *TimeoutReached, LVBoolean *TimeToCollectReached, unsigned short ImmediateEventData[], long len2, double *ElapsedTimeS, TD1 *errorOut);

Collects data from a previously initialized PhotoniQ. Options enable logging to a file, programmable termination conditions, and messaging data availability to another thread/window. Data is collected in Events, where an Event consists of all data generated by the PhotoniQ in response to a single trigger event.

fileRefnum	-	If a valid file refnum is entered in this control, all data collected is logged to that file.
BoolRefnum	-	Allows a calling LabVIEW panel to specify a Boolean control used to terminate data collection (True - Collect Data, False - End Collection and Return).
DigNumRefnum	-	Allows a calling LabVIEW panel to specify a Digital Numeric control used to display the running total number of events collected.
TrigCountRefnum	-	Allows a calling LabVIEW panel to specify a Digital Numeric control used to display the running total number of triggers from the trigger counter.
NumEvents	-	Specifies the number of Events to collect. The function will return after collecting the specified number of Events. Set to zero to collect an indefinite number of Events.
TimeoutS	-	Specifies the allowed time between Events If the specified time elapses between received Events, the function will return. Set to zero to disable the timeout. Value entered in seconds.
TimeToCollectS	-	Specifies the time to collect Events. The function will return after the specified time has elapsed. Set to zero to collect for an indefinite length of time.
HighSpeedMode	-	Used to select the acquisition mode. False should be entered if the returned event data is to be immediately displayed. True should be entered if large amounts of data are to be collected before being processed by another window/thread or logged to disk.
errorInNoError	-	Accepts a standard LabVIEW error cluster. Data collection is not performed if an error is present.
MessagingEnabled	-	Set to True if the data is to be messaged to another window. Set to False if messaging is not used. If True, the MessagingArray must be configured. When enabled, the Data Interface will call the Windows API function PostMessage(), indicating to the specified window/thread using the specified message that data is available to be processed. The wParam argument of the message will indicate which of the two specified buffers has been filled, and the lParam of the message will indicate the length of the data within that buffer. At the beginning of the data buffer are two 32-bit integers representing the running total counts of events and triggers received respectively. Both values are stored little-endian. The remainder of the buffer contains event data (length = lParam - 4).
MessagingArray	-	Contains the information required for messaging. Element 0 - The handle of the window to be messaged. Element 1 - The message to be sent to the specified window. Element 2 - A pointer to the first of two (A) 1MByte buffers. Element 3 - A pointer to the second of two (B) 1MByte buffers. Element 4 - A pointer to an unsigned 16-bit integer. Acquisition will stop if the referenced value is zero when either a message is sent or an internal timeout is reached.
len	-	Length of MessagingArray[] array.
NumEventsRead	-	Returns the number of events read by the Data Interface.
dupFileRefnum	-	Duplicate file refnum output.
NumEventsReached	-	Boolean output, returns True if the Data Interface returned as a result of reaching the number of events specified by NumEvents.
TimeoutReached	-	Boolean output, returns True if the Data Interface returned as a result of reaching the timeout specified by TimeoutS.
TimeToCollectReached	-	Boolean output, returns True if the Data Interface returned as a result of reaching the time to collect specified by TimeToCollectS.

ImmediateEventData	-	Returns a portion of the collect Event Data. This output is only guaranteed to be valid when NumEvents is set to 1 and NumEventsReached is True. The value of this output is unspecified when the Data Interface returns due to a timeout or a count larger than 1. To evaluate all data, use file logging or messaging.
len2	-	Length of ImmediateEventData[] array.
ElapsedTimeS	-	Returns the time elapsed while collecting data.
errorOut	-	Points to error information from the function in a standard LabVIEW error cluster.

ErrorHandler:

void __cdecl **ErrorHandler** (TD1 *errorInNoError, LVBoolean *OutputErrorResult, char OutputErrorString[], long len, TD1 *errorOut);

Converts a LabVIEW Error Cluster generated by a PhotoniQ function and returns a Boolean Error Result, and an Error String appropriate for display in a user interface.

errorInNoError	-	Accepts a standard LabVIEW error cluster.
OutputErrorResult	-	True if an error was present, False if no error.
OutputErrorString	-	Contains a description of the error present, blank if no error.
len	-	Length of the OutputErrorString[] array.
errorOut	-	Duplicate error in cluster output.

LVDLLStatus:

MgErr **LVDLLStatus** (CStr errStr, int32 errStrLen, void *module);

All Windows DLLs built from LabVIEW, in addition to the functions you export, contain this exported function. The calling program uses this function to verify that the LabVIEW DLL loaded correctly. If an error occurs while loading the DLL, the function returns the error.

errStr	-	Pass a string buffer to this parameter to receive additional information about the error.
errStrLen	-	Set to the number of bytes in the string buffer passed as errStr.
module	-	to retrieve the handle to the LabVIEW Run-Time Engine being used by the DLL. Typically, this parameter can be set as NULL.

Error Cluster Initialization

The error clusters should be initialized by the user application as shown below:

TD1 errIn = {LVFALSE, 0, NULL};

TD1 errOut = {LVFALSE, 0, NULL};

This initialization will create the equivalent of a "No Error" cluster for use with the DLL functions. The individual functions will update the errOut cluster if an error is detected during the execution of that function.

Control Interface Commands

The command op codes for the control interface (ControlInterface) are given in the table below.

Opcode	Function Name	Description
0x03	Update PhotoniQ Configuration	Updates the PhotoniQ configuration by writing parameters to the PhotoniQ User Configuration Table. Input Arguments: An unsigned 16-bit number followed by an array of unsigned 16-bit configuration table parameters. A zero as the first argument indicates a write of the configuration table to RAM only, while a one indicates a write to flash memory. Return Arguments: Error returned if necessary
0x04	Read PhotoniQ Configuration	Reads the three sections of the PhotoniQ Configuration Table Input Arguments: Single unsigned 16-bit number. A zero indicates a read of the configuration table from RAM, while a one indicates a read from flash memory. Return Arguments: Array of unsigned 16-bit configuration table parameters.
0x06	Read ADCs	Performs a read of the ADCs on the PhotoniQ. Input Arguments: None. Return Arguments: Results of eight ADC reads in an array of unsigned 16-bit values in the following order: HV1 monitor, HV2 monitor, SIB HV Monitor, +3.3VA, +5V UF, DCRD AIN1, DCRD AIN0, ADC Spare To convert codes to volts: (Codes/4096)* scale factor. Scale factor = 3 for assembly rev 0 and rev 1, 5 for assembly rev 2.
0x07	Calibrate	Performs a system calibration. Calculates either an offset or background calculation. (Offset calculation not recommended for users) Input Arguments: Three unsigned 16-bit arguments. 0x55, 0xAA, and 1 to indicate offset calculation desired, 2 to indicate background calculation. Return Arguments: Error if necessary.
0x09	Report Update	Increments the number of reports that the PC can accept. Input Arguments:0x55, 0xAA, and the increment to the number of reports allowed. Return Arguments: None, this opcode does not generate a response.
0x0B	System Mode	Changes the system mode from acquire to standby, or standby to acquire. Input Arguments: 0x55, 0xAA, and the new system mode (0 = standby, 1 = acquire) Return Arguments: Error if necessary.
0xAA	Re-boot for FW Update	Reboots the DSP and determines if system should enter the main code or PROM Burn code. Used for a system firmware update and available when running the main code or the PROM Burn code. Input Arguments: 0x55, 0xAA, and 1 to enter PROM Burn code, 0 to enter Main program code. Return Arguments: Error if necessary.

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Opcode	Function Name	Description
0xBB	Erase System Code (PROM Burn)	Erases current DSP or FPGA system code. Available only when running the PROM Burn code. Input Arguments: 0x55, 0xAA and 0xF0 for FPGA code, 0x0F for DSP code. Return Arguments: Error if necessary.
0xCC	Program System Code (PROM Burn)	Programs one line of DSP or FPGA system code. Available only when running the PROM Burn code. Input Arguments: 0x55, 0xAA, 0xF0 (FPGA code) or 0x0F (DSP code), Line from an Intel Hex-32 formatted programming file. Return Arguments: Error if necessary.

Table 16: Control Interface Commands

Low Level USB Interface Description

A description of the low level interface to the PhotoniQ using the USB port is provided for programmers who wish to write their own set of DLLs or drivers. The sections below summarize the details of the interface.

USB Device Defaults

Value	Details
USB Compatibility	USB 2.0 (High-speed)
Vendor ID	0x0925
Product ID	0x0480
Device ID	0x0000
Class	Human Interface Device (HID, 1.1)
Indexed String 1	"Vertilon"
Indexed String 2	"PhotoniQ"
Indexed String 3	"High" (when connected to high-speed host) "Full" (when connected to full-speed host)
Indexed String 4	"06032801"

Table 17: USB Device Details

HID Implementation

The PhotoniQ implements the reports listed below for communication. Report IDs 0x01, and 0x11 (Feature, Input, and Output) are used to send commands to the PhotoniQ and receive responses. Report ID 0x22 (Input only) is used to transfer event data from the PhotoniQ to the host. The opcodes that can be used with each report type are also listed.

Report ID	Type	Length (Bytes)	Opcodes (Hex)
0x01	Feature	63	00AA
0x11	Output	63	0003, 0004, 0006, 0007, 0009, 000B, 00BB, 00CC
0x11	Input	63	0003, 0004, 0006, 0007, 0009, 000B, 00BB, 00CC
0x22	Input	4095	0099

Table 18: HID Report Descriptions

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Report Format (IDs 0x01 and 0x11)

The commands sent to the PhotoniQ using report IDs 0x01 and 0x11 must have the format specified in the following table. Note that indices here are specified for shortword data.

Index	Value
0	Report ID – MSByte must be 0x00
1:3	Fixed Start Codon – ASCII string “CMD”
4	Opcode
5	Length – Number of data words
6:(Length+5)	Data
Length+6	Checksum – Sum of all values including checksum equals zero.

Table 19: Report Format (IDs 0x01 and 0x11)

Responses to commands are returned using the same report ID. Responses have a minimum Length value of 1, so that each response can return an error indicator in the first data location (1 – No Error, 0 – Error). If an error is present, another data word is added to the report in the second data location indicating the specific error. A list of error codes is provided below.

Code	Name	Description
0x01	Erase Failed	DSP or FPGA erase operation failed.
0x02	Program Failed	DSP or FPGA program operation failed.
0x77	Configuration ID mismatch	Factory configuration ID does not match user value.
0x88	Communication Timeout	A control transfer timeout occurred resulting in an incomplete packet.
0xAA	Invalid Argument	Argument is out of allowed range. Returns an additional data value containing the index of the offending argument.
0xAB	EEPROM Error	USB erase or program operation failed.
0xAC	EEPROM Bus Busy	USB erase or program operation failed.
0xBB	Invalid Number of Arguments	System received an unexpected number of arguments for a given command.
0xCC	Invalid Command	System received an unknown command opcode.
0xDD	Invalid Length	Receive data length does not match expected total length.
0xEE	Invalid Start Codon	System received an invalid start sequence (“CMD”).
0xFF	Invalid Checksum	System received an invalid checksum from the host.

Table 20: Report Error Codes

Report Format (ID 0x22)

The event data sent from the PhotoniQ using report ID 0x22 will have the format specified in the following table. Note that indices here are specified for shortword data. Note that an HID class driver will remove the Report ID before returning any data, and indices should be adjusted accordingly.

Index	Value
0	Report ID – MSByte must be 0x00
1:3	Fixed Start Codon – ASCII string “DAT”
4	Opcode – 0x0099
5	Length – Number of data words
6	Number of Events in Report
7	Words per Event
8	Number of Remaining Available Reports
9	Trigger Count (L)
10	Trigger Count (H)
11:(Length+10)	Data
Length+11	Checksum – Sum of all values including checksum equals zero.

Table 21: Report Format (ID 0x22)

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Appendix A: Sensor Interface Board Connector

The connection to a separate sensor interface board (SIB) that holds the sensor (a multi-anode PMT, silicon photomultiplier, or photodiode array) is made through a specialized cable that connects between it and the front panel SIB connectors on the PhotoniQ IQSP584. Thirty-two (32) low-noise, parallel coaxial connections are provided through each of these small form factor connectors. Ordinarily this interface is used with Vertilon's standard sensor interface boards and accompanying SIB cables. In this situation the user simply connects the SIB cables between the sensor interface boards and the front panel SIB connectors. For applications that utilize custom SIBs or require connectivity to the PhotoniQ in a non-standard way, the pinout for the SIB connectors is provided in Table 7. Signal ground is supplied on the cable shield which is shown as pins 41 and 42 in the table. The table shows the channel numbering for the first SIB connector (channels 1 to 32). For the other three SIB connectors, the pin outs are virtually identical to that of the first one except that the signal inputs are instead for channels 33 to 64, 65 to 96, and 97 to 128, respectively. Because of the complex analog connectivity requirements at this interface, it is strongly advised that the user contact Vertilon before mating a custom device to the PhotoniQ. For this reason, the table below is provided for reference only.

Signal Name	Pin #	Signal Name	Pin #
BIAS	1	HV MONITOR	2
SIB_DIN	3	SIB_CLK	4
IN16	5	IN32	6
IN15	7	IN31	8
IN14	9	IN30	10
IN13	11	IN29	12
IN12	13	IN28	14
IN11	15	IN27	16
IN10	17	IN26	18
IN9	19	IN25	20
IN8	21	IN24	22
IN7	23	IN23	24
IN6	25	IN22	26
IN5	27	IN21	28
IN4	29	IN20	30
IN3	31	IN19	32
IN2	33	IN18	34
IN1	35	IN17	36
SIB_DOUT	37	SIB_SYNC	38
SIB_DAC	39	+5V	40
GND	41	GND	42

Table 22: PhotoniQ Sensor Interface Board Connector

Appendix B: Optional High Voltage Supplies (HVPS001 / HVPS002 / HVPS701)

The HVPS series of high voltage power supplies is an upgrade option for all PhotoniQ multichannel PMT data acquisition systems. Fully controllable through the PhotoniQ graphical user interface and USB drivers, the HVPS option gives the user the ability to bias photomultiplier tubes, silicon photomultipliers, and avalanche photodiode arrays without the need for additional external equipment. These power supplies are available in a negative 1000 volt version (HVPS001) and negative 1500 volt version (HVPS002) for PMTs, and a negative 100 volt version (HVPS701) for silicon photomultipliers and APDs. All come equipped with a 90 cm cable for connection to any one of Vertilon's sensor interface boards. The cable includes an industry standard SHV plug on one end of the cable for direct connection to the front panel of the PhotoniQ. Connection to the sensor interface board is made using a specialized proprietary low-profile connector on the other end. An "M" version (e.g. HVPS001M) of the products are available for OEM applications and are identical to the "non M" versions except that the SHV plug is replaced with a second proprietary connector for direct connection to the PhotoniQ printed circuit board. All 64 channel versions of the PhotoniQ can be upgraded with up to two high voltage power supplies.

Description	HVPS001	HVPS002	HVPS701
Maximum Unloaded Voltage[1]	-1000 V	-1500 V	-100 V
Maximum Fully Loaded Voltage[2]	-925 V	-1390 V	-92.5 V
Minimum Voltage	-50 V	-100 V	-5.0 V
Voltage Accuracy	±3%	±3%	±3%
Voltage Adjustment Resolution[3]	275 mV	410 mV	27.5 mV
Maximum Voltage Ripple at Max Load	0.3% pk-pk	0.5% pk-pk	0.2% pk-pk
Nominal Voltage Ripple Frequency	150 Hz	150 Hz	150 Hz
Maximum Current at Maximum Voltage	370 uA	250 uA	1 mA
Power Consumption at Max Load	0.7 W	0.7 W	0.4 W
Cable Part Number (Included)	HVC090	HVC090	HVC090
Cable Length	90 cm	90 cm	90 cm
PhotoniQ Connector Type[4]	SHV Plug	SHV Plug	SHV Plug
Sensor Interface Board Connector Type	Proprietary	Proprietary	Proprietary

[1] Voltage limited to Maximum Fully Loaded Voltage in GUI

[2] Voltage range divided by three at SIB when using SIB216

[3] Voltage adjustment resolution is 100mV in GUI

[4] Proprietary connector is miniature low-profile 2-pin

Cable Handling Notice

The included high voltage power supply cables utilize a specialized two pin miniature connector for connection to the sensor interface board and PhotoniQ printed circuit board (OEM versions only). The connector is designed for low-profile applications such as where a sensor interface board or PhotoniQ printed circuit board is mounted in a confined space. For this reason care should be taken when connecting and disconnecting the cable. Never disconnect the cable by pulling on the wire. Instead, carefully grip the plastic housing and pull evenly with very light force.

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Appendix C: Optional External Data Word Interface (DIO100)

The digital I/O interface for the *external word* is similar to a standard SPI interface with handshaking consisting of a data ready (DR) and serial data output (SDO) from the external device; and a chip select (/CS) and serial data clock (SCK) from the PhotoniQ. Timing is as shown below and begins with SCK and /CS from the PhotoniQ idling high. A short time after the external hardware provides the trigger, it asserts the data ready signal (DR) indicating that the first serial bit (the MSB) is available on SDO. Upon sensing DR high, the PhotoniQ asserts /CS low after which SCK goes low. The interface then provides 16 rising edges on SCK which internally register the serial data in the PhotoniQ and also indicate to the external hardware that the next serial bit should be placed on the SDO pin. After the 16th rising clock edge, the SCK signal idles high again. The cycle is completed when /CS is de-asserted high. The external hardware should de-assert the DR signal prior to the end of the cycle. Ideally this should occur shortly after /CS goes low. The DR signal should be asserted by the external hardware no later than t_{dr} after the rising edge of the trigger signal. External words that do not meet this constraint may be ignored by the PhotoniQ and the value for the *external word* will be forced to zero. For conditions where a trigger signal is not accepted by the PhotoniQ — such as when two closely spaced triggers occur — the *external word* if present, is also not accepted.

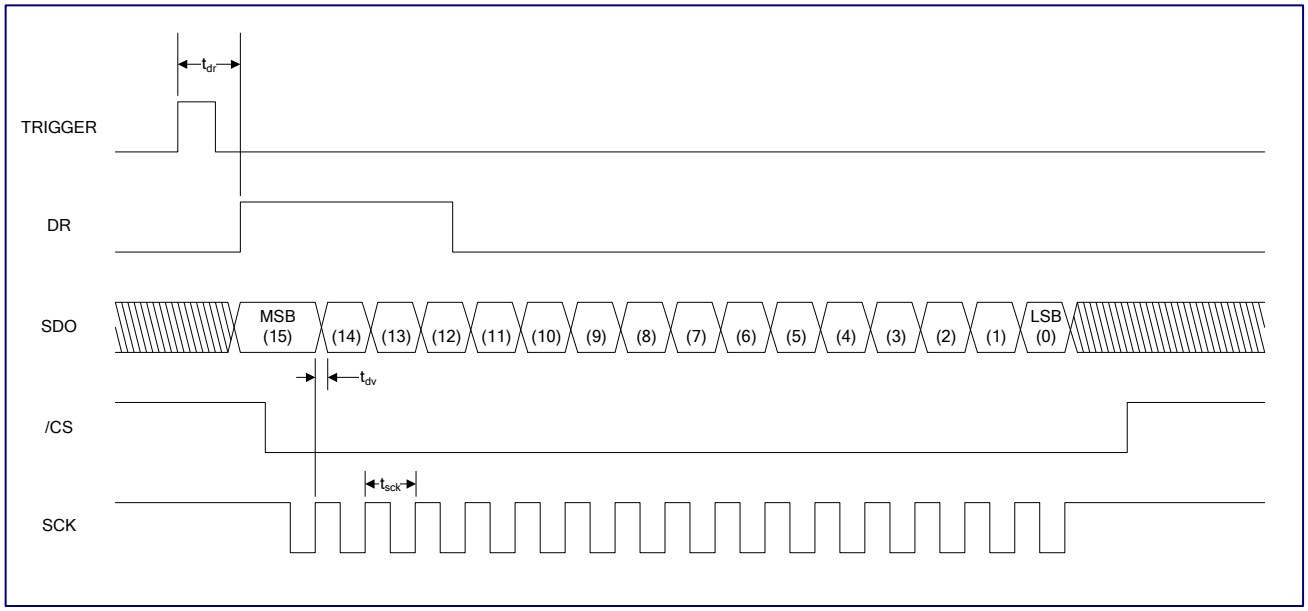


Figure 29: External Data Word Timing

Figure 30 below shows the pinout for *external word* interface connector on the back of the PhotoniQ. The signals are of the standard LVCMOS 3.3V type. Care should be taken to avoid shorts or overvoltage conditions.

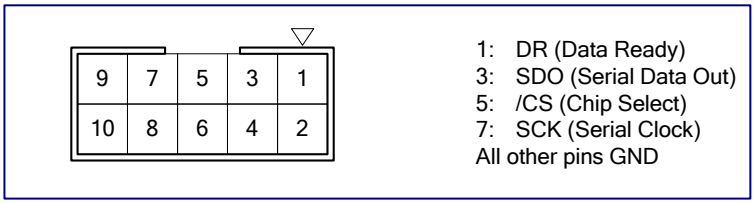


Figure 30: External Data Word Interface Connector

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