User Manual

PhotoniQ Series

IQSP480 / IQSP482 / IQSP580 / IQSP582
Multi-Channel Data Acquisition Systems

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 Models IQSP480, IQSP482, IQSP580, and IQSP582 interface to a sensor interface board (SIB) through a high voltage cable assembly. 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 Models IQSP480, IQSP482, IQSP580, and IQSP582 are 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 Models IQSP480, IQSP482, IQSP580, and IQSP582 are 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 set is provided for users who wish to write their own applications that interface directly to the unit.

Features

- Models IQSP480 / IQSP580 include 32 gated integrator / data acquisition channels
- Models IQSP482 / IQSP582 include 64 gated integrator / data acquisition channels
- Two dynamic range configurations permit event capture at high-speed 16-bit resolution (IQSP480 / IQSP482) or ultra high-speed 14-bit resolution (IQSP580 / IQSP582)
- Event pair resolution of 6.0 usec for model IQSP480 and 2.5 usec for model IQSP580
- Maximum trigger rate of 150 KHz for model IQSP480 and 390 KHz for model IQSP580
- 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, 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
- Graphical User Interface (GUI) for menu driven data acquisition and configuration
- LabVIEW™ generated DLLs for interface to user custom applications
- Available with optional single (IQSP480 and IQSP580) or dual (IQSP482 and IQSP582) 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 ▪ Arrays of Individual Sensors ▪ 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 ▪ SensL SPMArray 16 Element Silicon Photomultiplier P/N SPMArray ▪ Pacific Silicon Sensor 16 Channel Avalanche Photodiode Array P/N AD-LA-16-9-DIL18

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 (15')

Ordering Information

The PhotoniQ is ordered in one of four configurations of as shown in the table below.

Model Number	Dynamic Range	Number of Channels	Event Pair Resolution	Maximum Trigger Rate	Maximum Signal	Noise (RMS)
IQSP480	16 bit	32	6.0 usec	150 KHz	2000 pC	30 fC
IQSP482	16 bit	64	7.0 usec	120 KHz	2000 pC	30 fC
IQSP580	14 bit	32	2.5 usec	390 KHz	500 pC	55 fC
IQSP582	14 bit	64	3.2 usec	250 KHz	500 pC	55 fC

Table 1: Ordering Information

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

The PhotoniQ 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 for IQSP482/582
HVPS002	Negative 1500V on-board high voltage bias supply, includes 90 cm high voltage cable (HVC090)	Up to two may be added for IQSP482/582
HVPS701	Negative 100V on-board high voltage bias supply, includes 90 cm high voltage cable (HVC090)	Up to two may be added for IQSP482/582
MEM032	Memory upgrade, event image buffer 500K events for IQSP480/580, 250K events for IQSP482/582	32 channels per event for IQSP480/580 64 channels per event for IQSP482/582
MEM064	Memory upgrade, event image buffer 1M events for IQSP480/580, 500K events for IQSP482/582	32 channels per event for IQSP480/580 64 channels per event for IQSP482/582

Table 2: Ordering Information (Configuration Options)

Hardware Accessories

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

- 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 (SIB032)
- Sensor interface board for Hamamatsu H7260 series PMT, long integration times (SIB032D)
- Sensor interface board for Hamamatsu H8500D series PMT (SIB064)
- Sensor interface board for Hamamatsu H7546B series PMT (SIB164)
- Sensor interface board for SensL SPMArray silicon photomultiplier (SIB2316)
- 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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Typical PET Setup

A typical setup for a PET scanner application using a PhotoniQ, a SIB2316 and two silicon photomultiplier arrays (SPMArray) is shown below. The SPMArrays are positioned to detect incoming light from a scintillator crystal or optical assembly and connected to the SIB2316 by two FPC cables. The sensor interface board cable (SIB cable) connects the 32 detector outputs from the SIB2316 to a PhotoniQ IQSP480 or IQSP580 32 channel data acquisition system. Bias to the detectors is controlled by connecting the front panel DAC output from the PhotoniQ to the detector bias adjust input on the SIB2316. This allows the user to control the negative high voltage detector bias through the PhotoniQ GUI. The trigger output from the SIB2316 supplies the trigger to the PhotoniQ when coincident pulses exceeding a user-programmed energy threshold are detected on the two SPMArrays. Alternatively, the coincidence function can be bypassed altogether and the PhotoniQ triggered when a single pulse on either SPMArray exceeds the energy threshold. The energy threshold is also controlled through the PhotoniQ GUI as is carried to the arrays over the SIB cable. Digitized output data from the PhotoniQ is sent to a PC over a USB 2.0 connection for display, logging, or real time processing.

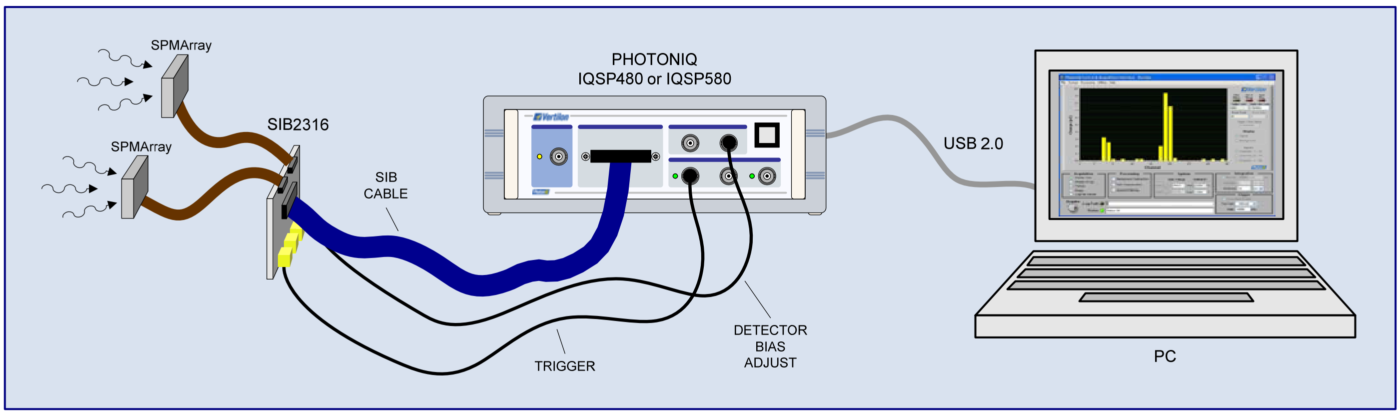

Figure 1: Typical Setup for PET Scanner

In a PET application, the PhotoniQ is configured in pre-trigger mode whereby the unit can capture 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 yet still collect all of the charge from the particle event — including the charge that preceded the peak of the event. Timing for this mode is shown below.

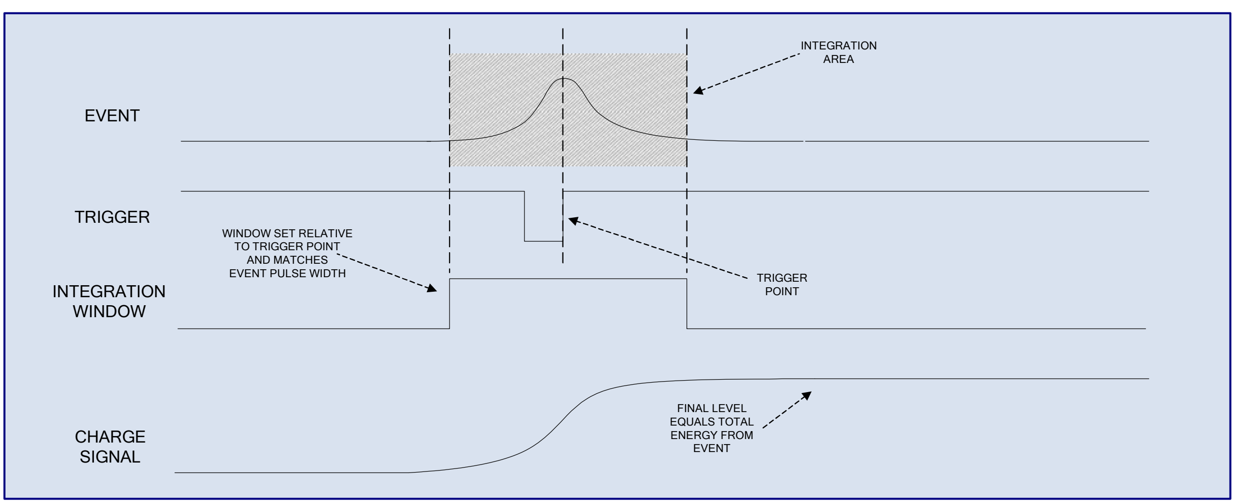

Figure 2: PhotoniQ Pre-Trigger Timing

Hardware

The two photos below show the PhotoniQ model IQSP480 (model IQSP580 is similar in appearance) and model IQSP482 (model IQSP582 is similar in appearance).

Figure 3: Model IQSP480 / IQSP580

Figure 4: Model IQSP482 / IQSP582

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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.

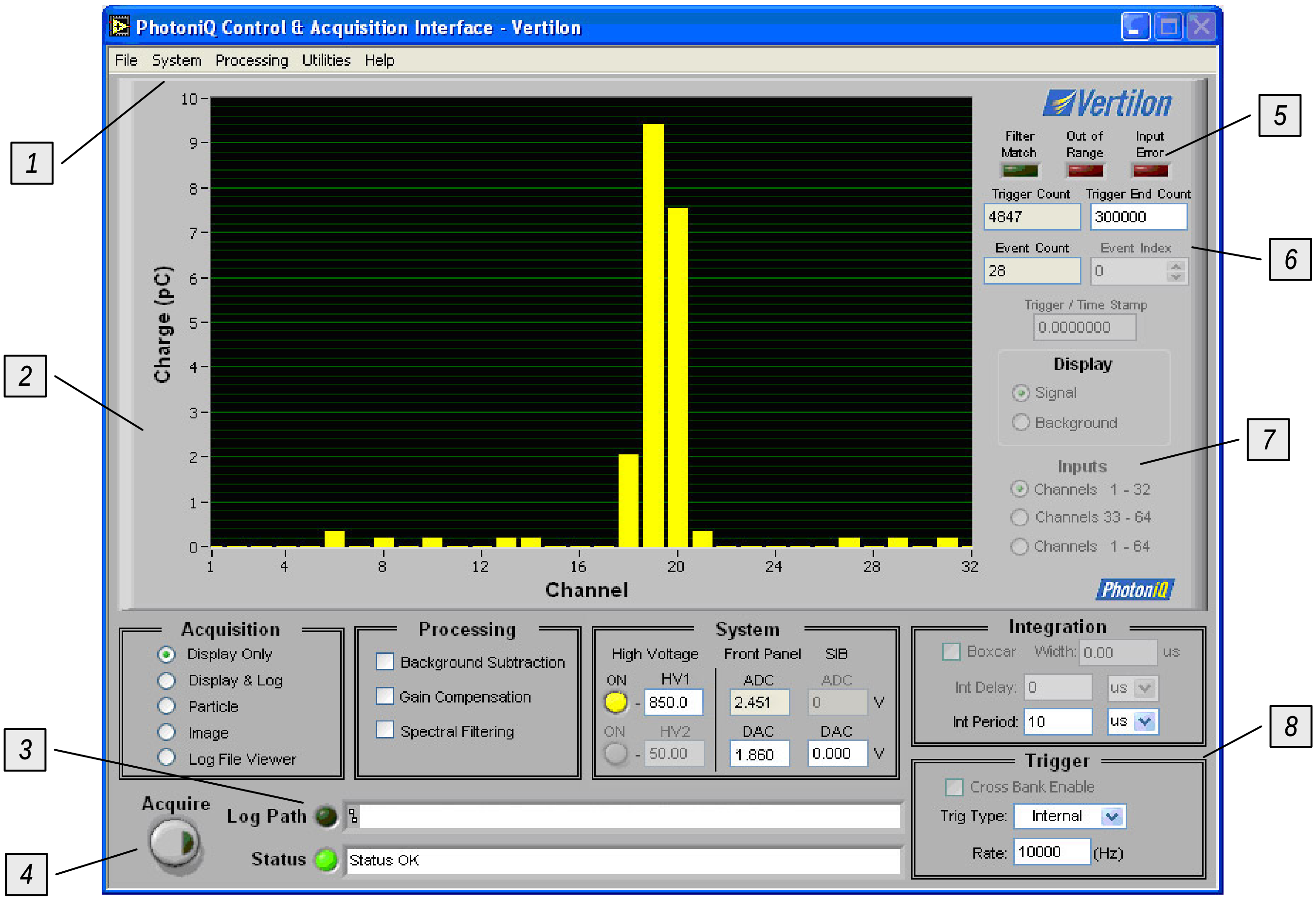

Figure 5: PhotoniQ Control and Acquisition Software Front Panel

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

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System Specifications[1]

Item	IQSP480 / IQSP482 Specifications	IQSP580 / IQSP582 Specifications
Number of Channels	32, IQSP480 64, IQSP482	32, IQSP580 64, IQSP582
Resolution	16 bits	14 bits
Dynamic Range	96 dB	84 dB
Equivalent Input Noise Charge[2]	30 fC RMS typ.	55 fC RMS typ.
Maximum Input Signal	2000 pC	500 pC
Channel-to-Channel Crosstalk[3]	-84 dB typical, -80 dB max.	-84 dB typical, -80 dB max.
Input Bias Current	±40 pA typical, ±150 pA max.	±40 pA typical, ±150 pA max.
Input Offset Voltage[4]	±1.5 mV max.	±1.5 mV max.
Minimum Event Pair Resolution (MEPR)[5]	6.0 usec max., IQSP480 7.0 usec max., IQSP482	2.5 usec max., IQSP580 3.2 usec max., IQSP582
Maximum Trigger Rate (MTR)[6]	150 KHz, IQSP480 120 KHz, IQSP482	390 KHz, IQSP580 250 KHz, IQSP582
Sustained Average Event Rate (SAER)[7] (Maximum Channels Enabled)	65,000 events/sec, IQSP480 (32 ch/event) 35,000 events/sec, IQSP482 (64 ch/event)	65,000 events/sec, IQSP580 (32 ch/event) 35,000 events/sec, IQSP582 (64 ch/event)
Sustained Average Event Rate (SAER)[8] (8 Channels Enabled)	130,000 events/sec	240,000 events/sec
Event Buffer Size (EBS)[9]	MEM032/064: 500K/1M events, IQSP480 MEM032/064: 250K/500K events, IQSP482	MEM032/064: 500K/1M events, IQSP580 MEM032/064: 250K/500K events, IQSP582
Power Consumption[10]	4.5 Watts typ., 5.5 Watts max.	4.5 Watts typ., 5.5 Watts max.
High Voltage Bias Supply Range (HVPS001)[11]	-50 V to -925 V	-50 V to -925 V
High Voltage Bias Supply Range (HVPS002)[12]	-100 V to -1390 V	-100 V to -1390 V
High Voltage Bias Supply Range (HVPS701)[13]	-5.0 V to -92.5 V	-5.0 V to -92.5 V

Table 3: System Specifications

1 Typical specifications at room temperature.
2 Edge triggered mode. Other modes slightly higher and lower.
3 For integration periods greater than 300 nsec.
4 Offset relative to input bias voltage which is 0.250V.
5 For edge triggering and integration period of 100nsec.
6 MEM064 event buffer option installed and integration period of 100 nsec.
7 Specification assumes PC and USB port capable of handling continuous data transfers at ~16MB/sec and all log file reporting functions disabled.
8 Specification assumes PC and USB port capable of handling continuous data transfers at ~16MB/sec and all log file reporting functions disabled.
9 The standard configuration does not include an event buffer.
10 Assumes no optional high voltage bias supplies. Add 0.7W for each bias supply at max voltage and max load.
11 At a load of 370 uA. Voltage range divided by three at SIB (-17V to -308V) when using SIB216.
12 At a load of 250 uA.
13 At a load of 1 mA.

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	65 nsec	75 nsec
Integration Start Jitter		Boxcar		± 5 nsec
Integration End Delay	t_{bcd2}	Boxcar	60 nsec	75 nsec
Boxcar Width Resolution	t_{bcw}	Boxcar		10 nsec
Integration Period	t_{int}	Edge	100 nsec	100 msec
		Internal	100 nsec	100 msec
		Level	100 nsec	100 msec
		Boxcar	100 nsec	100 msec
		Input	T_S	$1000T_S$
		Pre-trigger	$2T_S$	$1000T_S$
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	0.1 pC	1000 pC, IQSP480 / IQSP482 250 pC, IQSP580 / IQSP582
Sample Period	T_S		2.25 usec, IQSP480 2.85 usec, IQSP482 0.47 usec, IQSP580 0.94 usec, IQSP582	2.25 usec, IQSP480 2.85 usec, IQSP482 0.47 usec, IQSP580 0.94 usec, IQSP582

Table 4: Trigger and Integration Specifications

1 Typical specifications at room temperature.
2 A fixed delay of approximately 85 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.

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	+2.0 V	
Trigger Input, Input Impedance	TRIG IN	10 Kohm	
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}

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 8.2.1 for use with DLLs

Theory of Operation

The PhotoniQ models IQSP480 and IQSP580 consist of 32 input channels made up from four independent banks of eight charge collection and data acquisition channels. Models IQSP482 and IQSP582 consist of 64 input channels made up from four independent banks of sixteen charge collection and data acquisition channels. Each bank is independently configured and triggered and generates eight parallel streams of digital data as shown in the figure below. The dynamic range and acquisition speed is dependent on the model number — the IQSP480 and IQSP482 having the higher dynamic range and the IQSP580 and IQSP582 having the higher speed. 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. Thirty-two parallel digital data channels are output to the Pipelined Parallel Processor (P3) where it performs data discrimination and channel uniformity correction. The resulting data 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.

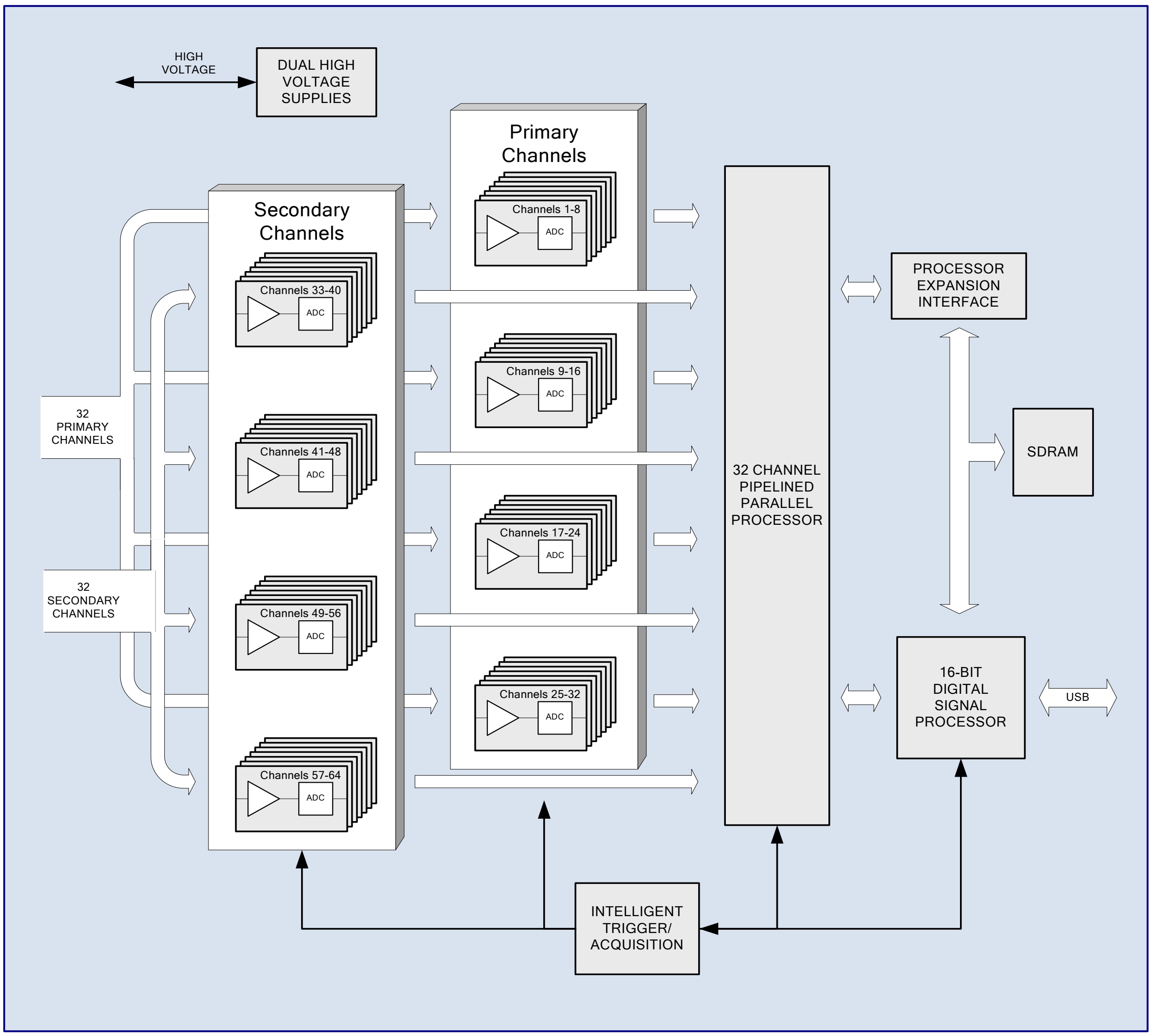

Figure 6: PhotoniQ Functional Block Diagram

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 multi-anode PMT, this circuit achieves single photon sensitivity at microsecond-level pulse-pair resolution.

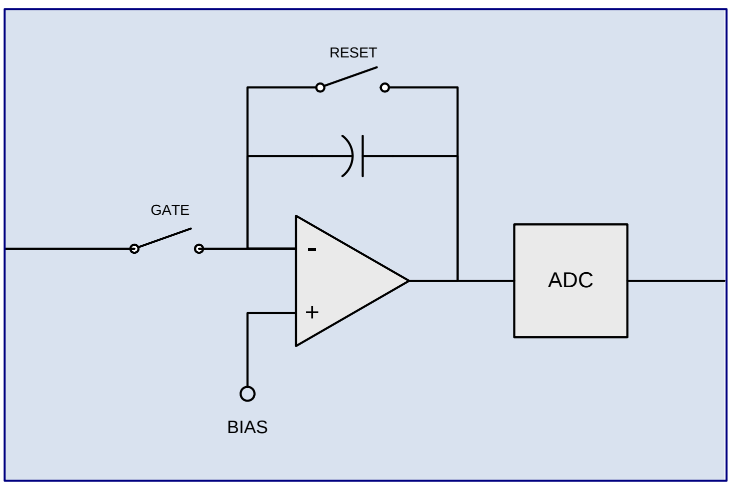

Figure 7: Front End Preamp Cell

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 in its linear region thus maintaining virtually all of its dynamic range.

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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. 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.

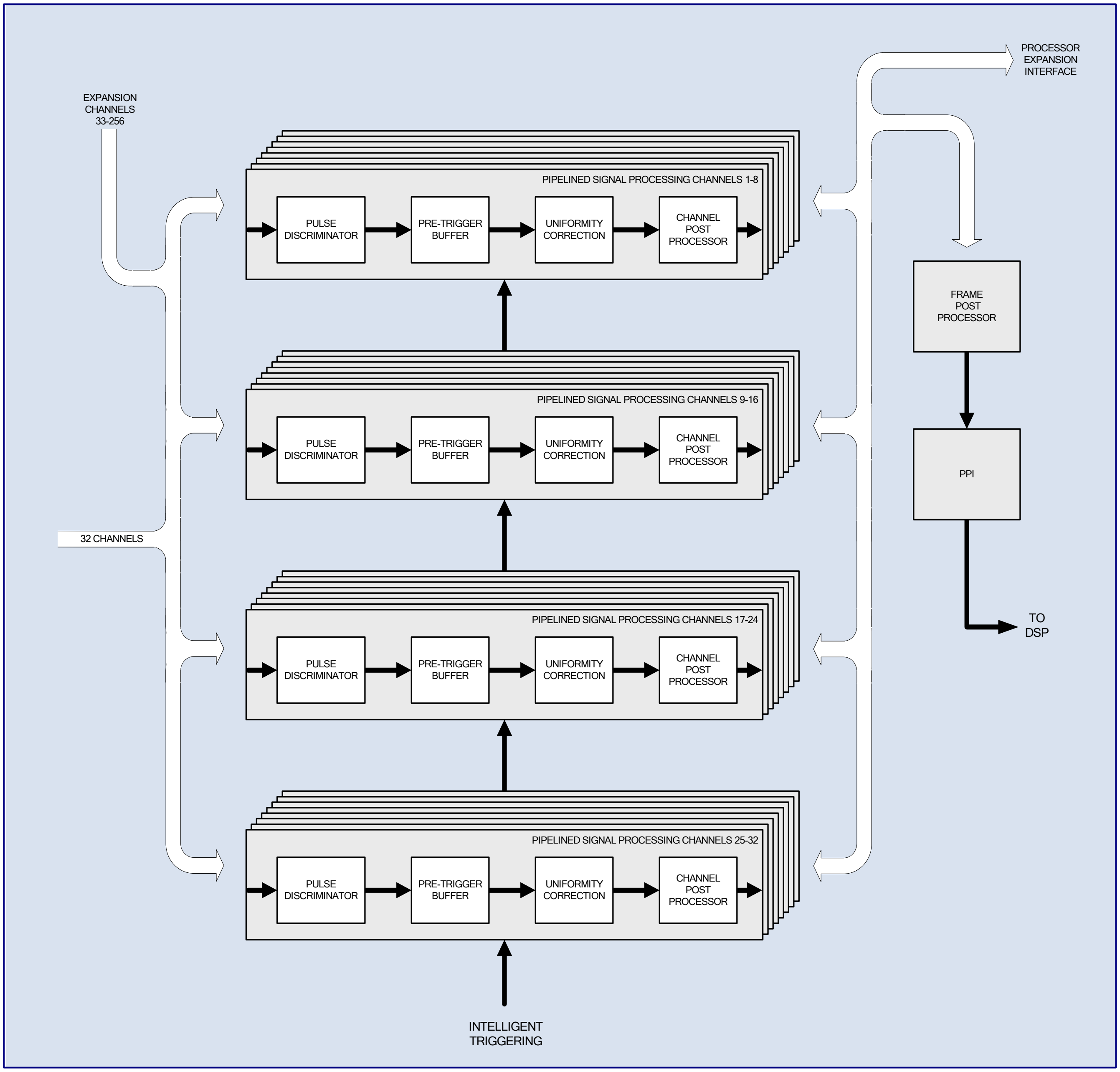

Figure 8: 32-Channel Pipelined Parallel Processor

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.

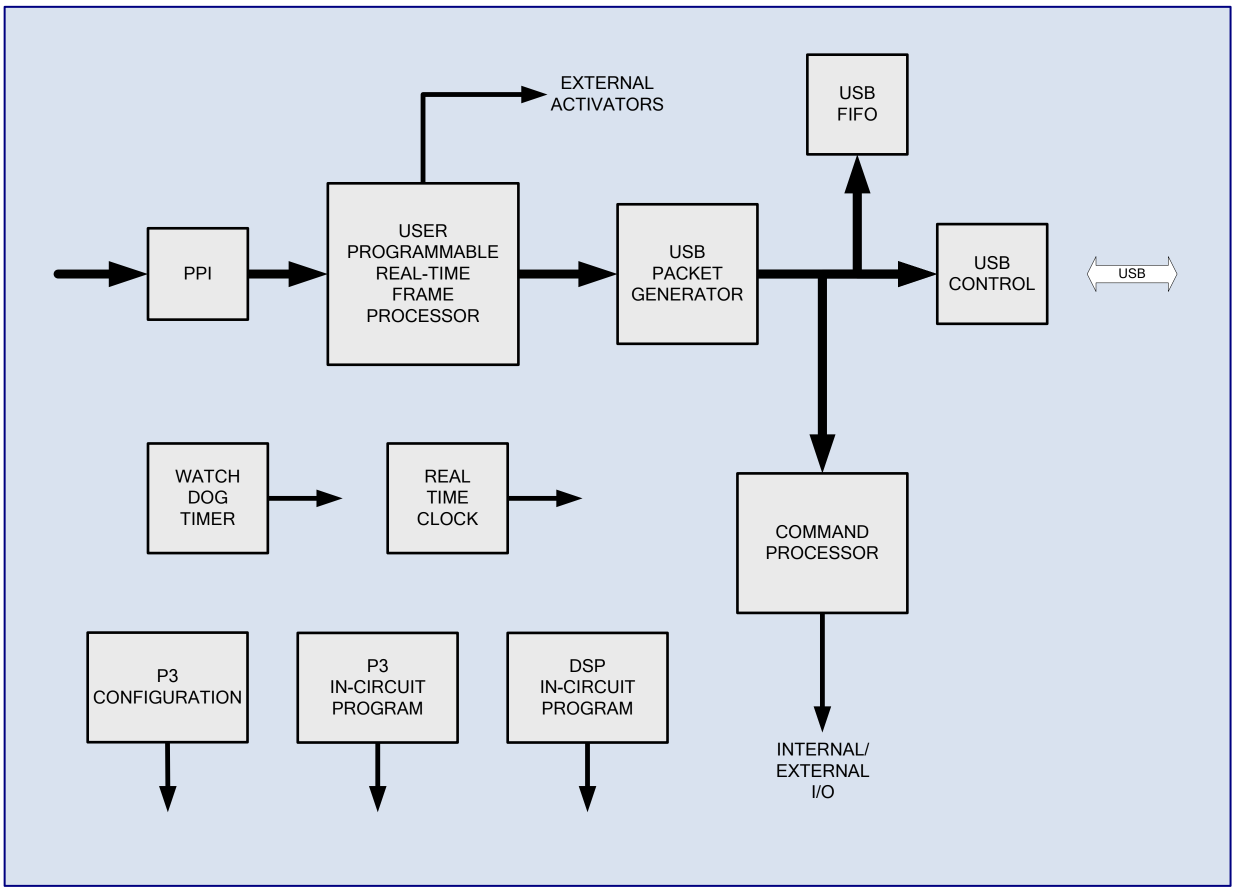

Figure 9: DSP Functional Block Diagram

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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.

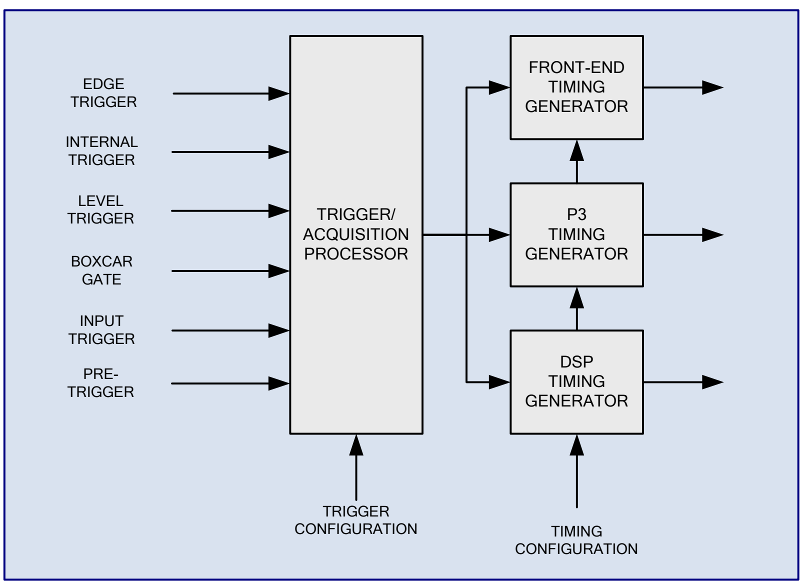
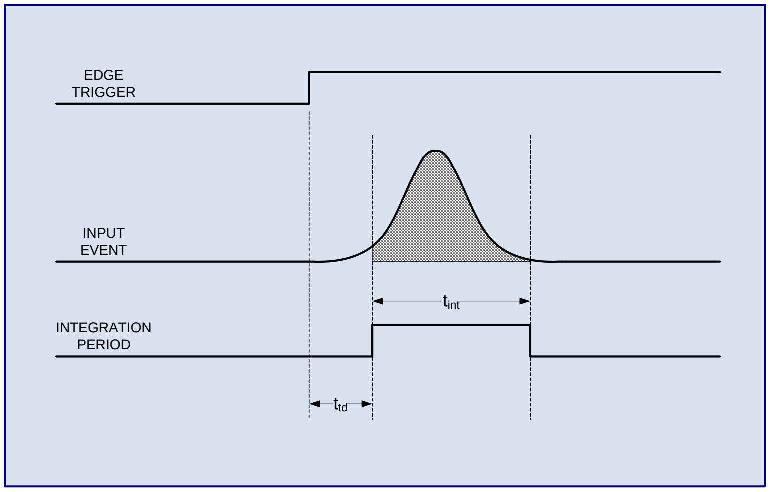


Figure 10: Intelligent Trigger Module

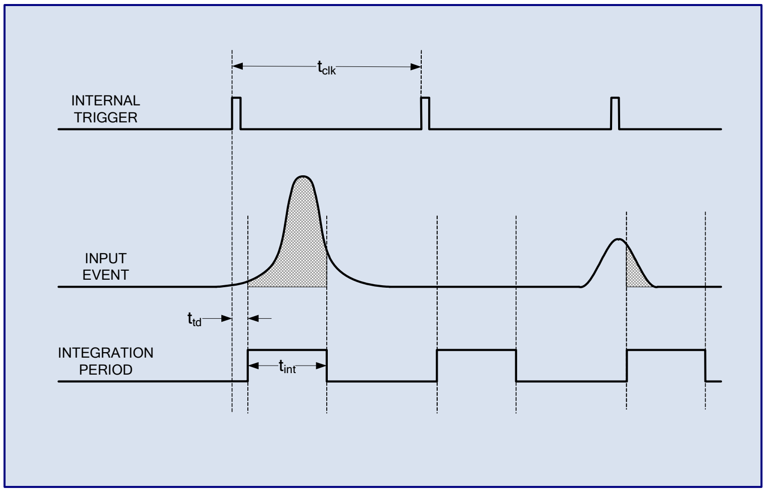
Edge Trigger

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.



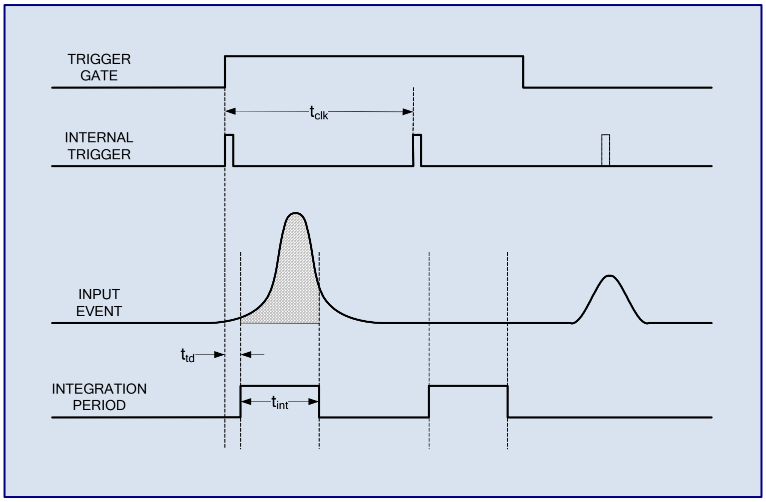
Internal Trigger

Continuous data acquisition is possible by operation of the unit in internal triggering mode. Here a programmable internal free running clock (tclk) 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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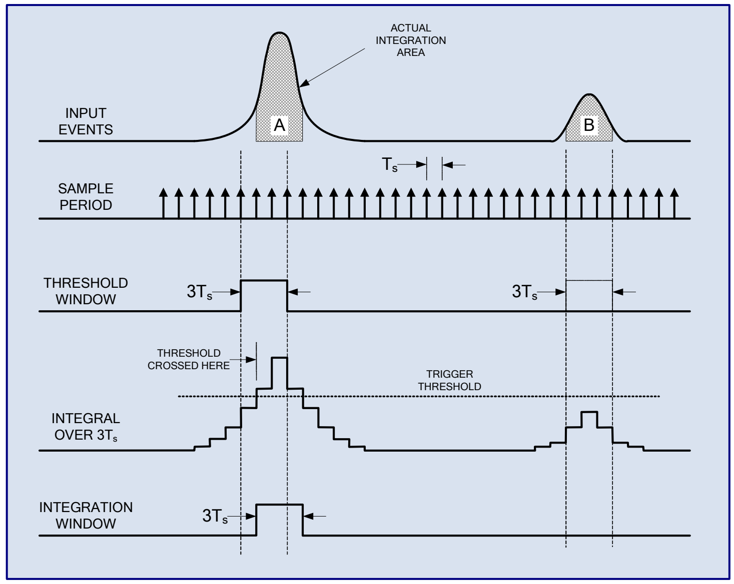
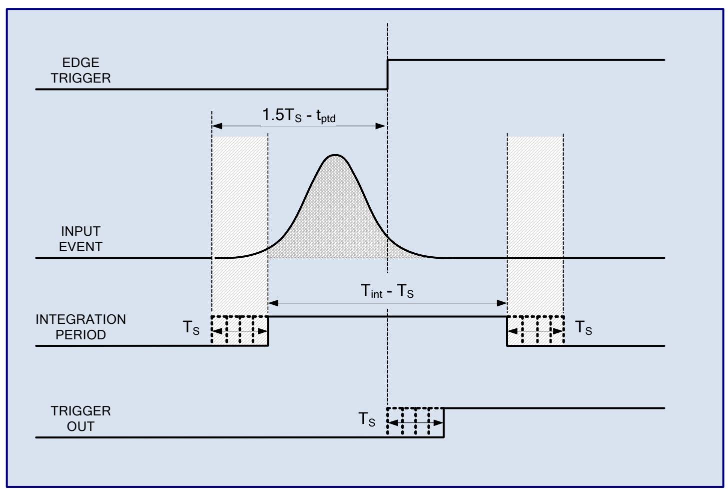
Input Trigger



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, t_{int} 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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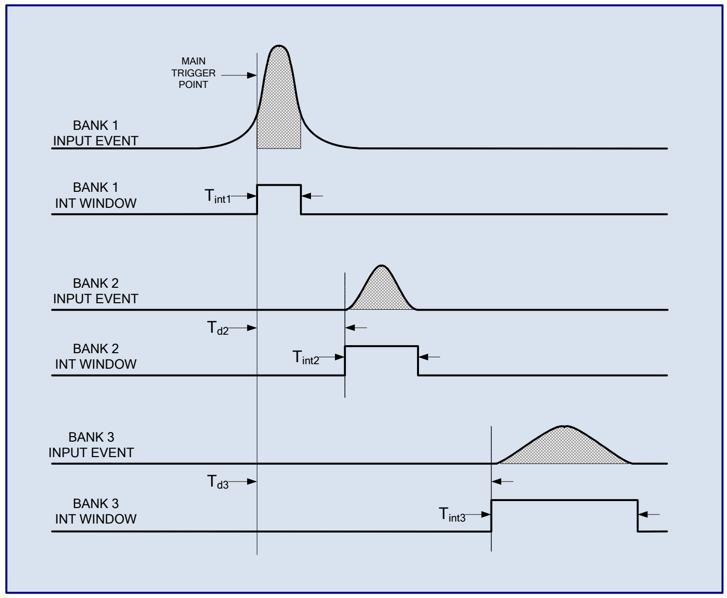
Cross Bank Triggering

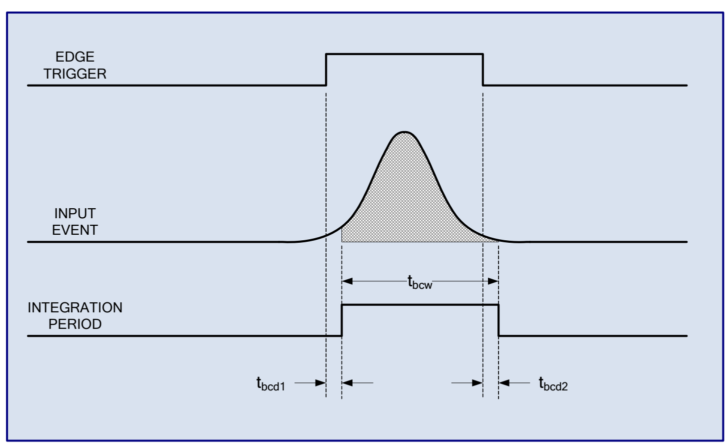


The flexibility of the PhotoniQ allows one or more channel banks to be triggered with one set of parameters which in turn trigger other banks using a different set of parameters. In a typical example, a bank is set up as an input trigger type with a particular integration period. The other banks are 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 panel interface connectors and status indicators on the PhotoniQ models IQSP480 / IQSP580 and the IQSP482 / IQSP582.

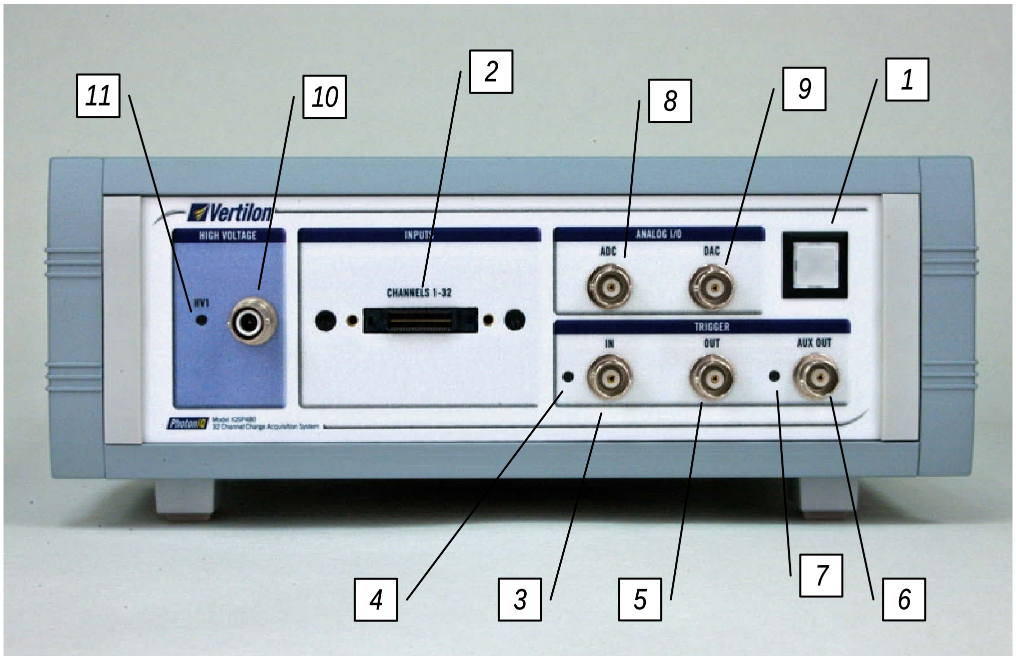

Figure 11: IQSP480 / IQSP580 Front Panel

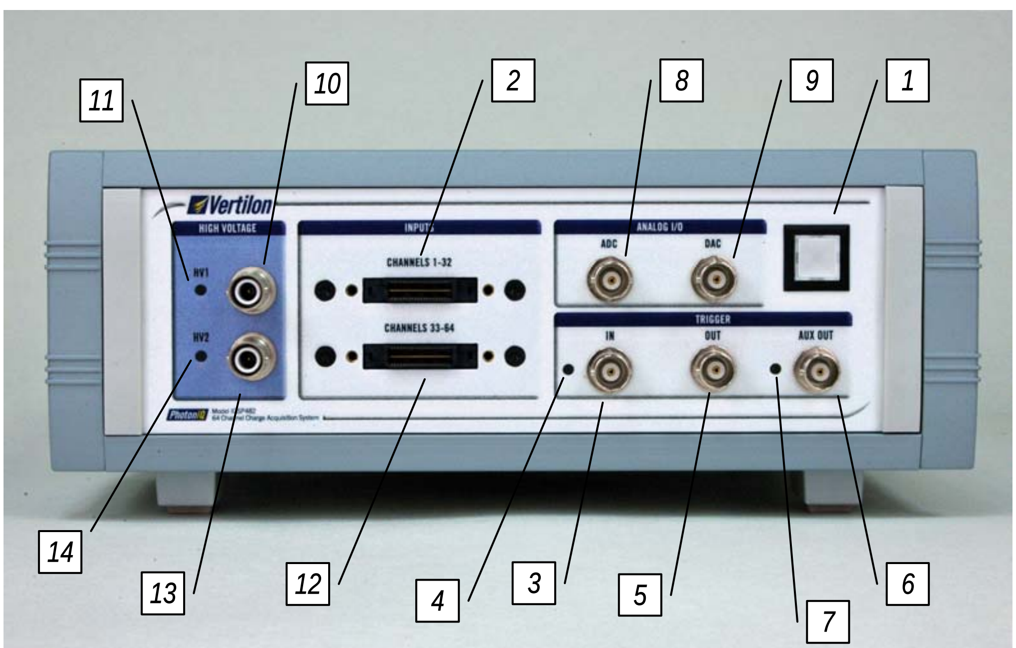

Figure 12: IQSP482 / IQSP582 Front Panel

1. Main Power Switch: PhotoniQ main power switch.

2. Sensor Interface Board Connector (SIB Connector): Connector to SIB cable for connection to a sensor interface board or signal distribution system. The connector and cable carry the primary 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). Typically used in conjunction with the PhotoniQ's primary 32 channels.

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

12. Sensor Interface Board Connector (SIB Connector, IQSP482 / IQSP582 only): Connector to SIB cable for connection to a sensor interface board or signal distribution system. The connector and cable carry the secondary 32 input channels over individual coaxial lines. Additional control and monitor lines are also carried.

13. High Voltage Bias Supply #2 Output (SHV, IQSP482 / IQSP582 only): Cable connector for the optional high voltage bias supply #2 (HV2). Typically used in conjunction with the PhotoniQ's secondary 32 channels.

14. High Voltage Bias Supply #2 Indicator (Yellow LED, IQSP482 / IQSP582 only): Indicates when the optional high voltage bias supply #1 (HV2) is energized.

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Control and Acquisition Interface Software

Running *ControlInterface.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.

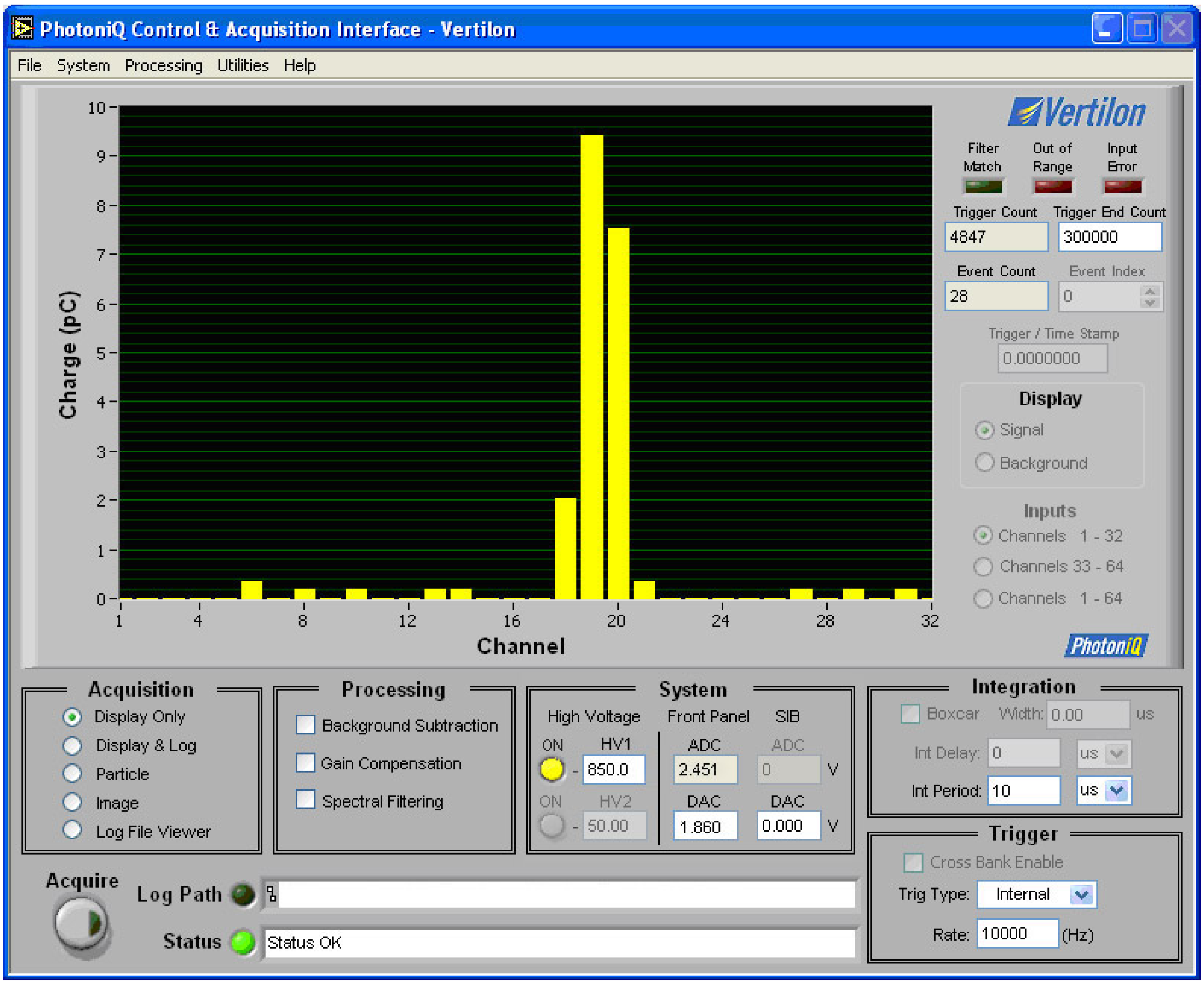

Figure 13: Front Panel

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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 severely 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.

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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.

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 to its left side is green under normal operating 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.

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 set to *in use* under the *High Voltage Supply* dialog box.

HV1 Set Point

Sets the output voltage of high voltage bias supply #1.

HV2 On

Enables high voltage bias supply #2. This function is available only if high voltage bias supply #2 is set to *in use* under the *High Voltage Supply* dialog box.

HV2 Set Point

Sets the output voltage of high voltage bias supply #2.

Front Panel ADC

Reports the input voltage of the front panel general purpose analog to digital converter. When used, this input should be driven by a low impedance device.

Front Panel DAC

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

SIB ADC

Reserved ADC function for special sensor interface boards.

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.

Trigger & Integration

Sets the trigger and signal integration 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.

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.

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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.

Boxcar Width

Displays the width of the boxcar input for the current event. To enable this feature, *Boxcar* mode must be selected in the front panel and the *Boxcar Width* box must be checked in the *Log File* menu.

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.

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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.

Display Limit Adjust

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

Filter Match

This function is active when the spectral 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.

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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.

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 *Log 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 *Log File Configuration* menu.

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Display

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.

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.

Channels

The horizontal channels for display are selected using this feature.

Channels 1 - 32

Only the primary 32 channels are plotted on the real time display.

Channels 33 - 64

Only the secondary 32 channels are plotted on the real time display (available on models IQSP482 and IQSP582 only).

Channels 1 - 64

All 64 channels are plotted on the real time display (available on models IQSP482 and IQSP582 only).

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Pull Down Menu: 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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Pull Down Menu: System

The PhotoniQ is configured through this pull down menu.

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 8 channels per bank maximum for the IQSP480 and IQSP580 and 16 channels per bank maximum for the IQSP482 and IQSP582.

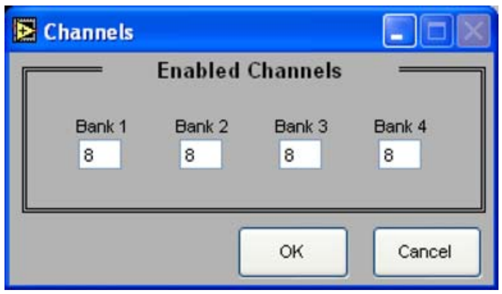

Figure 14: Channel Configuration Dialog Box

Sensor Interface Board

Selects which type of Sensor Interface Board (SIB) is connected to the PhotoniQ's primary (channels 1 – 32) and secondary (channels 33 – 64) channels. This setting is used by the system to set the high voltage power supplies appropriately. If sensor interface board is not listed use *Undefined*.

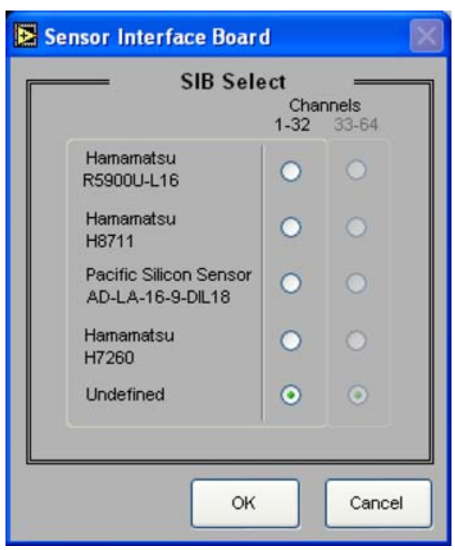

Figure 15: Sensor Interface Board Dialog Box

High Voltage Supplies

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

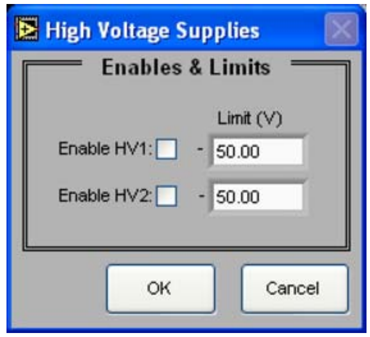

Figure 16: High Voltage Supply Dialog Box

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 primary 32 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 secondary 32 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.

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.

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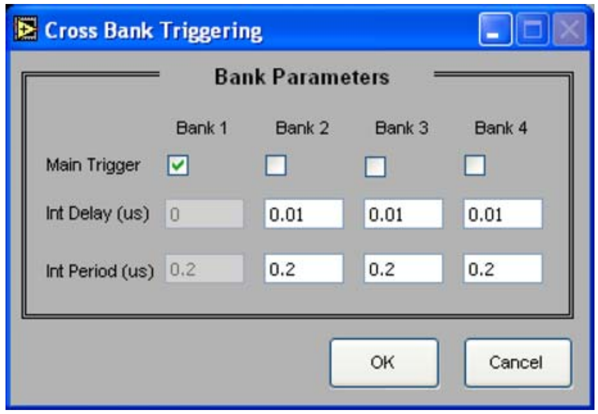

Figure 17: Cross Bank Triggering Dialog Box

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).

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*.

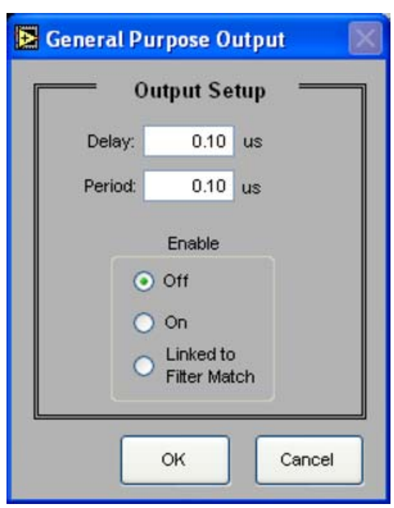

Figure 18: General Purpose Output Dialog Box

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.

Log File 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.

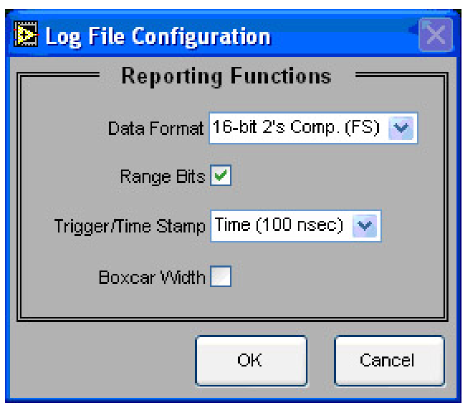

Figure 19: Log File Configuration Dialog Box

Data Format

The data format for the channel data in the log file can be configured in one of three ways; 17-bit Sign-Magnitude, 16-bit Two's Complement (Full Scale), and 16-bit Two's Complement (Half Scale). 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 32 channel configuration this format adds four extra words (eight extra words for a 64 channel) 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 17-bit option is the default selection and is most appropriate for use with the high resolution IQSP480 and IQSP482 where the input data is converted with 16-bit resolution and signal processed to 17-bit resolution.

The two 16-bit two's complement formats do not append additional *sign* words to the events in the log file. Channel data is simply inserted into 16-bit words in a standard two's complement representation. For the IQSP480 and IQSP482 where the processed data is 17 bits, the user can choose between *Full Scale* and *Half Scale* options. With the *Full Scale* format, the LSB of the processed data is truncated thus halving the resolution of the system while maintaining the full scale range. In the *Half Scale* format, resolution is maintained but the full scale range is reduced by a factor of two. The *Half Scale* format is not available for the IQSP580 and IQSP582 because the 15 bits of processed channel data fit into the 16-bit words in the log file.

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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Configuration ID

This value is used for special restricted versions of the product. The value is set to the default value of 0x6F2A.

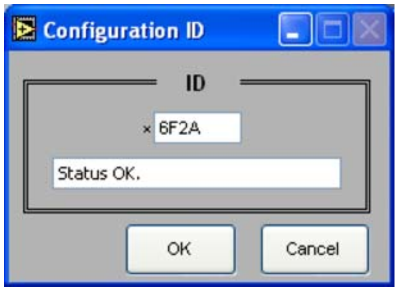

Figure 20: Configuration ID Dialog Box

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Pull Down Menu: 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 21 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.

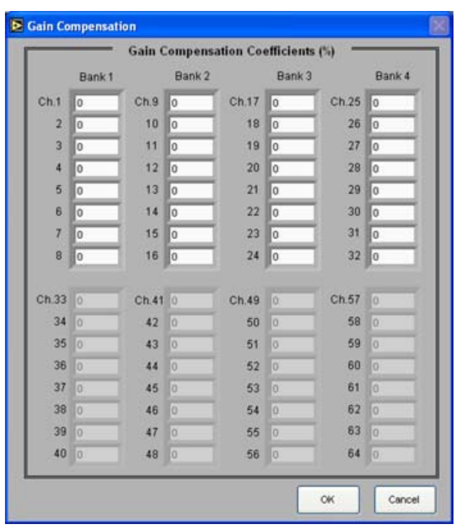

Figure 21: Gain Compensation Dialog Box

Data Filtering

Data Filtering is used to selectively display, log, or tag events that meet a specific user defined matching criteria. It is described in more detail in the Data Filtering section.

Pull Down Menu: Utilities

Generate Diagnostic Report

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

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.

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.

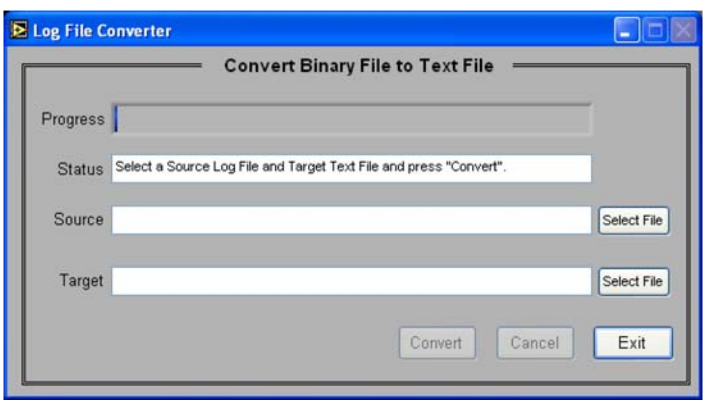

Figure 22: Log File Converter Dialog Box

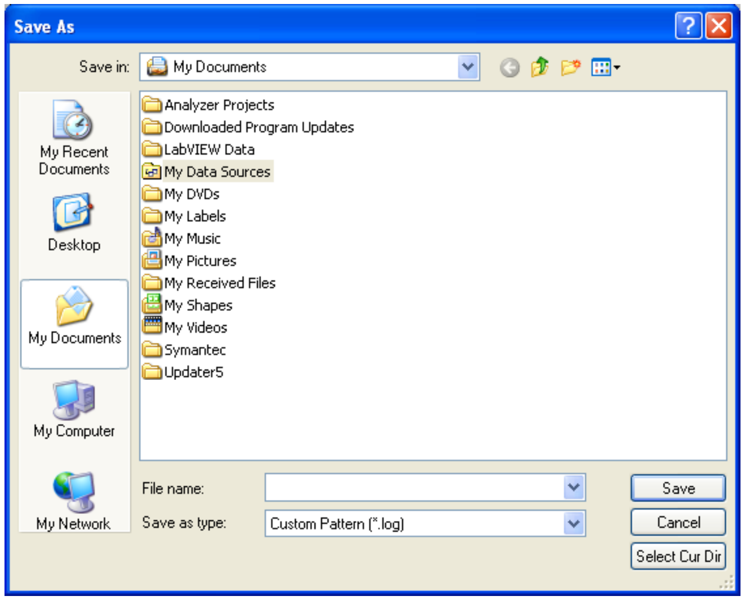

Figure 23: Select File Dialog Box

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 the spectral filter processing function is enabled, an output marker can be generated for each event that meets the 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 filtering is a real-time embedded DSP function in the PhotoniQ, a reduction in the maximum high speed data acquisition rate can be expected when this function is enabled.

Data filtering parameters 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 bands defined by the user in the *Band Definition* pane according to a Boolean expression defined in the *Flag Definition* and *Discriminant Definition* panes.

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 1 through 8 and Band 2 as Channels 16 through 20. 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.

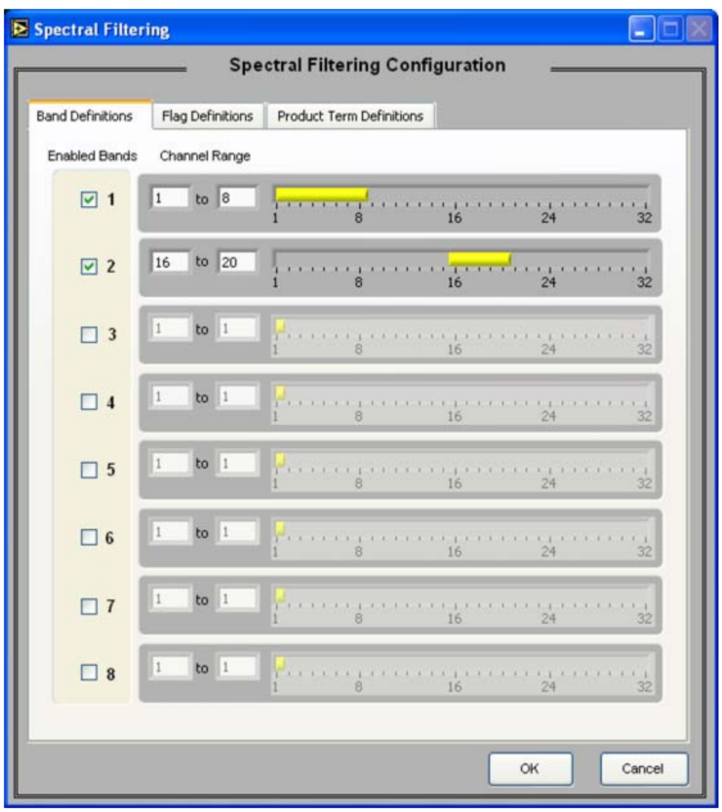

Figure 24: Band Definition Pane

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 0.342 pC (the LSB weight for an IQSP480 with 17 bit sign-magnitude data format) and Flag 2 is true if one times the average of Band 1 is less than 70 times 0.342 pC. The data discriminator operates on these two flags with a user defined function to determine if a filter match occurred. Note, even though Band 2 was defined in the *Band Definition* pane, it is not used in flag definitions in this example. However, the user should only use bands in the flag definitions that have been enabled and defined in the *Band Definition* pane.

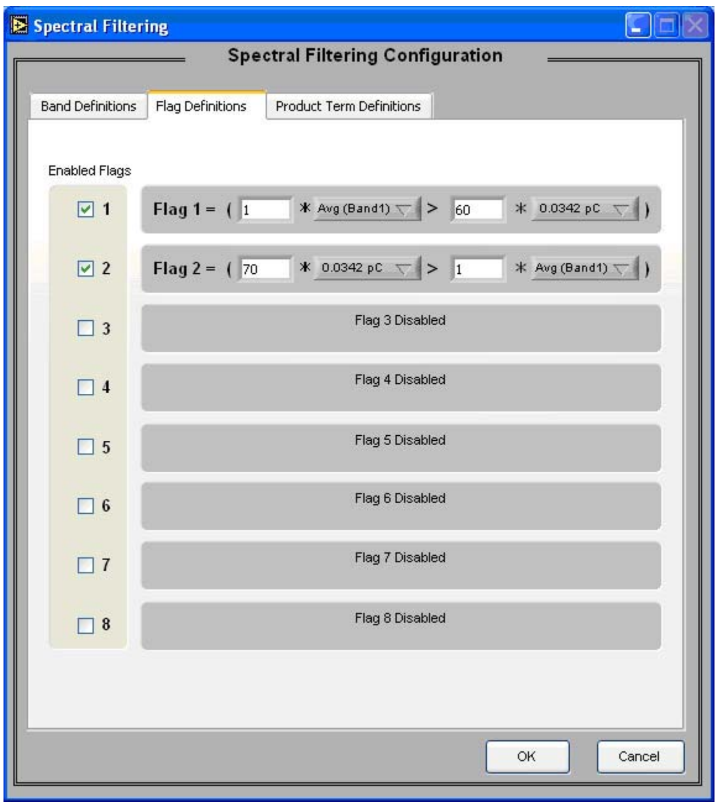

Figure 25: Flag Definition Pane

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.

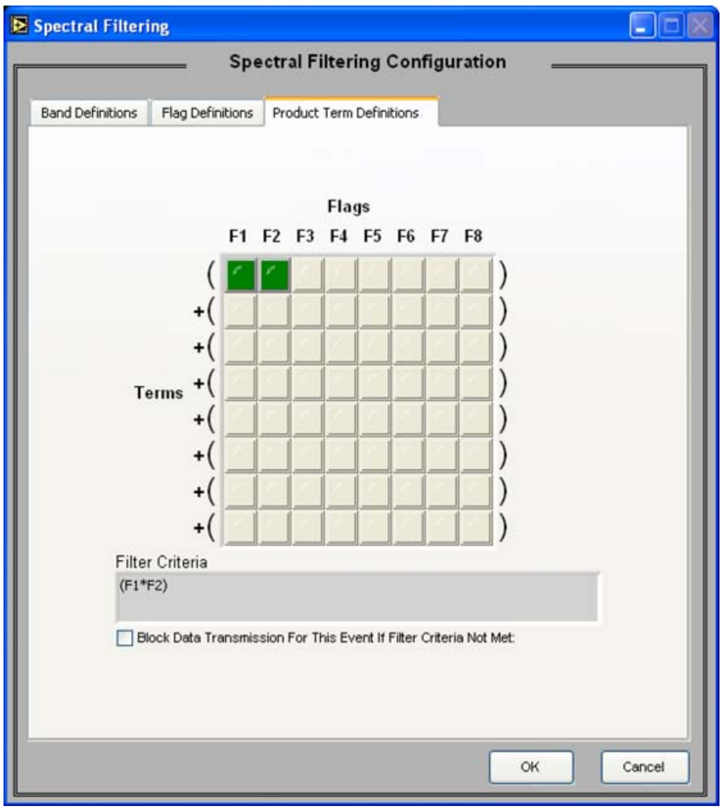

Figure 26: Discriminant Definition Pane

With the product term definition shown above, the data filter function will generate a match only if the average of channels 1 through 8 is between 20.52 pC and 23.94 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.

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	750	User Configuration Binary Data
783	Custom Config Table	500	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 either event data or background data. An *event* packet contains the data for each channel and is created for each event that is acquired while logging. A *background* packet is an occasional packet containing the calculated background signal for each channel. It is reported every second or 1000 events, whichever comes first. If *Background Subtraction* is disabled, no *background* packet is logged. *Background* packet logging is currently not supported in PhotoniQ. Packet data is partitioned along 16-bit word boundaries. The length (L) in words of each packet is given by the equation:

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

The packet length is dependent on the configuration settings selected in the user interface and is the same for both *event* and *background* packets. 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 two 16-bit formats do not (F=0). Packet length is also dependent on the settings for the reporting enables for the *Range Bits* (R), *Trigger/Time Stamp* (TS), and *Boxcar Width* (BW). The reporting enables are set in the *Log File 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:

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

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+1Event Packet
2033 +(n+1)*L	Data Packet # n+2	L	Background Packet
2033 +(n+2)*L	Data Packet # n+3	L	nth+2 Event Packet
…	…	…	…

Table 9: Binary Log File (Data Block Section)

Event Packet

Each event processed by the PhotoniQ system generates an *event* packet of length, L, where L is in 16-bit words. The packet consists of a single word header followed by several blocks of data containing the signal information for each channel in the system. Depending on the configuration, there may be additional words following the signal data that hold the trigger/time stamp and boxcar width. 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*, *Trigger/Time Stamp* (TS) and *Boxcar Width* (BW) enabled. The numbers in parenthesis in the figure indicate the number of words for each data type in the packet. No numbers are shown for the channel data because the size of these packets is dependent on the number of configured channels. Models IQSP480 and IQSP580 produce a maximum of 40 data words (32 with *sign* and *range* words off) and models IQSP482 and IQSP582 produce a maximum of 80 data words (64 with *sign* and *range* words off).

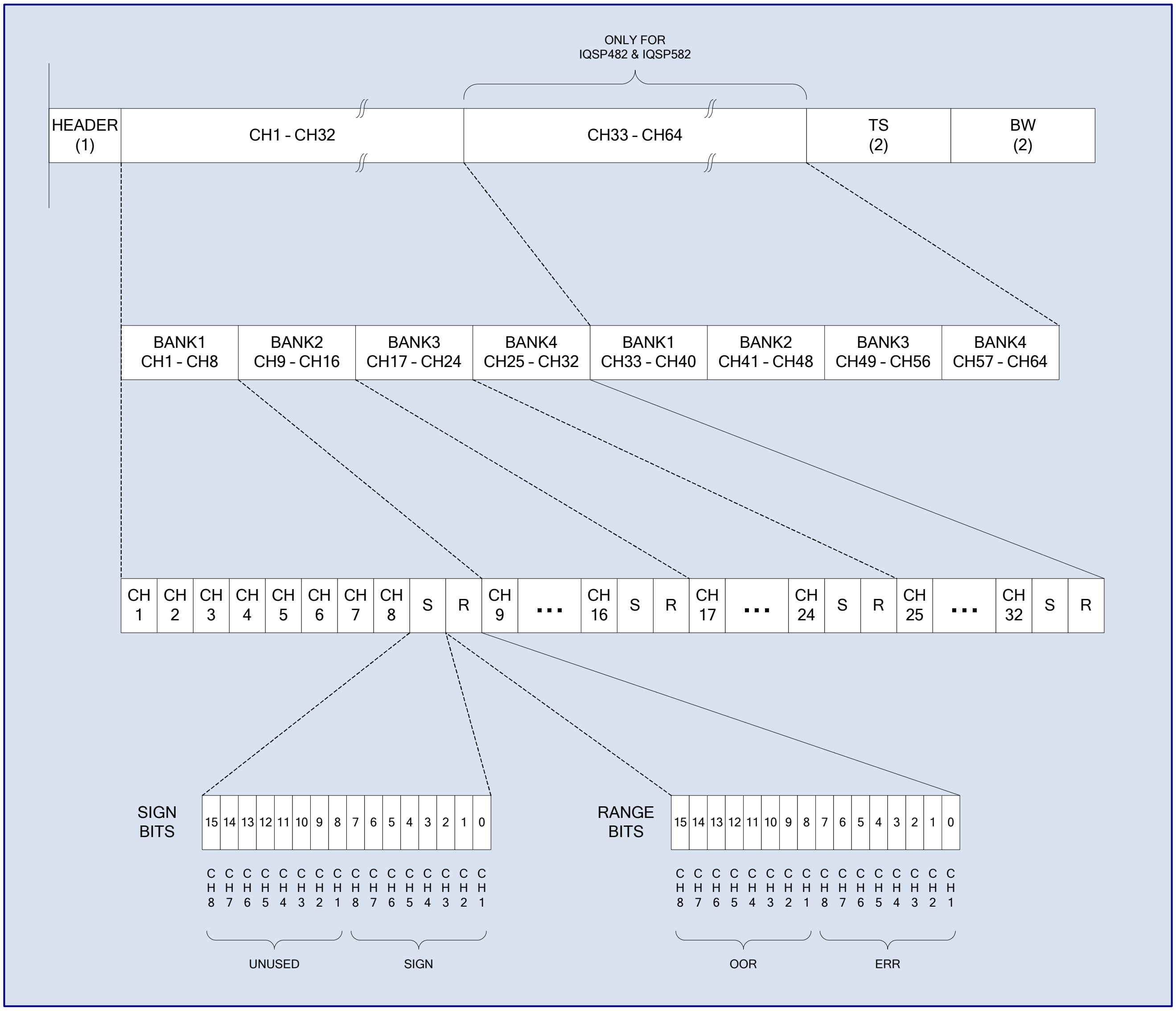

Figure 27: Event Packet

The trigger/time stamp and boxcar width each require two words. 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 *Log File Configuration* menu. The boxcar width is computed by multiplying the two-word, 32-bit boxcar value by 10 nanoseconds. Disabling the reporting enables for these fields removes that data from the packet. The header word cannot be removed from the *event* packet. It holds data that includes information about the packet type, out of range and input error conditions, and filter matching results. 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 10: Event Packet Header Word

Signal data blocks are organized sequentially starting with the data from the first 32 channels followed by the data from the second 32 channels (IQSP482 and IQSP582 only). Individual channels within the data blocks are included in the *event* packet only if they are enabled under the *Channels* menu. Within each data block, the signal channels are organized by banks. There are four banks, Bank1 through Bank4. The data for each bank in a block can have up to eight signal channels. Unused channels are not included in the blocks of bank data. Depending on the *Data Format* selected under the *Log File Configuration* menu, signal channels are formatted as either, unsigned 16-bit magnitude-only 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 bank data also includes a *sign* word "bit-packed" as shown in Figure 27, 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 *Log File 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 weights from the table below. The 17-bit format should be treated as sign-magnitude and the 16-bit formats as two's complement.

Data Format	IQSP480 / IQSP482 Bit Weighting (fC / bit)	IQSP580 Bit Weighting (fC / bit)	IQSP582 Bit Weighting (fC / bit)
17-bit Sign-Magnitude	34.18	33.56	41.19
16-bit Two's Complement (Full Scale)	68.36	33.56	41.19
16-bit Two's Complement (Half Scale)	34.18	N/A	N/A

Table 11: Log File Bit Weights

Background Packet

Background packets are organized similarly to *event* packets except that the header is encoded as defined in the table below and the channel data is replaced by the calculated background. Background packet logging is currently not supported in the PhotoniQ.

Bit	Function	Description
15-13	Packet Type	'001' = Background Packet
12	Out of Range Fault	'0' = No Faults Detected '1' = At Least 1 Fault Detected
11	Input Error Fault	'0' = No Faults Detected '1' = At Least 1 Fault Detected
10-0	Reserved	Reserved for Future Use

Table 12: Background Packet Header Word

Minimum Event Packet Size

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 it overflows. In a scanned imaging application this means that larger image sizes or higher scan rates can be accommodated. For a 32 channel configuration the minimum *event* packet size is achieved by disabling all reporting functions and selecting either of the two 16-bit data formats. Since the header word cannot be disabled, the resulting event packet size is 33 words (66 bytes).

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. If *Background Subtraction* is enabled, an occasional row of data representing the background level is interleaved with the rows of events. *Event* rows are distinguished from *background* rows by a packet type descriptor in the row data. The *event* and *background* 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) and *Boxcar Width* (BW) are stored in the last two columns, respectively. A '4' in the *Packet Type* column indicates an *event* row and a '1' indicates a *background* row. Currently, *background* packet logging is not supported and therefore only *event* rows appear in the text file. 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'. The figure on the following page shows an example of a typical 7 channel text log file. 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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PhotoniQ Logfile to Textfile Converter
Convert Timestamp: Tuesday, September 25, 2007 at 2:39PM
Binary File Timestamp: 9/10/2007 4:31:00 AM
LabVIEW UI Version: 13.1

PhotoniQ Configuration Parameters:
Number of Channels Bank 1: 8
Number of Channels Bank 2: 0
Number of Channels Bank 3: 2
Number of Channels Bank 4: 0
High Voltage Setpoint 1: 750.00V
High Voltage Setpoint 2: 50.00V
HV1: ENABLED
HV2: DISABLED
Integration Period: 1.0000us
Integration Delay: 0.0000us
Trigger Source: Internal Trigger Trigger Rate: 10000.00Hz

#	**PT**	**OR**	**IE**	**FM**	**Ch. 1**	**Ch. 2**	**Ch. 3**	**Ch. 4**	**Ch. 5**	**Ch. 6**	**Ch. 7**	**Ch. 8**	**Ch. 17**	**Ch. 18**	**TS**
1	4	0	0	0	0.0000	0.0000	0.0684	0.0684	0.0000	0.0000	2.8027	0.0684	-0.0684	0.0000	25
2	4	0	0	0	0.0684	0.0684	0.0000	0.0684	0.0684	0.0684	1.9824	0.0684	-0.0684	0.0684	137
3	4	0	0	0	0.0684	0.0000	0.0684	0.0684	0.0684	0.0000	1.6406	0.0684	-0.0684	0.0684	252
4	4	0	0	0	0.0000	0.0000	0.0000	0.0684	0.0684	0.0684	2.2559	0.0684	0.0000	0.0000	376
5	4	0	0	0	0.0000	0.0684	0.0000	0.0684	0.0684	0.0684	1.9824	0.0000	0.0000	0.0000	496
6	4	0	0	0	0.0000	0.0684	0.0000	0.0684	0.0684	0.0684	2.1191	0.0000	0.0000	0.0684	617
7	4	0	0	0	0.0684	0.0000	0.0684	0.0684	0.0684	0.0684	2.1191	0.0684	0.0000	0.0000	732
8	4	0	0	0	0.0000	0.0000	0.0000	0.0684	0.0684	0.0684	2.6660	0.0000	0.0000	0.0000	849
9	4	0	0	0	0.0000	0.0684	0.0000	0.0684	0.0000	0.0684	1.8457	0.0684	-0.0684	0.0000	971
10	4	0	0	0	0.0684	0.0684	0.0000	0.0684	0.0684	0.0000	2.3926	0.0684	0.0000	-0.0684	1095
11	4	0	0	0	0.0000	0.0684	0.0000	0.0684	0.0000	0.0684	2.5977	0.0000	-0.0684	0.0684	1213
12	4	0	0	0	0.0000	0.0000	0.0000	0.0684	0.0000	0.0684	2.2559	0.0000	0.0000	0.0000	1328
13	4	0	0	0	0.0000	0.0684	0.0000	0.0000	0.0000	0.0684	2.1875	0.0684	0.0000	0.0000	1445
14	4	0	0	0	0.0684	0.0000	0.0000	0.0684	0.0684	0.0684	2.1875	0.0000	0.0000	0.0000	1555
15	4	0	0	0	0.0000	0.0000	0.0000	0.0684	0.0000	0.0684	2.6660	0.0684	0.0000	0.0000	1666
16	4	0	0	0	0.0000	0.0684	0.0000	0.0684	0.0684	0.0000	2.2559	0.0684	0.0000	0.0000	1814
17	4	0	0	0	0.0000	0.0000	0.0000	0.0000	0.0684	0.0684	1.7090	0.0000	0.0000	0.0000	1925
18	4	0	0	0	0.0684	0.0000	0.0684	0.0684	0.0684	0.0684	2.7344	0.0684	0.0000	0.0000	2036
19	4	0	0	0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0684	2.6660	0.0000	-0.0684	0.0684	2148
20	4	0	0	0	0.0684	0.0000	0.0000	0.0684	0.0684	0.0684	1.7773	0.0000	0.0000	0.0000	2259
21	4	0	0	0	0.0684	0.0000	0.0000	0.0684	0.0000	0.0684	1.8457	0.0000	0.0000	0.0684	2370
22	4	0	0	0	0.0684	0.0000	0.0000	0.0000	0.0684	0.0684	1.9824	0.0000	0.0000	0.0000	2619
23	4	0	0	0	0.0000	0.0000	0.0684	0.0684	0.0000	0.0684	2.1191	0.0684	-0.0684	-0.0684	2732
24	4	0	0	0	0.0684	0.0000	0.0000	0.0684	0.0000	0.0684	2.5977	0.0684	-0.0684	0.0000	2845
25	4	0	0	0	0.0684	0.0000	-0.0684	0.0000	0.0000	0.0000	2.0508	0.0684	-0.0684	0.0000	2956
26	4	0	0	0	0.0000	0.0684	0.0684	0.0684	0.0684	0.0684	2.5977	0.0000	0.0000	0.0000	3065
27	4	0	0	0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	2.3242	0.0684	0.0000	0.0000	3173
28	4	0	0	0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0684	1.9141	0.0000	-0.0684	0.0000	3425
29	4	0	0	0	0.0684	0.0000	0.0684	0.0684	0.0684	0.0000	2.5293	0.0684	0.0000	0.0000	3531
30	4	0	0	0	0.0000	0.0684	0.0000	0.0684	0.0000	0.0684	2.4609	0.0684	-0.0684	0.0000	3638
31	4	0	0	0	0.0000	0.0684	0.0000	0.0684	0.0000	0.0684	2.2559	0.0000	0.0000	0.0000	3747
32	4	0	0	0	0.0000	0.0000	0.0000	0.0684	0.0000	0.0684	2.1875	0.0684	0.0000	0.0000	3854
33	4	0	0	0	0.0000	0.0000	0.0684	0.0684	0.0684	0.0684	2.1191	0.0684	0.0000	0.0000	3961
34	4	0	0	0	0.0000	0.0684	0.0684	0.0684	0.0000	0.0000	2.1875	0.0000	-0.0684	0.0000	4069
35	4	0	0	0	0.0684	0.0684	-0.0684	0.0000	0.0684	0.0684	2.7344	0.0684	-0.0684	0.0684	4208
36	4	0	0	0	0.0684	0.0684	0.0000	0.0000	0.0684	0.0000	2.5977	0.0684	0.0000	0.0000	4315
37	4	0	0	0	0.0000	0.0684	0.0684	0.0000	0.0000	0.1367	1.9141	0.0684	-0.0684	0.0000	4424
38	4	0	0	0	0.0684	0.0684	0.0000	0.0684	0.0000	0.0684	2.4609	0.0684	0.0000	0.0000	4533
39	4	0	0	0	0.0684	0.0684	0.0000	0.0684	0.0684	0.0684	2.2559	0.0684	0.0000	0.0000	4639
40	4	0	0	0	0.0684	0.0684	0.0000	0.1367	0.0684	0.0684	1.7090	0.0000	-0.0684	0.0000	4753
41	4	0	0	0	0.0684	0.1367	0.0684	0.1367	0.0684	0.0684	2.8711	0.0684	0.0684	0.0684	4861
42	4	0	0	0	0.0684	0.0684	0.0684	0.0684	0.0000	0.0684	2.1191	0.0684	0.0000	0.0000	4969
43	4	0	0	0	0.0684	0.0684	0.0684	0.0000	0.0000	0.0000	2.2559	0.0000	-0.0684	0.0000	5076
44	4	0	0	0	0.0000	0.0684	0.0000	0.0684	0.0000	0.0684	2.3242	0.0000	0.0000	0.0000	5194
45	4	0	0	0	0.0000	0.0684	0.0000	0.0000	0.0000	0.0684	2.0508	0.1367	-0.0684	0.0000	5300
46	4	0	0	0	0.0684	0.0684	0.0000	0.0684	0.0000	0.0684	2.2559	0.0000	0.0000	0.0000	5436
47	4	0	0	0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0684	2.3242	0.0684	-0.0684	0.0000	5545
48	4	0	0	0	0.0000	0.0000	0.0684	0.0684	0.0684	0.0684	1.9824	0.0684	-0.0684	0.0000	5654

Figure 28: Text Log File Example

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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.

User Configuration Table

The *user* table contains the configuration of the PhotoniQ set by the user through the user interface. It is 750 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 = 500 – 9250 (50 – 925V)
2	HVLimit1	16 SHORT	Maximum allowed voltage on HV supply 2	Range = 500 – 9250 (50 – 925V)
3	NumChannelsB0	16 SHORT	Number of channels enabled bank 1	Range = 0 – 16 (1 channel per bit)
4	NumChannelsB1	16 SHORT	Number of channels enabled bank 2	Range = 0 – 16 (1 channel per bit)
5	NumChannelsB2	16 SHORT	Number of channels enabled bank 3	Range = 0 – 16 (1 channel per bit)
6	NumChannelsB3	16 SHORT	Number of channels enabled bank 4	Range = 0 – 16 (1 channel per bit)
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 = 500 – 9250 (50 – 925 V)
9	HVSetpoint1	16 SHORT	Current setpoint HV supply 2 (DAC 7)	Range = 500 – 9250 (50 – 925 V)
10	UserConfigID	16 SHORT	Unused	N/A (0 – 65535)
11	DCRD_AOut_0	16 SHORT	Daughtercard analog out control (DAC 8)	0-65535 (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 – 63 (1 channel per bit)
14	Band0EndIndex	16 SHORT	End index for spectral filtering band 1	Range = 0 – 63 (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 – 63 (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

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Index	Parameter Name	Type	Description	Parameter Limits
38-41	Flag2Operand0-Flag2Operand3	16 SHORT	Spectral filtering operands for flag 3 configuration	Same as Above
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)	0-65535 (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 = 3 – 29326 (0.1 – 1000pC)
81	InputTrigChannel	16 SHORT	Input trigger current channel	Range = 0 – 64 (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

Index	Parameter Name	Type	Description	Parameter Limits
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)
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 = 10 – 10000000 (0.1 – 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)

Table 13: User Configuration Table

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Custom Configuration Table

The *custom* table is a reserved space of 500 words that is used by applications programmers to store custom configuration data.

Index	Parameter Name	Type	Description	Parameter Limits
750-1249	CustomElement0-CustomElement499	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 = Option IQSP480 2 = Option IQSP580 3 = Option SS20 4 = Option HS20
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)	0-0xFFFF (3.0V full scale)

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Index	Parameter Name	Type	Description	Parameter Limits
1775	DREVoltage0	16 SHORT	Can be configured for an alternative front-end configuration (DAC4)	0-0xFFFF (3.0V full scale)
1776	RESERVED	16 SHORT	Reserved for expansion	
1777-1780	ResetLowThresh0-ResetLowThresh3	16 SHORT	Reset low threshold bank 1 to bank 4	0 - 0xFFFF
1781-1784	ResetHighThresh0-ResetHighThresh3	16 SHORT	Reset high threshold bank 1 to bank 4	0 - 0xFFFF
1785-1788	OORLowThresh0-OORLowThresh3	16 SHORT	Out of range threshold low	0 - 0xFFFF
1789-1792	OORHighThresh0-OORHighThresh3	16 SHORT	Out of range threshold high	0 - 0xFFFF
1793-1794	VBTest0- VBTest1	16 SHORT	Test voltages (DAC2 and DAC3)	0-0xFFFF (3.3V full scale)
1795-1798	ChProcessingEnables0 ChProcessingEnables3	16 SHORT	Channel processing enables	Bit 0 = Deserializer Enable Bit 1 = Reset Threshold Enable Bit 2 = Buffer Enable Bit 3 = Differencer Subtracted or Raw Bit 4 = Offset Enable Bit 5 = Gain Enable Bit 6 = Range Adjust Enable Bit 7 = Data Trigger Enable 0 = Disabled, Raw 1 = Enabled, Subtracted
1799-1802	NumChPopulated0-NumChPopulated3	16 SHORT	Number of channels populated 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) 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

Index	Parameter Name	Type	Description	Parameter Limits
1809	AssemblyRevisionPCRev	16 SHORT	PCB Revision Number	None (0 – 0xFFFF)
1810	AssemblyRevision Letter	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 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 8.2.1. 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.

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.

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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.

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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/4095)* 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

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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

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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 connector(s) on the PhotoniQ. Thirty-two (32) low-noise, parallel coaxial connections are provided through this small form factor connector. Ordinarily this interface is used with one of Vertilon's standard sensor interface boards and accompanying SIB cable. In this situation the user simply connects the SIB cable between the sensor interface board and the front panel SIB connector. However, for applications that utilize a custom SIB or require connectivity to the PhotoniQ in a non-standard way, the pinout for the SIB connector is provided in Table 22. For 64 channels versions of the PhotoniQ the pinout for the second SIB connector is virtually identical to that of the first connector except that the signal inputs are for channels 33 to 64. 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

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