User Manual

PhotoniQ Series

DAQXY504

X-Y Positioning Data Acquisition System

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General Safety Precautions

Warning – High Voltages

The PhotoniQ Model DAQXY504 interfaces to photomultiplier tubes, silicon photomultipliers, and avalanche photodiodes which require potentially harmful high voltages (up to 2000 Volts) during operation. Extreme care should be taken.

Use Proper Power Source

The PhotoniQ Model DAQXY504 is supplied with a +5V desktop power source. Use with any power source other than the one supplied may result in damage to the product.

Operate Inputs within Specified Range

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

Electrostatic Discharge Sensitive

Electrostatic discharges may result in damage to the PhotoniQ or its accessories. 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.

Product Overview

The PhotoniQ Model DAQXY504 is designed to offer scientists, engineers, and developers an off-the-shelf solution for their multi-channel electro-optic sensor needs. Implemented as a stand-alone laboratory instrument with a PC interface, the PhotoniQ is used for charge integration and data acquisition (DAQ) from Anger logic-connected multianode photomultiplier tubes (MAPMT) and silicon photomultiplier (SiPM) arrays. The use of Anger logic allows for high channel count MAPMTs and SiPM arrays to be reduced to just four channels (using position of the centroid or center of the light distribution) by means of a simple resistive network. The DAQXY504 is fully configurable through the PC via its USB 2.0 port using an included graphical user interface. Continuous high speed data transfers to the PC are also handled through this interface. Additionally, a LabVIEW™ generated DLL is provided for users who wish to write their own applications that interface directly to the unit.

Features

- Four gated integrator / data acquisition input channels
- Inputs configurable for current mode or voltage mode
- Four buffered output channels for monitoring signals with external equipment
- Graphical User Interface (GUI) for menu driven data acquisition and configuration
- USB 2.0 interface supports high data transfer rates
- Three real-time GUI displays of charge per channel, total charge (oscilloscope mode), and X-Y position
- High-speed event capture at 14-bit resolution
- Event pair resolution of 2.5 usec with a maximum trigger rate of 390 KHz
- Data acquisition optimized for randomly arriving particle analysis
- On-board high speed discriminator for connection to MAPMT last dynode
- Triggering by discriminator, external input, or internal source
- Switchable fixed delay on each input for trigger signal delay compensation
- Flexible control of integration gate parameters such as delay and period
- Event trigger stamping and time stamping with 100 nsec resolution
- Optional high voltage output for MAPMT or SiPM array bias
- LabVIEW™ generated DLL for interface to user custom applications

Applications

- PET and SPECT
- Spatial Radiation Detection
- Gamma Cameras
- Particle Physics
- Multianode Photomultiplier Tubes
- Silicon Photomultipliers Arrays

Hardware

The photo below shows the PhotoniQ model DAQXY504.

Figure 1: Model DAQXY504 (Front View)

Figure 2: Model DAQXY504 (Rear View)

Software

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

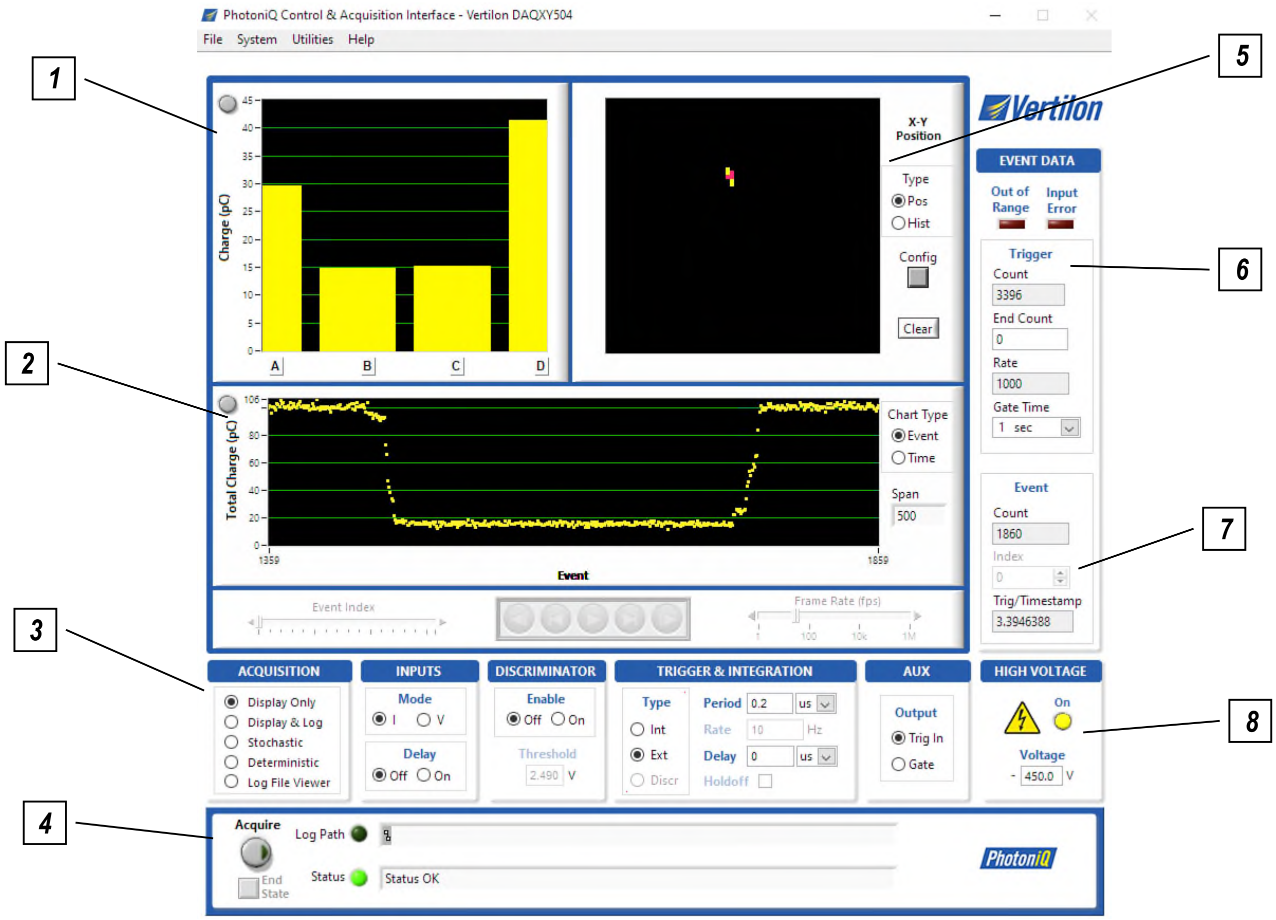


Figure 3: PhotoniQ Control and Acquisition Software Front Panel

1. Signal Channel Display
2. Total Charge Display (Oscilloscope Mode)
3. Instrument Control Area
4. Acquisition Section
5. X-Y Position Display
6. Trigger Data
7. Event Data
8. High Voltage Bias Control

Included Components and Software

The PhotoniQ model DAQXY504 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

Optional Components

The PhotoniQ model DAQXY504 can be ordered with the following options pre-installed:

Option Number	Option Description
HVPS001	Internal negative 1000V high voltage power supply for MAPMT bias
HVPS002	Internal negative 1500V high voltage power supply for MAPMT bias
HVPS701	Internal negative 100V high voltage power supply for SiPM array bias

Table 1: Configuration Options

DAQXY504

Power Supply

USB Cable

Optional High Voltage Cable

Figure 4: Included and Optional Items

Typical Setup

A typical setup using a DAQXY504 and Vertilon SIB71256 Anger logic sensor interface board for the Hamamatsu H13700 16 x 16 MAPMT is shown below. The Hamamatsu H13700 MAPMT is mounted to the SIB71256 and positioned to detect incoming light from a scintillator crystal or optical assembly. The four anger logic outputs from the SIB71256 connect to four inputs on a PhotoniQ DAQXY504 four channel charge integrating MAPMT data acquisition system. Digitized output data from the DAQXY504 is sent through a USB 2.0 connection to a PC for display, logging, or real time processing. The amplified last dynode signal from the SIB71256 connects to the DAQXY504 internal discriminator that generates a trigger to the PhotoniQ. A high voltage bias of up to negative 1200 volts is sent directly to the PMT from an SHV connector located on the front panel of the PhotoniQ. Note that the high voltage output is an optional configuration on the DAQXY504.

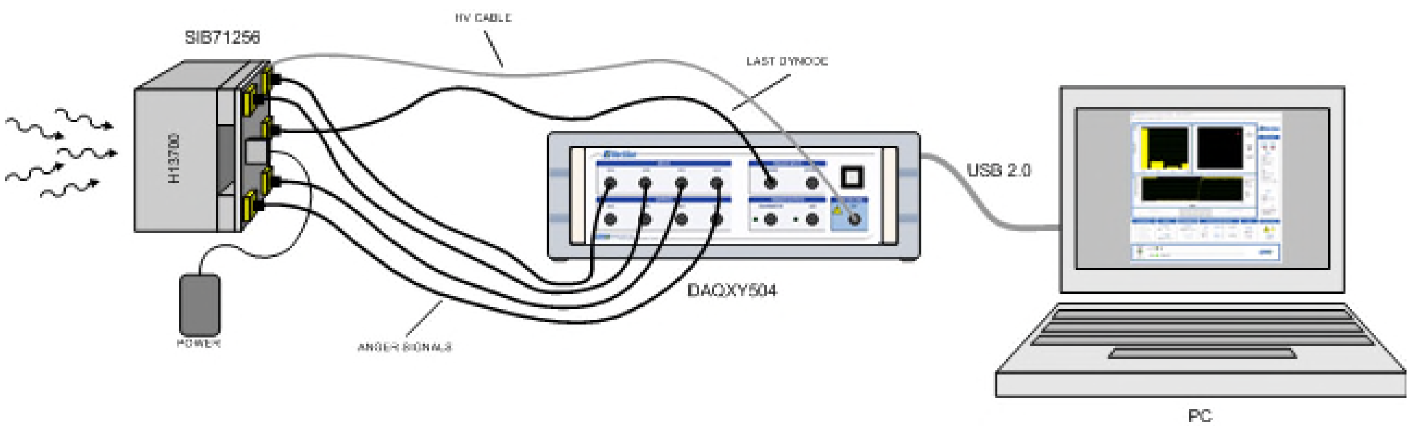


Figure 5: Typical Setup

Specifications[1]

General Specifications

Item	Specification
Number of Channels	4
Resolution	14 bits
Dynamic Range	84 dB
Switchable Channel Delay	60 nsec typical
Minimum Event Pair Resolution (MEPR)[2]	2.5 usec max.
Maximum Trigger Rate (MTR)[2]	390 KHz
Sustained Average Event Rate (SAER)[3]	500,000 events / sec
Event Buffer Size (EBS)	8,000,000 events
Power Consumption[4]	2.0 Watts typ.

Table 2: System Specifications

Input Specifications

Description	Current Mode	Voltage Mode
Input Impedance	50 ohms	50 ohms
Polarity	Negative Current	Positive Voltage
Input Range	0 to -25mA	0 to +5V
Maximum Charge Input Signal[5]	875 pC	875 pC
Equivalent Input Noise Charge[5]	100 fC RMS typ.	100 fC RMS typ.
Channel-to-Channel Crosstalk[6]	-84 dB typical, -80 dB max.	-84 dB typical, -80 dB max.
Input Bias Current	±40 pA typical, ±150 pA max.	-1.2 uA typical, -1.6 uA max.
Input Offset Voltage	±1.5 mV max.	±125 uV max.

Table 3: Input Specifications

1 Typical specifications at room temperature.
2 For integration period of 100nsec.
3 Specification assumes PC and USB port capable of handling continuous data transfers at ~16MB/sec and all log file reporting functions disabled.
4 Assumes no optional high voltage bias supplies. Add 0.7W for each bias supply at max voltage and max load.
5 Specification calculated for voltage mode by dividing input voltage by voltage-to-current scale factor of 200 ohms
6 For integration periods greater than 300 nsec.

Discriminator Specifications

Description	Specification
Discriminator Type	Leading Edge
Input Impedance	50 ohms
Polarity	Positive Current
Input Range	0 to +25mA
Delay	15 nsec typ.
Discriminator Output Range	0 to +3.3V
Discriminator Output Impedance	50 ohms typ.

Table 4: Discriminator Specifications

Miscellaneous Specifications

Description	Sym	Minimum	Maximum
Trigger to Integration Delay[1]	t_{td}	0 nsec	1 msec
Trigger to Integration Jitter	t_{td}		± 5 nsec
Integration Period Error	t_{int}		±5 nsec
Internal Trigger Rate	f_{trig}	10 Hz	200 KHz
Trigger Input Voltage Range		0 V	+3.3V, +5.0 V max.
Trigger Input Logic Low Threshold			+0.8 V
Trigger Input Logic High Threshold		+4.2 V	
Trigger Input, Input Impedance		50 ohms	
Trigger Input, Rise Time			20 nsec
Trigger Input, Positive Pulse Width		100 nsec	
Trigger Input, Negative Pulse Width		100 nsec	
Discriminator Output Range		0 V	+3.3V
Aux Output Range		0 V	+3.3V
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

[1] A fixed delay of approximately 15 nsec is in addition to the delay setting.

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 10 operating system or later
- Intel USB 2.0 high-speed host controller with 82801Dx chipset (low speed is not supported)
- Run-time engine for LabVIEW™ version 2016 for use with DLL

Theory of Operation

The PhotoniQ DAQXY504 consists of four configurable charge integration and data acquisition channels as shown in the figure below. All channels are configured and triggered together and generate four parallel streams of digital data that are stored in the Data Buffer. The buffer data is sent to the Digital Signal Processor (DSP) where it is further processed, packetized, and sent to the USB output port. The Trigger Processor and Timing module configures the triggering, integration, and acquisition parameters for each channel based on the selections made by the user in the graphical user interface (GUI). Additional functionality in the DAQXY504 includes an on-board high speed discriminator and optional high voltage generator to bias MAPMTs and SiPM arrays.

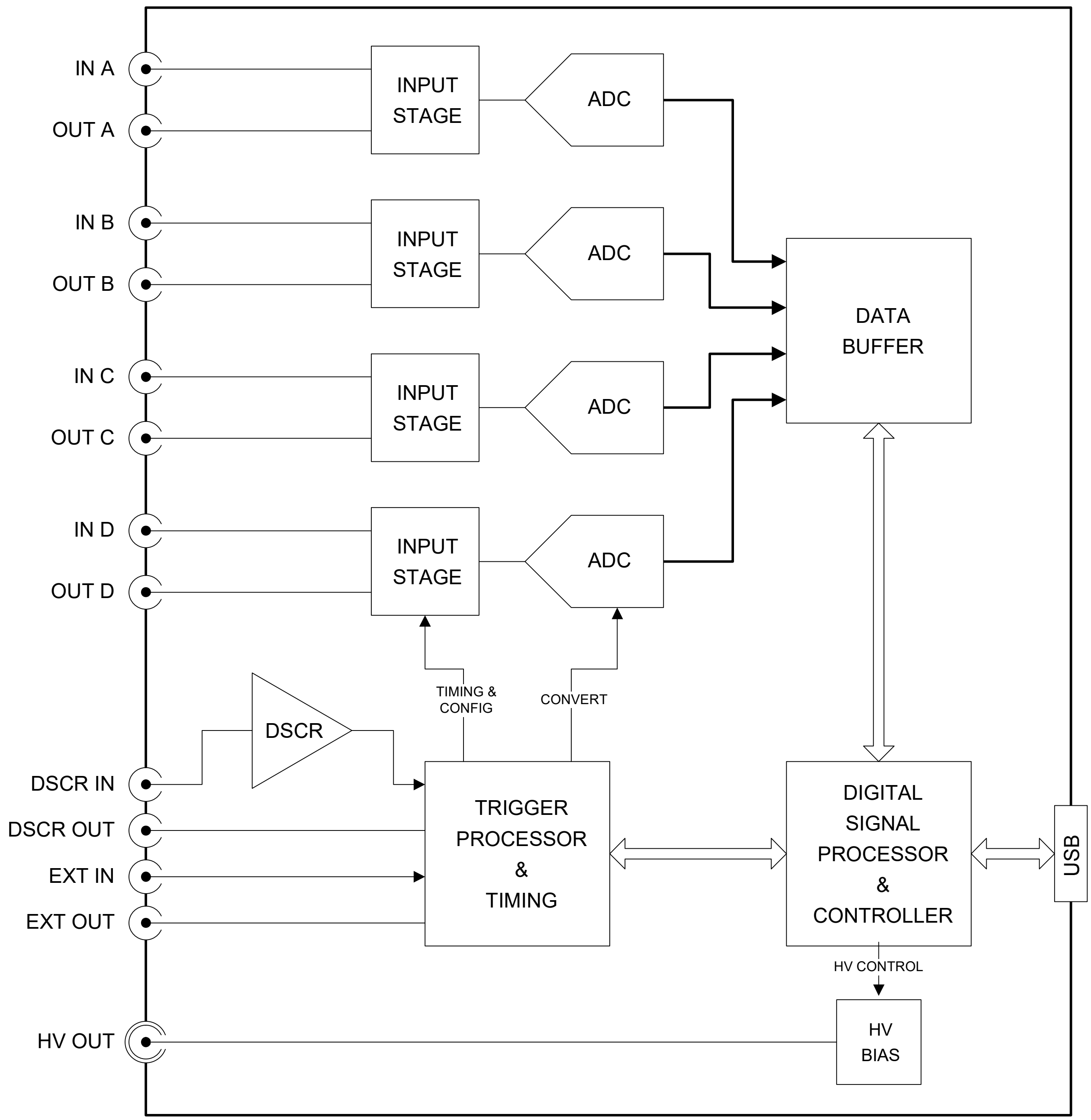


Figure 6: PhotoniQ DAQXY504 Functional Block Diagram

Charge Integration & Data Acquisition Channels

Data acquisition is initiated by a trigger signal detected by the DAQXY504 Trigger Processor and Timing module. Each trigger starts the collection and digitization of charge signals from the MAPMT or silicon photomultiplier array across all channels. This functionality, which is shown in the previous figure as a generic Input Stage followed by an ADC, is implemented primarily as precision analog circuit elements that delay, 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 high sensitivity at very high repetition rates.

Configurable Input Stage

The DAQXY504 input stage shown below is designed for use in demanding low noise, high speed applications. Consisting of a switchable analog delay line, a switchable voltage-to-current amplifier, a current sensitive integrator with an independent reset function, and other proprietary functionality not shown in the figure, the front end is dynamically controlled and reconfigured to support a wide variety of MAPMT and SiPM array interface boards utilizing anger logic and having current or voltage mode outputs. When coupled to these devices, this circuit achieves high sensitivity at microsecond-level pulse-pair resolution. Each channel has a buffered output so that the input signals can be monitored using external test equipment.

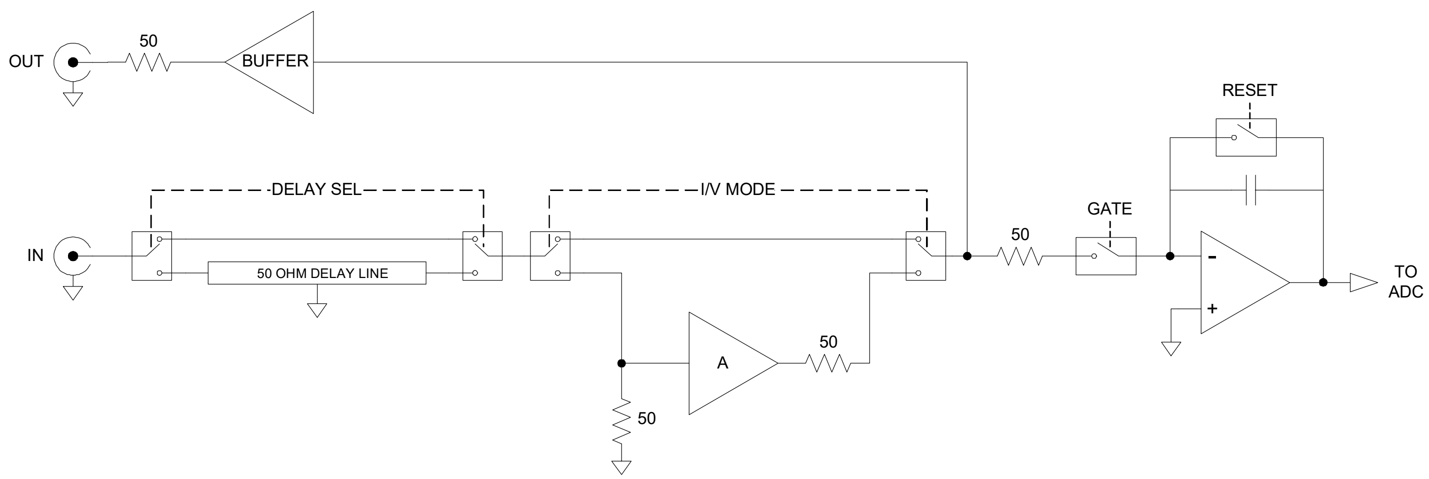


Figure 7: Input Stage

Output signals from the user's sensor interface board are connected to the input stage through BNCs on the DAQXY504 front panel. The input stage is configured for either negative current mode or positive voltage mode. For applications utilizing pure resistor-based anger logic circuitry with a MAPMT, current mode is most often selected. Voltage mode is usually selected for anger logic circuits that have positive voltage amplifiers on their outputs. Depending on the triggering requirements, the user can connect each input signal directly to the amplifiers, or alternatively, connect through a delay line that adds a fixed delay. In many applications the system trigger signal is derived from a randomly arriving particle that interacts with the sensor and producing a trigger that is inherently delayed relative to the arrival of the current / voltage signals on the four input channels. As a result, some signal loss occurs because the trigger arrives after the signals that are to be measured. By using the switchable delay line, the input signals can be further delayed so that the trigger precedes their arrival. The integration timing parameters can then be adjusted to achieve the optimum gating conditions. Regardless of whether the delay line is employed, current mode input signals connect directly to the charge integrator, while voltage mode input signals first pass through the voltage-to-current converter.

The charge integrator is ideal for use in applications where the integration period is precisely timed relative to the trigger signal. The *Gate* switch is used to selectively connect the MAPMT or SiPM array signals 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. Under certain low trigger rate conditions, the integrator is at risk of saturation because of constant optical background signals and electrical bias currents. 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.

Discriminator

The leading edge discriminator is designed for either direct (current mode) or preamplified (voltage mode) connection to a multianode PMT's last dynode output. In applications where particles arrive randomly, the last dynode is a convenient means to determine if an event has occurred on any of the MAPMTs multiple anodes. Since the last dynode typically produces a positive going analog current signal, the discriminator takes this signal and generates a digital timing signal. The user-adjusted threshold to the discriminator sets the crossover point of the analog signal at which the timing signal transitions. Circuitry internal to the discriminator prevents oscillations at crossover and also adds a user-selectable temporal holdoff that prevents inadvertent multiple triggering. The discriminator signal can be used to internally trigger the DAQXY504 or external equipment using the dedicated discriminator output BNC on the unit. In many nuclear physics applications, the discriminator threshold corresponds to a particle's energy level and thus only particles exceeding a particular energy level will be acquired.

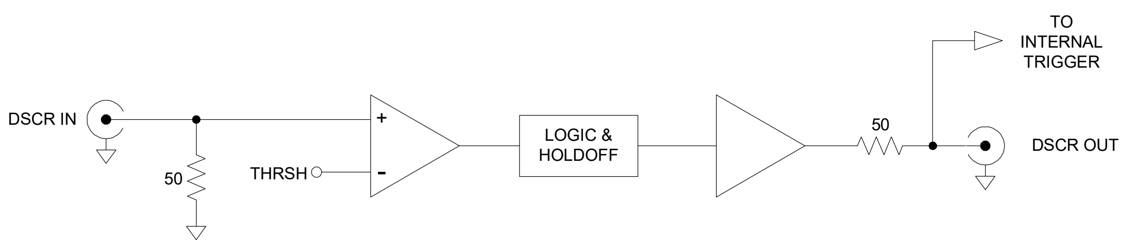


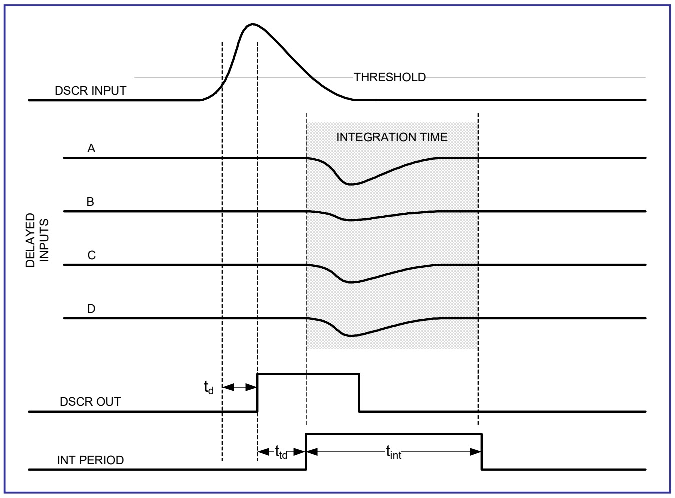
Figure 8: Discriminator

Triggering Modes

The DAQXY504 has three trigger modes, *Discriminator*, *External*, and *Internal*. The *Discriminator* mode is most commonly used with multianode PMTs in randomly arriving particle applications. This mode uses the internal discriminator connected to the MAPMTs last dynode to create an internal timing signal that triggers the unit. The discriminator is flexible enough that it can also be connected to other timing sources such as a reference PMT. The *External* trigger mode can be used with an external discriminator if the user has more stringent requirements that cannot be met using the DAQXY504 internal discriminator. Additionally, *External* trigger is useful when the DAQXY504 is employed in applications utilizing a synchronous light source. Here, the trigger and acquisition process can precisely timed to the excitation source. The *Internal* trigger mode is helpful for general setup and system diagnostics. In this mode, the DAQXY504 generates an internal trigger signal at a user-programmable rate. Although this signal runs asynchronously to external events, it is effective in evaluating connectivity to external electronics and verifying software functionality.

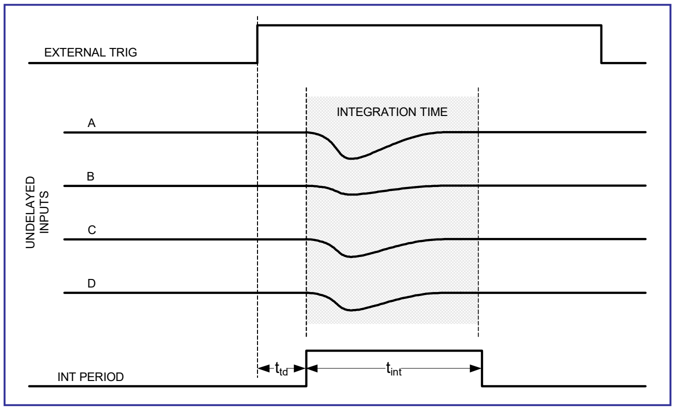
Discriminator Trigger

A positive-going analog signal such as the last dynode from a MAPMT is applied to the discriminator input. The discriminator output goes high after a fixed delay (t_d) when its input crosses the user-adjustable threshold. In typical applications, the four inputs to the DAQXY504 (which are usually derived from Anger logic circuitry around the MAPMT's anodes) are synchronous to the last dynode output and thus the trigger to the DAQXY504 lags the input signals. By enabling the input delay feature and the user-adjustable integration delay (t_{td}) as shown in the figure at right, the integration period (t_{int}) can be positioned to capture the entirety of the event of interest.



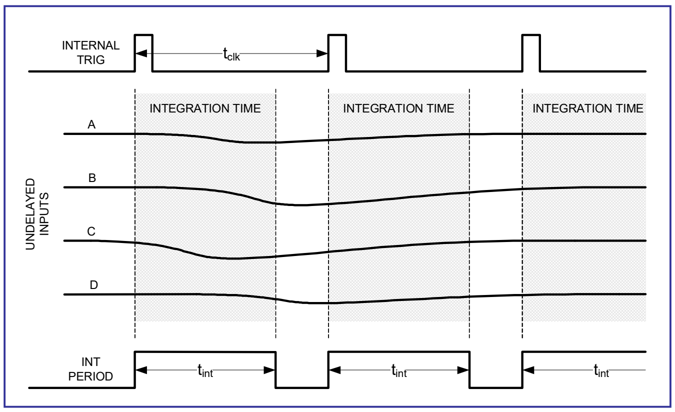
External Trigger

External trigger is a simple trigger mode whereby an externally-supplied positive signal edge to the DAQXY504 starts the event acquisition process. The rising edge of the trigger initiates the start of the integration. It is not necessary to enable the input delay feature as long as the external trigger precedes the start of the event to be captured by an adequate amount of time.



Internal Trigger

Continuous data acquisition is possible by operating the unit in internal triggering mode. Here a programmable internal free running clock (t_{clk}) replaces the external trigger signal. Data is continuously acquired on each edge of the clock signal. This mode is particularly useful when slowly varying asynchronous signals are present, but no trigger signal is available.



Control and Acquisition Interface Software

The DAQXY504 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 unit such as trigger and acquisition modes, integration time, discriminator parameters, etc. is input through this interface. As configuration data is modified, the DAQXY504'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 DAQXY504, the configuration data must be reprogrammed through the GUI. At power-up, the hardware loads configuration data from a file on the user's PC. 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.

Hardware Interface

The photo below shows the front panel connectors and indicators on the PhotoniQ model DAQXY504.

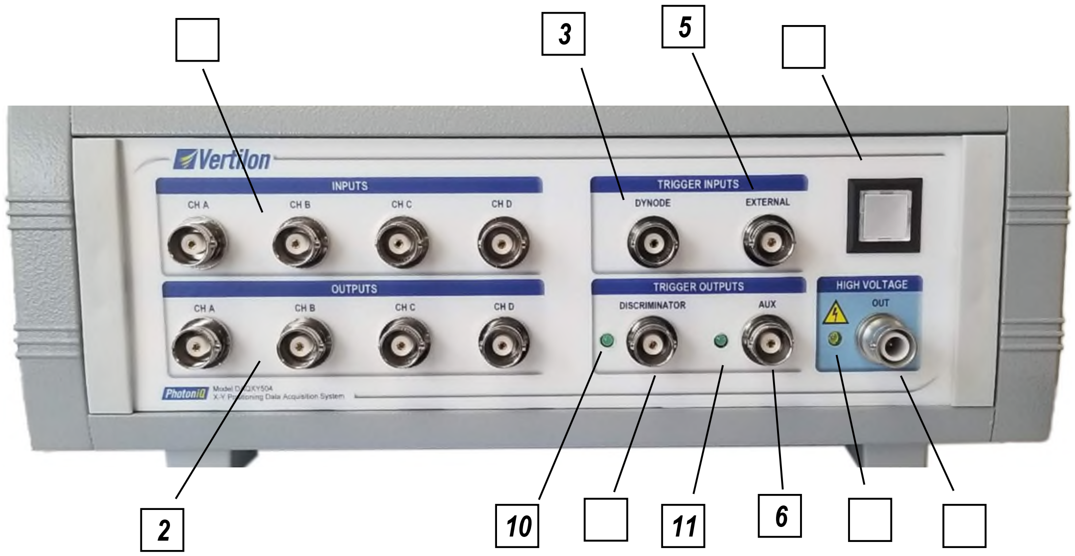


Figure 9: DAQXY504 Front Panel

1. **Input Channels (BNC):** Charge integrating input channels, total of four.
2. **Monitor Channels (BNC):** Input channel monitors, total of four.
3. **Discriminator Input (BNC):** Typically originates from last dynode from MAPMT.
4. **Discriminator Output (BNC):** Digital timing output from internal discriminator.
5. **Trigger Input (BNC):** Positive edge sensitive external trigger input to the DAQXY504.
6. **Auxiliary Output (BNC):** Configurable general purpose output.
7. **High Voltage Output (SHV):** Output from optional internal high voltage bias supply.
8. **High Voltage On Indicator (Yellow LED):** Indicates when the high voltage is on.
9. **Main Power Switch:** Lighted main power switch.
10. **Discriminator Activity Indicator (Green LED):** Indicates that the discriminator is active.
11. **Acquisition Indicator (Green LED):** Indicates when an event is acquired by the DAQXY504.

Control and Acquisition Interface Software

Running GUI program will open the main window (front panel) of the Control and Acquisition Interface Software. The front panel is 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 DAQXY504 and for performing diagnostic routines.

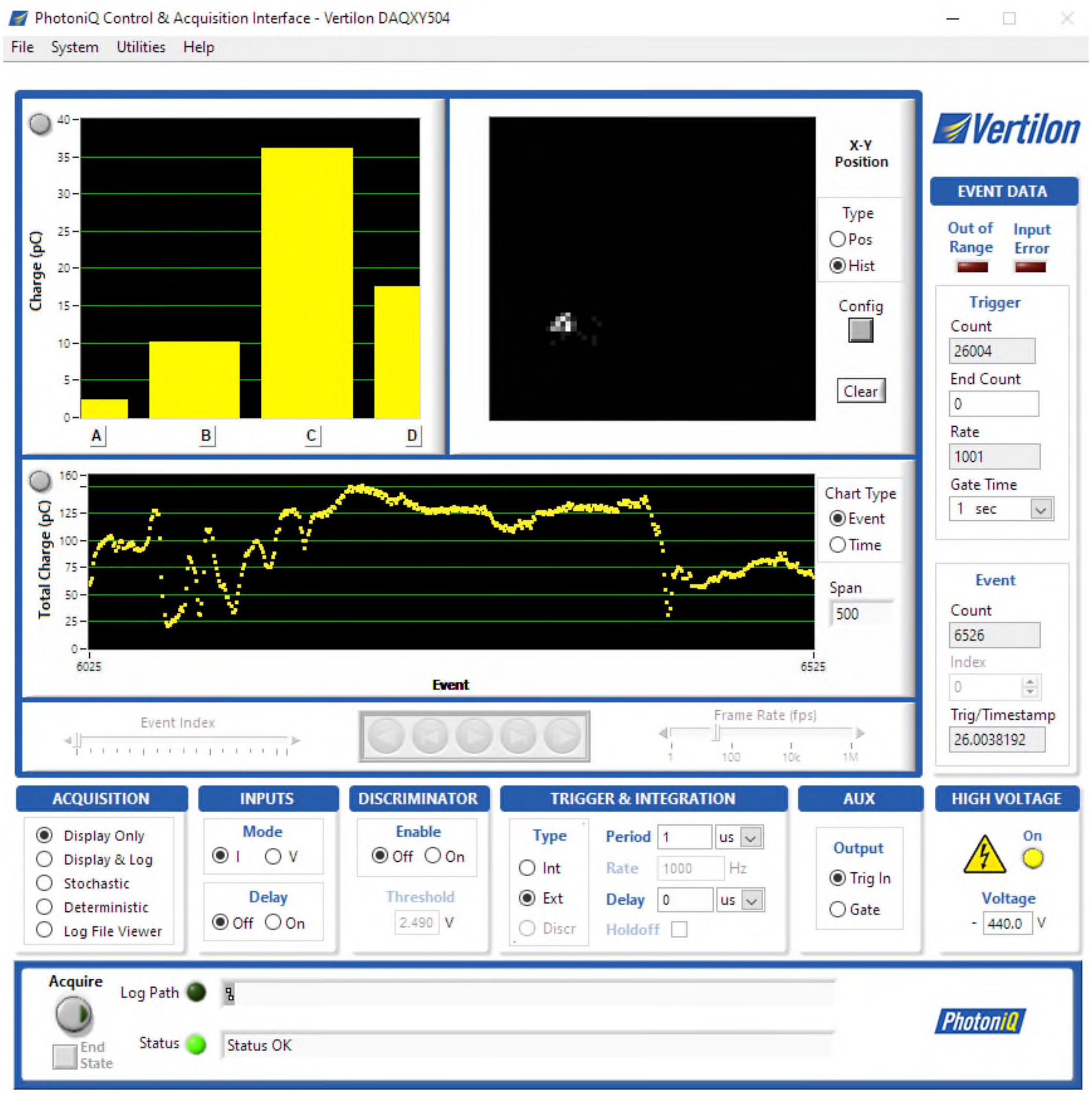


Figure 10: Front Panel

Control Area

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

Acquisition

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

Display Only

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

Display & Log

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

Stochastic

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.

Deterministic

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 and event playback controls.

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.

End State
The *End State* button is active during any of the three data logging modes. Pressing the button opens the dialog box shown below. Here the user can specify the condition to terminate the acquisition / logging process. If no condition is specified, the acquisition will run indefinitely unless the *Trigger End Count* is reached or the user presses the *Acquire* button again.

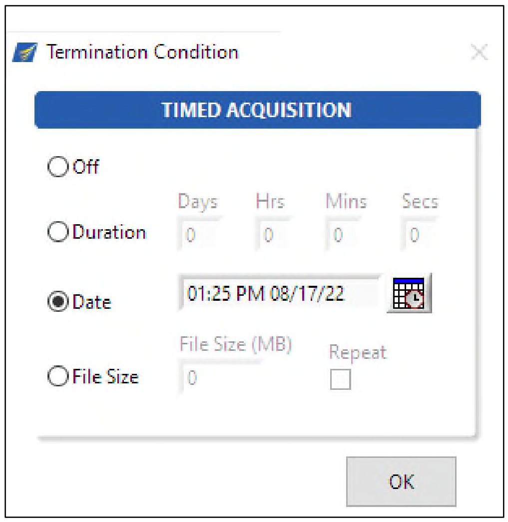


Figure 11: Timed Acquisition Dialog Box

Duration
Acquisition terminates after a duration of time specified in the *Days*, *Hours*, *Minutes*, and *Seconds* boxes.

Date
Acquisition terminates when the specified date and time is reached.

File Size
When logging over extended periods of time at high data rates, it is often necessary to limit the size of the log files that are created. In this mode the user can specify the maximum log file size in 10 megabyte (MB) increments. If the *Repeat* box is checked, the system will continually create sequentially numbered log files of the *File Size* specified. Only one log file of the specified *File Size* will be created when *Repeat* box is unchecked.

Inputs

Controls the configuration of the four charge integrating inputs.

I / V Mode

Sets the four inputs to be either current or voltage sensitive inputs. *Current* mode is typically used when the inputs are directly connected to PMTs, silicon photomultipliers, and other current or charge output devices. *Voltage* mode is used when the inputs are connected to voltage output amplifiers like those from a buffered sensor interface board such as the Vertilon SIB71256 or 50 ohm laboratory equipment.

Delay

Enables the four channel input analog delay line that is typically used so that the actual event signals arrive after the trigger signal. This feature ensures that the entire randomly-arriving event is captured.

Discriminator

Controls the internal high speed discriminator.

Enable

Turns on and off the internal discriminator.

Threshold

Sets the threshold for triggering the internal discriminator. In typical particle physics applications, the threshold corresponds to an energy level.

Trigger & Integration

Sets the trigger integration parameters for the acquisition process.

Type

Used to select the trigger type of *Discriminator, External*, or *Internal*. For *Discriminator* type, the trigger signal is derived from the discriminator output. For *External* type, the user supplies the trigger signal (positive edge) 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.

Integration Period

Used with all trigger types, this parameter sets the duration of the integration period.

Rate

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

Integration Delay

Used with *Discriminator and External* trigger types, this parameter sets the delay from the trigger source to the start of the integration period.

Holdoff

This feature reduces excessive triggers that occur from noise or from very high event rates by *holding off* additional triggers within a preset time period. The trigger holdoff time, T_{hoff}, is internally set to optimally match the DAQXY504 maximum trigger rate.

High Voltage

Controls the optional internal high voltage bias supply. Note that this section is active only if the optional internal high voltage power supply is installed and enabled under the High Voltage Power Supply dropdown menu.

On
Turns on and off the optional internal high voltage power supply.

Voltage
Sets the output voltage of the optional internal high voltage bias supply.

Real Time Display Areas

The display areas 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 areas when viewing a previously logged file in *Log File View* mode. The display areas and its associated control functions are disabled when either *Stochastic* or *Deterministic* is selected as the acquisition mode.

Instantaneous Charge Display

Displays the instantaneous real time signal in picocoulombs (pC) from each of the four input channels as bar graphs. The display is continuously refreshed as new events are captured. Data is also shown on the display when viewing a previously logged file in *Log File View* mode.

Instantaneous Charge Autoscale Button

Clicking the small button near the top of the vertical scale adjusts the *Instantaneous Charge Display* limits to be between zero and the maximum value currently being recorded.

Total Charge Display (Oscilloscope Mode)

Displays the total charge in picocoulombs (pC) from the four input channels. This display operates like an oscilloscope and thus shows previously acquired data as scrolling from right to left as new events are acquired. Data is also shown on the display when viewing a previously logged file in *Log File View* mode.

Total Charge Autoscale Button

Clicking the small button near the top of the vertical scale adjusts the *Total Charge Display* limits to be between zero and the maximum value currently being recorded.

X-Y Display

The four Anger logic-encoded input channels are decoded and mapped into an X-Y position space in this display. A user-selectable number of events can be simultaneously shown in either the *Position* display or *Histogram* display. The *Position* display allows the user to set the minimum threshold for displaying events in one color, and an additional upper threshold for displaying events in a different color. This is useful in applications where particles of multiple discrete energy levels are to be acquired. The *Histogram* display uses a grey scale intensity graph to display the number of points collected in each position as a grey scale value. This is useful when the variance in position (positional noise) needs to be observed in real-time. The user can change the mapping parameters and the total number of events displayed by pressing the graph configuration button. Data is also shown on the display when viewing a previously logged file in *Log File View* mode.

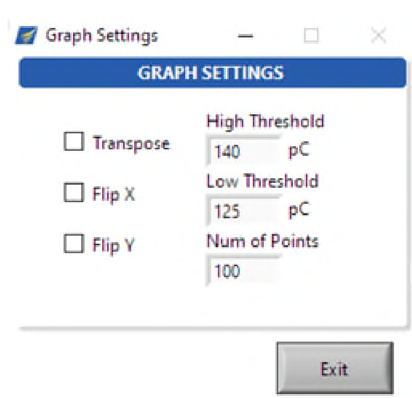


Figure 12: X-Y Display Dialog Box

Transpose
Swaps the X and Y axes of the display.

Flip X
Inverts the X-axis of the display.

Flip Y
Inverts the Y-axis of the display.

High Threshold
Sets the maximum display threshold for an event's total charge (energy). Events above this threshold are displayed in red.

Low Threshold
Sets the minimum display threshold for an event's total charge (energy). Events below this threshold are not displayed while events above this threshold (but below the *High Threshold*) are displayed in yellow.

Num of Points
Sets the total number of events that can be simultaneously displayed.

Event Data

Displays real-time event specific data.

Out of Range

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

Input Error

Indicates when a problem 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 *Deterministic* 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 *Stochastic* 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 *Stochastic* and *Deterministic* mode where the displayed *Trigger Count* will be equal to the *Trigger End Count* at the end of the acquisition period, this will usually not be the case when using the *Display* and *Display & Log* modes. Although the system in these modes will accurately count the triggers and stop when the *Trigger End Count* is reached, the final displayed *Trigger Count* will only indicate the number of triggers counted when the last event was acquired. The additional triggers are counted to reach the *Trigger End Count* but not displayed because none of them resulted in the acquisition of an event.

Trigger End Count

A user programmable value that specifies the *Trigger Count* value that terminates the *Acquire* period. This is normally used in *Deterministic* 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.

Trigger Rate

Reports the average trigger rate measured over the time interval set in the *Gate Time* box. The reported rate is calculated by taking the total number of triggers seen by the system during the *Gate Time* and dividing by the *Gate Time*. The *Trigger Rate* is unaffected by the actual number of events collected by the unit.

Gate Time

The period of time over which the *Trigger Rate* is calculated.

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 *Stochastic* or *Deterministic* 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 displays significantly slow the event acquisition rate. The *Stochastic* and *Deterministic* 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. However, changing any of the front panel controls while in either of the two display modes, will reset the time stamp. Time stamps are taken in fixed resolution steps as determined in the *Data Configuration* pull-down menu and are also referenced to the start of the *Acquire* period. The *Trigger/Time Stamp* counter rolls over after the maximum value is reached. To enable this feature the *Trigger/Time Stamp* must be selected in the *Data Configuration* menu.

Pull Down Menus

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

File

File operations generally consist of storing and retrieving PhotoniQ configurations between the PC and the PhotoniQ's volatile 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 unless a previous configuration was saved on the host PC. The last configuration will automatically be saved with no user intervention on exit from the GUI provided that the GUI was properly closed.

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.

Print Window
Prints the current window.

Exit
Closes the executable.

System

The PhotoniQ basic operation is configured through this pull down menu.

Data Configuration

Opens the dialog box shown below where the PhotoniQ basic system parameters are configured. The system speed and log file size are affected when any of these items are selected. See section on Log Files for the specifics on the log file sizes.

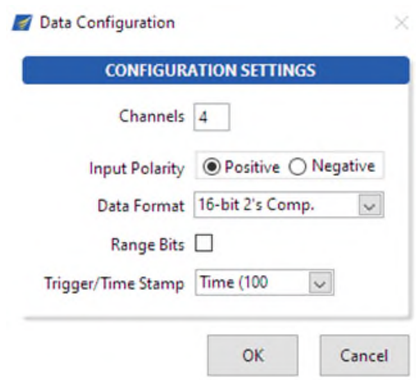


Figure 13: Data Configuration Dialog Box

Enabled Channels

Configures the number of input channels used by the system which in-turn determines the size of the output data packets. Under most conditions this number should be set to four.

Input Polarity

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

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* word. This format adds one extra word 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.

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. 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.

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.

High Voltage Supply
Opens the dialog box shown below where the optional high voltage bias supply is configured.

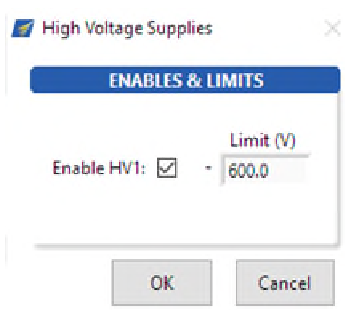


Figure 15: High Voltage Supply Dialog Box

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.

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

Units
Opens the dialog box shown below where the front panel display units and scaling can be customized.

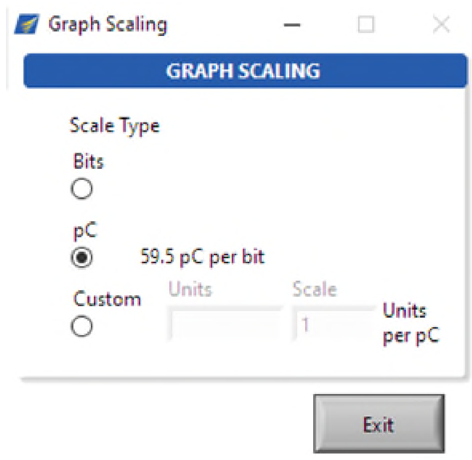


Figure 15: Graph Scaling Dialog Box

Scale Type
Sets the vertical scale for the front panel displays to be either bits, picocoulombs (pC) or a user's custom scale. The *Bits* scale is the raw data value coming from the internal hardware. The *pC* scale is the actual amount of charge measured by the DAQXY504's front end circuitry. This value is derived by multiplying the *Bits* value by the scale factor shown to the right of the *pC* radio button. The *Custom* scale is useful when the user wants to view the front panel displays' vertical scale in units more relevant to the user's application.

Custom Units
In a typical physics application, the units could be KeV or MeV.

Custom Scale Factor
The scale factor used could represent for example the conversion of charge to energy level.

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.

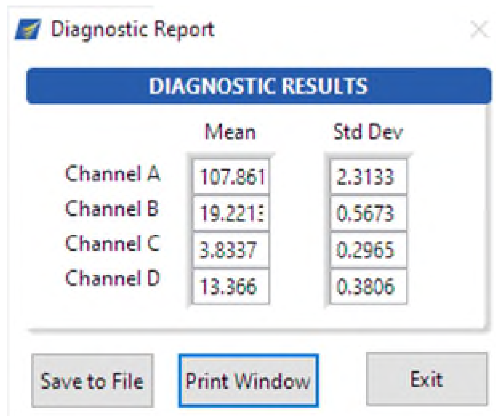


Figure 15: Diagnostic Report Dialog Box

Calibrate

Calibrates the PhotoniQ hardware. This function is generally not intended for the user and should only be initiated at the factory. However, if a calibration becomes necessary, first configure the PhotoniQ and confirm that the inputs are unconnected. Then 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 14 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 15 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.

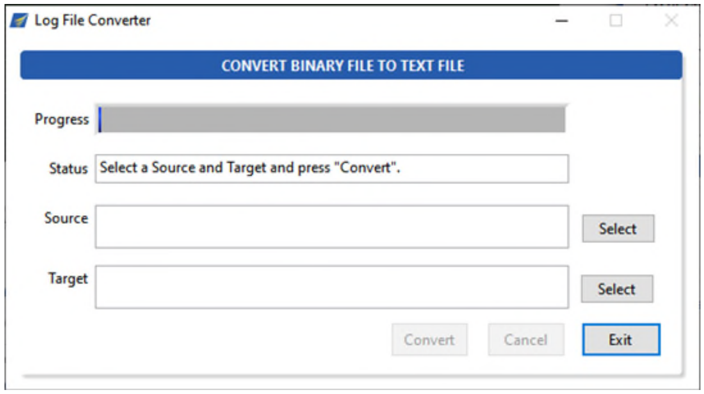


Figure 14: Log File Converter Dialog Box

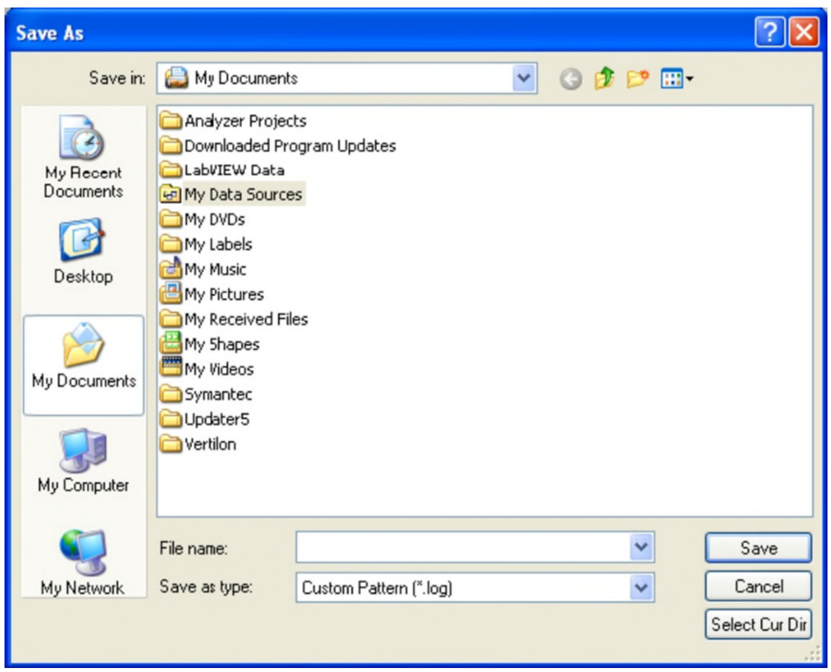


Figure 15: Select File Dialog Box

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* (current directory) 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.

Add Option

This utility allows the user to add certain software features to the PhotoniQ in the field. An *option code* obtained from Vertilon is inserted in the dialog box to upgrade the unit.

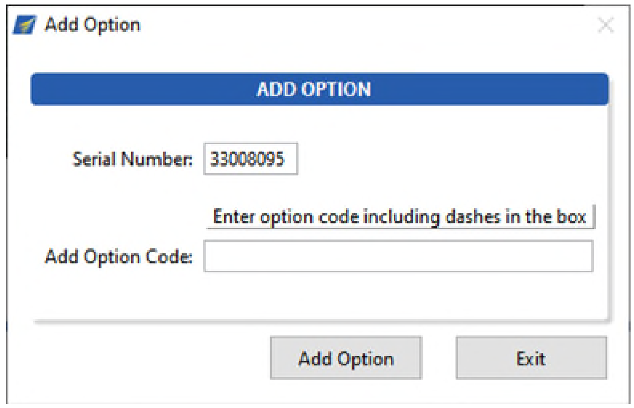


Figure 16: Add Option Dialog Box

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 *count* records 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 DAQXY504 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 DAQXY504 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 unit set by the user through the user interface. Any custom configuration data is stored in the *custom* table. Factory-programmed, read-only configuration data is found in the *factory* table.

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

Table 8: Binary Log File (Config Table Section)

The *Data Block* section defined in Table 9 below is made up of records that contain the *count* data for each channel. One record is created for each trigger that is acquired while logging. The length (L) of the record is dependent on the configuration settings selected in the user interface. Count record data is partitioned along 16-bit word boundaries.

Offset (Words)	Description	Length (Words)	Contents
2033	Record # 1	L	First Count Record
2033 +L	Record # 2	L	Second Count Record
…	…	L	…
2033 +(n-1)*L	Record # n	L	nth Count Record
…	…	…	…

Table 9: Binary Log File (Data Block Section)

Count Record Description

Count Record Format

Each *trigger* processed by the system generates a record of length L, where L is in 16-bit words. The record consists of a single word header followed by one additional word of count data for each channel enabled in the system. Depending on the configuration, there may be additional words following the count data. The figure below shows a generic example of a count record for a system configured with reporting for *Range Bits* and *Trigger/Time Stamp* (TS1, TS2) enabled. The DAQXY504 produces a maximum of 8 data words per trigger (5 data words with *range* and *trigger / time stamp* words off) when all four channels are enabled.

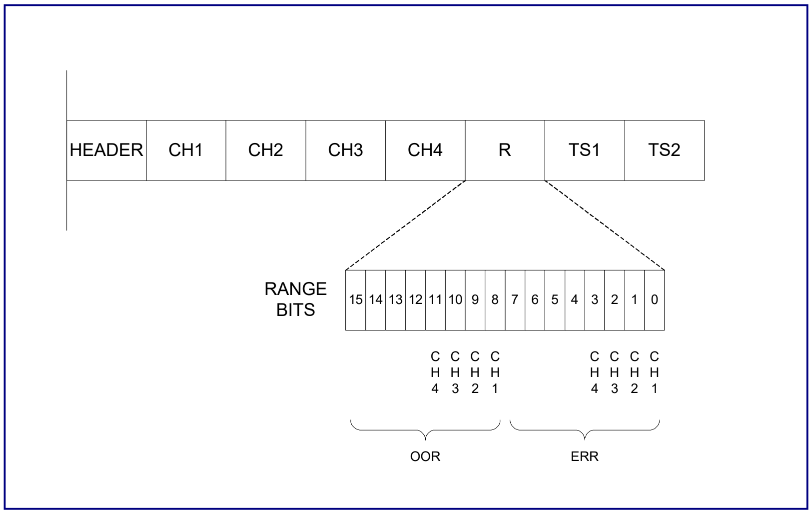


Figure 17: Count Record Format

Header Word

The contents of the count record header word are detailed in the table below.

Bit	Function	Description
15-13	Record Type	'100' = Normal Record
12	Out of Range Fault	'0' = No Faults Detected in Record '1' = At Least 1 Fault Detected in Record
11	Input Error Fault	'0' = No Faults Detected in Record '1' = At Least 1 Fault Detected in Record
10-0	Reserved	Reserved for Future Use

Table 10: Data Packet Header Word

Signal Data

Signal data is organized sequentially starting with the count data from the first channel followed by the data from the second channel, and so on. Individual channels are included in the count record only if they are enabled under the *Data Configuration* menu. Signal channels are formatted as unsigned 16-bit magnitude-only words with the LSB for each word located in bit 0. The integer value for each signal channel is equal to the total number of counts accumulated by the system during the count period.

Range Bits

Following the signal data in the record is the “bit-packed” *range* word that, if enabled, holds the range reporting bits. Disabling the range bit reporting under the *Data Configuration* menu removes the range words from the count record. Out-of-range (OOR) and input error (ERR) bits are formatted as shown in Figure 17. Range bits for unused channels should be ignored.

Trigger / Time Stamp

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

Count Record Length

The length (L) in words of each count record is given by the equation:

$$L = 1 + NC + R + 2 \cdot TS$$

The settings include the *Number of Channels* (NC) and the reporting enables for the *Range Bits* (R) and *Trigger/Time Stamp* (TS). The reporting enables are set in the *Data Configuration* menu to either a ‘1’ or a ‘0’.

Converting a Binary Log File to Text

Text log files should be used if a user wishes to import logged event data into a spreadsheet for further processing. A built in routine is included in the GUI for the purpose of converting a binary log file (.log extension) into a text file (.txt extension). The output of this conversion is a file containing a time and date stamp header and the logged event data organized by row where each row represents a successive event. The *event* rows are stored as tab-delimited numbers where the columns represent from left to right, *Packet Number* (#), *Packet Type* (PT), *Out of Range* (OR), *Input Error* (IE), *Filter Match* (FM), and channels 1 through N in picocoulombs. Only configured channels appear in the log file — unused channels are left out. If enabled, the *Trigger/Time Stamp* (TS) is stored in the last columns. A ‘4’ in the *Packet Type* column indicates an *event* row — other packet types are currently unsupported. An out of range condition on any of the N data channels is identified in the *Out of Range* column by a ‘1’. Input errors are similarly reported in the *Input Error* column. If range bit reporting was enabled during logging, the individual channel data columns will contain the value “MAX” or “MIN” depending on whether the signal was out of range high or low, respectively. An input error on a particular channel is identified by the value “ERR” in its respective column in the table. The *Filter Match* column is unused. 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.

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**	**TS**
1	4	0	0	0	0.0000	0.0000	0.0684	0.0684	25
2	4	0	0	0	0.0684	0.0684	0.0000	0.0684	137
3	4	0	0	0	0.0684	0.0000	0.0684	0.0684	252
4	4	0	0	0	0.0000	0.0000	0.0000	0.0684	376
5	4	0	0	0	0.0000	0.0684	0.0000	0.0684	496
6	4	0	0	0	0.0000	0.0684	0.0000	0.0684	617
7	4	0	0	0	0.0684	0.0000	0.0684	0.0684	732
8	4	0	0	0	0.0000	0.0000	0.0000	0.0684	849
9	4	0	0	0	0.0000	0.0684	0.0000	0.0684	971
10	4	0	0	0	0.0684	0.0684	0.0000	0.0684	1095
11	4	0	0	0	0.0000	0.0684	0.0000	0.0684	1213
12	4	0	0	0	0.0000	0.0000	0.0000	0.0684	1328
13	4	0	0	0	0.0000	0.0684	0.0000	0.0000	1445
14	4	0	0	0	0.0684	0.0000	0.0000	0.0684	1555
15	4	0	0	0	0.0000	0.0000	0.0000	0.0684	1666
16	4	0	0	0	0.0000	0.0684	0.0000	0.0684	1814
17	4	0	0	0	0.0000	0.0000	0.0000	0.0000	1925
18	4	0	0	0	0.0684	0.0000	0.0684	0.0684	2036
19	4	0	0	0	0.0000	0.0000	0.0000	0.0000	2148
20	4	0	0	0	0.0684	0.0000	0.0000	0.0684	2259
21	4	0	0	0	0.0684	0.0000	0.0000	0.0684	2370
22	4	0	0	0	0.0684	0.0000	0.0000	0.0000	2619
23	4	0	0	0	0.0000	0.0000	0.0684	0.0684	2732

Figure 18: Text Log File Example

Configuration Tables

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

User Configuration Table

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

Index	Parameter Name	Type	Description	Parameter Limits
0	SystemMode	16 SHORT	Indicates current system mode, acquire or standby mode	0 = Standby Mode 1 = Acquire Mode
1	HVLimit0	16 SHORT	Maximum allowed voltage on HV supply 1	Range = 100 – 13900 (10 – 1390V)
2	HVLimit1	16 SHORT	Maximum allowed voltage on HV supply 2	Range = 100 – 13900 (10 – 1390V)
3	NumChannelsB0	16 SHORT	Number of channels enabled bank 1	Range = 0 – 64
4	NumChannelsB1	16 SHORT	Number of channels enabled bank 2	Range = 0 – 64
5	NumChannelsB2	16 SHORT	Number of channels enabled bank 3	Range = 0 – 64
6	NumChannelsB3	16 SHORT	Number of channels enabled bank 4	Range = 0 – 64
7	HVEnabled	16 SHORT	Enables for high voltage supplies	Bit 0 = HV Supply 1 Enable/Disable Bit 1 = HV Supply 2 Enable/Disable
8	HVSetpoint0	16 SHORT	Current setpoint HV supply 1 (DAC 6)	Range = 100 – 13900 (10 – 1390V)
9	HVSetpoint1	16 SHORT	Current setpoint HV supply 2 (DAC 7)	Range = 100 – 13900 (10 – 1390V)
10	UserConfigID	16 SHORT	Unused	N/A (0 – 65535)
11	DCRD_AOut_0	16 SHORT	Daughtercard analog out control (DAC 8)	0-4095 (3.0V full scale)
12	BandEnables	16 SHORT	Spectral filtering band enables	Range = 0 – 255 (each bit position corresponds to 1 of 8 band enables)
13	Band0StartIndex	16 SHORT	Start index for spectral filtering band 1	Range = 0 – 255 (1 channel per bit)
14	Band0EndIndex	16 SHORT	End index for spectral filtering band 1	Range = 0 – 255 (1 channel per bit)
15-28	Band Indices for Remaining Bands	16 SHORT	Start index for spectral filtering band 2 - 8 End index for spectral filtering band 2 - 8	Range = 0 – 255 (1 channel per bit)
29	FlagEnables	16 SHORT	Spectral filtering flag enables	Range = 0 – 255 (each bit position corresponds to a flag enable)
30-33	Flag0Operand0-Flag0Operand3	16 SHORT	Spectral filtering operands for flag 1 configuration	Flag0Operand0,2 Range = 0 – 32767 Flag0Operand1,3 Range = 0 – 7 or 65535 (1 channel per bit or LSB wgt, 65535)
34-37	Flag1Operand0-Flag1Operand3	16 SHORT	Spectral filtering operands for flag 2 configuration	Same as Above
38-41	Flag2Operand0-Flag2Operand3	16 SHORT	Spectral filtering operands for flag 3 configuration	Same as Above
42-45	Flag3Operand0-Flag3Operand3	16 SHORT	Spectral filtering operands for flag 4 configuration	Same as Above
46-49	Flag4Operand0-Flag4Operand3	16 SHORT	Spectral filtering operands for flag 5 configuration	Same as Above
50-53	Flag5Operand0-Flag5Operand3	16 SHORT	Spectral filtering operands for flag 6 configuration	Same as Above
54-57	Flag6Operand0-Flag6Operand3	16 SHORT	Spectral filtering operands for flag 7 configuration	Same as Above
58-61	Flag7Operand0-Flag7Operand3	16 SHORT	Spectral filtering operands for flag 8 configuration	Same as Above
62-69	PTerm0-PTerm7	16 SHORT	Spectral filtering product terms	Range = 0 – 255 (each bit position corresponds to a flag)
70	DataFilterEnable	16 SHORT	Spectral filtering data filter blocks data output if there is no spectral filter match	0 = Disabled 1 = Enabled
71	ProcessingEnables	16 SHORT	Enables for various signal processing options	Bit 0 = Spectral Filtering Enable Bit 1 = Gain Enable Bit 2 = Background Subtraction Enable
72	TimestampEnable	16 SHORT	Enables/Disables timestamp output	0 = Disabled 1 = Enabled
73	DAC_Spare	16 SHORT	SIB analog out control (DAC 5)	0-4095 (3.0V full scale)

Index	Parameter Name	Type	Description	Parameter Limits
74-75	TimestampInterval	32 LONG	Timestamp interval configuration	Range = 10 – 100000 (10ns per bit)
76	CustomWordsEnable	16 SHORT	Enables/Disable custom words output	0 = Disabled 1 = Enabled
77	EventCustomCount	16 SHORT	Number of custom words	Range = 0 – 64 (1 word per bit)
78	RESERVED	16 SHORT	Unused	N/A (0 – 65535)
79	ImageAcqMode	16 SHORT	Image Acquisition Mode Enable	0 = Particle 1 = Image
80	InputTrigThresh	16 SHORT	Input trigger threshold	Range = 1 – 8191
81	InputTrigChannel	16 SHORT	Input trigger current channel	Range = 0 – 256 (1 channel per bit)
82	RangeErrorEnable	16 SHORT	Enables/Disables range and error output	0 = Disabled 1 = Enabled
83	CrossBankConfig	16 SHORT	Current cross-bank configuration	Bit 0 = Cross Bank Enable Bit 1 = Bank 1 Main Trigger Bit 2 = Bank 2 Main Trigger Bit 3 = Bank 3 Main Trigger Bit 4 = Bank 4 Main Trigger
84	ReportPackingMode	16 SHORT	Indicates high speed or real-time acquisition	0 = Real-Time Acquisition (no packing) 1 = High Speed Acquisition
85	GPOutputEnable	16 SHORT	Enables/Disables general purpose output	0 = GP Output Disabled 1 = GP Output Always On 2 = GP Output Linked to Spectral Filter Match
86-87	GPOutputDelay	32 LONG	General purpose output delay	Range = 10 – 200000 (0.1 – 2000us)
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 Trigger 1 = Internal Trigger 2 = Level Trigger 3 = Input Trigger 4 = DSP Trigger (Cross bank use only) 5 = Pre-trigger
104-111	TrigPeriod0-TrigPeriod3	32 LONG	Trigger period bank 1 to 4	Range = 500 – 10000000 (200kHz – 10Hz)
112-119	IntegPeriod0-IntegPeriod3	32 LONG	Integration period bank 1 to 4	Range = 5 – 10000000 (0.05 – 100000us)
120-127	IntegDelay0-IntegDelay3	32 LONG	Integration delay bank 1 to 4	Range = -400000 – 10000000 (-4000us – 100000us)
128	SibSel0	16 SHORT	Hamamatsu R5900U-L16	Range = 0 – 0xFFFF
129	SibSel1	16 SHORT	Hamamatsu H8711	Range = 0 – 0xFFFF
130	SibSel2	16 SHORT	Pacific Silicon Sensor AD-LA-16-9-DIL18	Range = 0 – 0xFFFF
131	SibSel3	16 SHORT	Hamamatsu H7260	Range = 0 – 0xFFFF
132	SibSel4	16 SHORT	Undefined	Range = 0 – 0xFFFF
133-135	SibSel5- SibSel7	16 SHORT	Reserved for SIB expansion	Range = 0 – 0xFFFF
136-137	TriggerEndCount	32 LONG	Number of Triggers allowed in Acquire mode	Range = 0 – 0xFFFFFFFF
138	TrigStampSelect	16 SHORT	Triggerstamp Enable	0 = Disabled 1 = Enabled
139-142	DataFormat0-DataFormat3	16 SHORT	Bank 1 to 4 data format	0: 17-bit Sign-Magnitude 1: 16-bit 2's Comp w/ shift (FS) 2: 16-bit 2's Comp no shift (HS)
143-149	RESERVED		Reserved for expansion	

Index	Parameter Name	Type	Description	Parameter Limits
150-405	Ch0GainComp-Ch255GainComp	16 SHORT	Gain compensation values for each channel	0 – 0xFFFF
406-661	Ch0TrigThresh-Ch255TrigThresh	16 SHORT	Input triggering threshold values for each channel	0 – 0xFFFF
662-677	Ch0TrigEnb-Ch255TrigEnb	16 SHORT	Input triggering enables bit packed for each channel	0 = Disabled One bit per channel
678	MBandEnables	16 SHORT	Matrix filtering band enables	Range = 0 – 255 (each bit position corresponds to 1 of 8 band enables)
679	MBand0StartIndex	16 SHORT	Start index for matrix filtering band 1	Range = 0 – 255 (1 channel per bit)
680	MBand0EndIndex	16 SHORT	End index for matrix filtering band 1	Range = 0 – 255 (1 channel per bit)
681-694	MBand Indices for Remaining MBands	16 SHORT	Start index for matrix filtering band 2 - 8 End index for matrix filtering band 2 - 8	Range = 0 – 255 (1 channel per bit)
695	MFlagEnables	16 SHORT	Matrix filtering flag enables	Range = 0 – 255 (each bit position corresponds to a flag enable)
696-699	MFlag0Operand0-MFlag0Operand3	16 SHORT	Matrix filtering operands for flag 1 configuration	Flag0Operand0,2 Range = 0 – 32767 Flag0Operand1,3 Range = 0 – 7 or 65535 (1 channel per bit or LSB wgt, 65535)
700-703	MFlag1Operand0-MFlag1Operand3	16 SHORT	Matrix filtering operands for flag 2 configuration	Same as Above
704-707	MFlag2Operand0-MFlag2Operand3	16 SHORT	Matrix filtering operands for flag 3 configuration	Same as Above
708-711	MFlag3Operand0-MFlag3Operand3	16 SHORT	Matrix filtering operands for flag 4 configuration	Same as Above
712-715	MFlag4Operand0-MFlag4Operand3	16 SHORT	Matrix filtering operands for flag 5 configuration	Same as Above
716-719	MFlag5Operand0-MFlag5Operand3	16 SHORT	Matrix filtering operands for flag 6 configuration	Same as Above
720-723	MFlag6Operand0-MFlag6Operand3	16 SHORT	Matrix filtering operands for flag 7 configuration	Same as Above
724-727	MFlag7Operand0-MFlag7Operand3	16 SHORT	Matrix filtering operands for flag 8 configuration	Same as Above
728-735	MPTerm0-MPTerm7	16 SHORT	Matrix filtering product terms	Range = 0 – 255 (each bit position corresponds to a flag)
736	MDataFilterEnable	16 SHORT	Matrix filtering data filter blocks data output if there is no matrix filter match	0 = Disabled 1 = Enabled
737	MDataFilterConfig	16 SHORT	Matrix A/B combine parameters	
738	MDataFilterAChannels	16 SHORT	Matrix A channel span in GUI	
739	MDataFilterBChannels	16 SHORT	Matrix B channel span in GUI	
740	MDataFilterA	16 SHORT	Matrix A parameters in row/column format	
741	MDataFilterB	16 SHORT	Matrix B parameters in row/column format	
742	DisplaySetting	16 SHORT	Display mode for GUI graphs	Bit 0 = Bar 32 Bit 1 = Bar 64 Bit 2 = Bar 128 Bit 3 = Bar 256 Bit 4 = Dual 4 x 4 Bit 5 = 8 x 8 Bit 6 = Dual 8 x 8 Bit 7 = 16 x 16
743	Bar32Channels	16 SHORT	Channels for Bar 32 graph	
744	Bar64Channels	16 SHORT	Channels for Bar 64 graph	
745	Bar128Channels	16 SHORT	Channels for Bar 128 graph	
746	Bar256Channels	16 SHORT	Channels for Bar 256 graph	
747	S8x8Channels	16 SHORT	Channels for single 8 x 8 graph	

Index	Parameter Name	Type	Description	Parameter Limits
748	D4x4ChannelsA	16 SHORT	Channels dual 4 x 4 graph A	
749	D4x4ChannelsB	16 SHORT	Channels dual 4 x 4 graph B	
750	D8x8ChannelsA	16 SHORT	Channels dual 8 x 8 graph A	
751	D8x8ChannelsB	16 SHORT	Channels dual 8 x 8 graph B	
752	S16x16Channels	16 SHORT	Channels single 16 x16 graph	
753	Bar32Attributes	16 SHORT	Attributes for Bar 32 graph	
754	Bar64Attributes	16 SHORT	Attributes for Bar 64 graph	
755	Bar128Attributes	16 SHORT	Attributes for Bar 128 graph	
756	Bar256Attributes	16 SHORT	Attributes for Bar 256 graph	
757	S8x8Attributes	16 SHORT	Attributes for single 8 x 8 graph	Bit 0 = Graph x flip Bit 1 = Graph y flip Bit 2 = Graph transpose Bit 6 = Graph color/BW
758	D4x4Attributes	16 SHORT	Attributes dual 4 x 4 graphs	Bit 0 = Graph A x flip Bit 1 = Graph A y flip Bit 2 = Graph A transpose Bit 3 = Graph B x flip Bit 4 = Graph B y flip Bit 5 = Graph B transpose Bit 6 = Graph color/BW
759	D8x8Attributes	16 SHORT	Attributes dual 8 x 8 graphs	Bit 0 = Graph A x flip Bit 1 = Graph A y flip Bit 2 = Graph A transpose Bit 3 = Graph B x flip Bit 4 = Graph B y flip Bit 5 = Graph B transpose Bit 6 = Graph color/BW
760	S16x16Attributes	16 SHORT	Attributes single 16 x16 graph	Bit 0 = Graph x flip Bit 1 = Graph y flip Bit 2 = Graph transpose Bit 6 = Graph color/BW
761	MGateEnable	16 SHORT	MGate mode	
762	MGateSyncEdge	16 SHORT	MGate trigger edge	
763	MGateGatePolarity	16 SHORT	MGate gating polarity	
764	MGateDelayX2	16 SHORT	MGate delay	
765	MGateWidthX2	16 SHORT	MGate width	
766	MGateSetpoint	16 SHORT	Discriminator threshold	
767	MGateSetpointExt	16 SHORT	External threshold enable	
768	ADCDataInvert	16 SHORT	Input polarity invert	0 = Normal, 1 = Invert
769	IN_POL	16 SHORT	MCPC polarity	0 = Positive, 1 = Negative
770	PW_MODE	16 SHORT	MCPC discrimination mode	000: Leading Edge 001: Trailing Edge 010: Narrow 011: Wide
771	THRSH	16 SHORT	MCPC discriminator threshold	
772	CP_MODE	16 SHORT	MCPC counting mode	0 = Fixed, 1 = Continuous
773	LEVEL_ONLY	16 SHORT	MCPC Level only mode	0 = No, 1 = Yes
774	PW_N_MAX	16 SHORT	MCPC Narrow PW Maximum	FA=500nsec, xx02=4nsec
775	PW_N_MIN	16 SHORT	MCPC Narrow PW Minimum	FA=500nsec, 01=2nsec
776	PW_W_MAX	16 SHORT	MCPC Wide PW Maximum	FA=2.5usec, x14 = 0.2usec
777	PW_W_MIN	16 SHORT	MCPC Wide PW Minimum	FA=2.5usec, 0A =0.1usec
778		16 SHORT	Waveform graph Y scale minimum	
779		16 SHORT	Waveform graph Y scale maximum	
780-799			Unused	
800	TA_DAYS	16 SHORT	Timed acquisition, # of days	
801	TA_HRS	16 SHORT	Timed acquisition, # of hours	
802	TA_MIN	16 SHORT	Timed acquisition, # of minutes	

Index	Parameter Name	Type	Description	Parameter Limits
803	TA_SEC	16 SHORT	Timed acquisition, # of seconds	
804	TA_FILE_SIZE	16 SHORT	Timed acquisition, end file size	
805	TA_REPEAT	16 SHORT	Timed acquisition, # of hours	
806	HI_THRESHOLD	16 SHORT	X-Y display, high threshold value	
807	LO_THRESHOLD	16 SHORT	X-Y display, low threshold value	
808	SCALE_TYPE	16 SHORT	Vertical scale type for displays	
809	CUSTOM_SCALE	16 SHORT	Scale value for custom scale	
810	CHART_TYPE	16 SHORT	Chart type, Event or Time	
811	TIME_SPAN	16 SHORT	Time span for time chart	
812	EVENT_SPAN	16 SHORT	Event span for event chart	
813	CUSTOM_UNITS	16 SHORT	Units for custom scale	
814	NUM_OF_POINTS	16 SHORT	X-Y display, number of points to display	

Table 11: User Configuration Table

Custom Configuration Table

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

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

Table 12: Custom Configuration Table

Factory Configuration Table

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

Index	Parameter Name	Type	Description	Parameter Limits
1250-1251	DSPRevCode	32 LONG	DSP Revision Code	None (0 – 0xFFFFFFFF)
1252-1253	FPGARevCode	32 LONG	FPGA Revision Code	None (0 – 0xFFFFFFFF)
1254-1509	Ch0BckgndOffset-Ch255BckgndOffset	16 SHORT	DSP calculated background for each channel	0 - 0xFFFF
1510-1765	Ch0ElecOffset-Ch255ElecOffset	16 SHORT	DSP calculated electrical offsets for each channel	0 – 0xFFFF
1766-1767	SiteSerNum	32 LONG	Unused	None (0 – 0xFFFFFFFF)
1768-1769	BoardSerNum	32 LONG	Board Serial Number	None (0 – 0xFFFFFFFF)
1770	SIBSpareControl	16 SHORT	Unused	Unused
1771	SpeedDyRange	16 SHORT	Speed Dynamic Range for each bank, nibble based	For each nibble (4 bits) 0 = Standard 1 = 16 Bit 2 = 14 Bit
1772	HVPopulated0	16 SHORT	High voltage supply 1 populated	0 = Unpopulated 1 = Populated
1773	HVPopulated1	16 SHORT	High voltage supply 2 populated	0 = Unpopulated 1 = Populated
1774	BiasVoltage	16 SHORT	Bias Voltage Control (DAC 1)	0-4095 (3.0V full scale)
1775	DREVoltage0	16 SHORT	Can be configured for an alternative front-end configuration (DAC4)	0-4095 (3.0V full scale)
1776	RESERVED	16 SHORT	Reserved for expansion	
1777-1780	ResetLowThresh0-ResetLowThresh3	16 SHORT	Reset low threshold for bank 1 to bank 4	0 - 0xFFFF
1781-1784	ResetHighThresh0-ResetHighThresh3	16 SHORT	Reset high threshold for bank 1 to bank 4	0 - 0xFFFF
1785-1788	OORLowThresh0-OORLowThresh3	16 SHORT	Out of range low threshold for bank 1 to bank 4	0 - 0xFFFF
1789-1792	OORHighThresh0-OORHighThresh3	16 SHORT	Out of range high threshold for bank 1 to bank 4	0 - 0xFFFF
1793-1794	VBTest0- VBTest1	16 SHORT	Test voltages (DAC2 and DAC3)	0-4095 (3.0V full scale)
1795-1798	ChProcessingEnables0 ChProcessingEnables3	16 SHORT	Channel processing enables for bank 1 to bank 4	Bit 0 = Deserializer Enable Bit 1 = Reset Threshold Enable Bit 2 = Buffer Enable Bit 3 = Differencer Raw or Subtract Bit 4 = Offset Enable Bit 5 = Gain Enable Bit 6 = Range Adjust Enable Bit 7 = Data Trigger Enable 0 = Disabled, Raw 1 = Enabled, Subtract
1799-1802	NumChPopulated0-NumChPopulated3	16 SHORT	Number of channels populated for bank 1 to bank 4	0- 0xFFFF (Should never exceed 64 channels per bank, 256 total channels)
1803	SignalPolarity	16 SHORT	Signal polarity	Nibble-based (4-bits/nibble) per bank signal polarity select.

Index	Parameter Name	Type	Description	Parameter Limits
1804	TestVoltageEnable	16 SHORT	Test voltage enables bank 1 to bank 4	0 = Sign Magnitude 1 = Magnitude 0 = TV1 Disabled, TV2 Disabled 1 = TV1 Enabled, TV2 Disabled 2 = TV1 Disabled, TV2 Enabled 3 = TV1 Enabled, TV2 Enabled
1805-1806	HV0Parameter0-HV0Parameter1	16 SHORT	High voltage supply 1 normalization parameters	Factory calculated values. Floating-point calculation results * 100 are entered into table.
1807-1808	HV1Parameter0-HV1Parameter1	16 SHORT	High voltage supply 2 normalization parameters	Same As Above
1809	AssemblyRevisionPCRev	16 SHORT	PCB Revision Number	None (0 – 0xFFFF)
1810	AssemblyRevisionLetter	16 SHORT	Assembly Revision Letter	None (Only letters are A-F)
1811	RESERVED	16 SHORT	Reserved for expansion	
1812	X1	16 SHORT	Trigger Indicator LED On Period	1 – 0x32
1813	Y1	16 SHORT	Trigger Indicator LED Off Period	1 – 0x32
1814	X2	16 SHORT	Acquisition Indicator LED On Period	1 – 0x32
1815	Y2	16 SHORT	Acquisition Indicator LED Off Period	1 – 0x32
1816	CPLDRevCode	16 SHORT	CPLD Revision Code	0 – 0xFF
1817 - 1832	ModelNumber	16 SHORT	Model Number String	None (ASCII Codes)
1833	SDRAMPopulated	16 SHORT	SDRAM Type Populated	0: None 1: 32 MByte 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 13: Factory Configuration Table

DLL Function Prototypes

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

Function Prototypes

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

Initialize:

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

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

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

Close:

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

Closes the interface to a previously initialized PhotoniQ.

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

ControlInterface:

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

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

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

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DataInterface:

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

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

fileRefnum - If a valid file refnum is entered in this control, all data collected is logged to that file.

BoolRefnum - Allows a calling LabVIEW panel to specify a Boolean control used to terminate data collection (True - Collect Data, False - End Collection and Return).

DigNumRefnum - Allows a calling LabVIEW panel to specify a Digital Numeric control used to display the running total number of events collected.

TrigCountRefnum - Allows a calling LabVIEW panel to specify a Digital Numeric control used to display the running total number of triggers from the trigger counter.

NumEvents - Specifies the number of Events to collect. The function will return after collecting the specified number of Events. Set to zero to collect an indefinite number of Events.

TimeoutS - Specifies the allowed time between Events If the specified time elapses between received Events, the function will return. Set to zero to disable the timeout. Value entered in seconds.

TimeToCollectS - Specifies the time to collect Events. The function will return after the specified time has elapsed. Set to zero to collect for an indefinite length of time.

HighSpeedMode - Used to select the acquisition mode. False should be entered if the returned event data is to be immediately displayed. True should be entered if large amounts of data are to be collected before being processed by another window/thread or logged to disk.

errorInNoError - Accepts a standard LabVIEW error cluster. Data collection is not performed if an error is present.

MessagingEnabled - Set to True if the data is to be messaged to another window. Set to False if messaging is not used. If True, the MessagingArray must be configured. When enabled, the Data Interface will call the Windows API function PostMessage(), indicating to the specified window/thread using the specified message that data is available to be processed. The wParam argument of the message will indicate which of the two specified buffers has been filled, and the lParam of the message will indicate the length of the data within that buffer. At the beginning of the data buffer are two 32-bit integers representing the running total counts of events and triggers received respectively. Both values are stored little-endian. The remainder of the buffer contains event data (length = lParam - 4).

MessagingArray - Contains the information required for messaging.
Element 0 - The handle of the window to be messaged.
Element 1 - The message to be sent to the specified window.
Element 2 - A pointer to the first of two (A) 1MByte buffers.
Element 3 - A pointer to the second of two (B) 1MByte buffers.
Element 4 - A pointer to an unsigned 16-bit integer. Acquisition will stop if the referenced value is zero when either a message is sent or an internal timeout is reached.

len - Length of MessagingArray[] array.

NumEventsRead - Returns the number of events read by the Data Interface.

dupFileRefnum - Duplicate file refnum output.

NumEventsReached - Boolean output, returns True if the Data Interface returned as a result of reaching the number of events specified by NumEvents.

TimeoutReached - Boolean output, returns True if the Data Interface returned as a result of reaching the timeout specified by TimeoutS.

TimeToCollectReached - Boolean output, returns True if the Data Interface returned as a result of reaching the time to collect specified by TimeToCollectS.

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

ErrorHandler:

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

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

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

LVDLLStatus:

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

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

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

Error Cluster Initialization

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

TD1 errIn = {LVFALSE, 0, NULL};

TD1 errOut = {LVFALSE, 0, NULL};

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

Control Interface Commands

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

Opcode	Function Name	Description
0x03	Update PhotoniQ Configuration	Updates the PhotoniQ configuration by writing parameters to the PhotoniQ User Configuration Table. Input Arguments: An unsigned 16-bit number followed by an array of unsigned 16-bit configuration table parameters. A zero as the first argument indicates a write of the configuration table to RAM only, while a one indicates a write to flash memory. Return Arguments: Error returned if necessary
0x04	Read PhotoniQ Configuration	Reads the three sections of the PhotoniQ Configuration Table Input Arguments: Single unsigned 16-bit number. A zero indicates a read of the configuration table from RAM, while a one indicates a read from flash memory. Return Arguments: Array of unsigned 16-bit configuration table parameters.
0x06	Read ADCs	Performs a read of the ADCs on the PhotoniQ. Input Arguments: None. Return Arguments: Results of eight ADC reads in an array of unsigned 16-bit values in the following order: HV1 monitor, HV2 monitor, SIB HV Monitor, +3.3VA, +5V UF, DCRD AIN1, DCRD AIN0, ADC Spare To convert codes to volts: (Codes/4096)* scale factor. Scale factor = 3 for assembly rev 0 and rev 1, 5 for assembly rev 2.
0x07	Calibrate	Performs a system calibration. Calculates either an offset or background calculation. (Offset calculation not recommended for users) Input Arguments: Three unsigned 16-bit arguments. 0x55, 0xAA, and 1 to indicate offset calculation desired, 2 to indicate background calculation. Return Arguments: Error if necessary.
0x09	Report Update	Increments the number of reports that the PC can accept. Input Arguments:0x55, 0xAA, and the increment to the number of reports allowed. Return Arguments: None, this opcode does not generate a response.
0x0B	System Mode	Changes the system mode from acquire to standby, or standby to acquire. Input Arguments: 0x55, 0xAA, and the new system mode (0 = standby, 1 = acquire) Return Arguments: Error if necessary.
0x13	Update SmartSIB Table	Updates the SmartSIB table (consisting of four ports times four devices by 64 locations) by writing parameters to the PhotoniQ. Input Arguments: TBD Return Arguments: TBD
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.

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 14: Control Interface Commands

Low Level USB Interface Description

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

USB Device Defaults

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

Table 15: 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 16: HID Report Descriptions

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: Length+7	Checksum – Sum of all values including checksum but excluding Index 0 equals zero. Two data words long.

Table 17: Report Format (IDs 0x01 and 0x11)

Responses to commands are returned using the same report ID, Start Codon, and Opcode. 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 18: 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: Length+12	Checksum – Sum of all values including checksum (but excluding Index 0) equals zero. Two data words long.

Table 19: Report Format (ID 0x22)

SmartSIB Configuration Table

Loc	Function	Name*	Bits	Values	Dflt
0	Device ID	DEV_ID	B15:B0	x006C=SIB2316, x006D:x006F=Reserved	0018
1	Reset	NRST	B15	0=Reset, 1=No Reset	1
		RELOAD	B14	1=Reload, sets each time dialog data changes	1
2	System	DLY_CNTRL	B15	0=Off, 1=On	0
		POL_CNTRL	B14	0=Pos, 1=Neg	0
		SHDN	B13	0=DSCR Enabled, 1=DSCR Disabled	0
		Unused	B12-B11		
		HOLDOFF	B10	0=Off, 1=On	1
		AUX_SEL	B9	0=DSCR, 1=IQSP	1
		TRIG_SEL	B8:B7	00=DSCR, 01=EXT, 10=INT	10
		Unused	B6:B0		
3-55	Unused	Reserved			
56-63	Dialog box data	Reserved	-	-	

Table 20: SmartSIB Configuration Table

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Optional High Voltage Supplies (HVPS001 / HVPS002 / HVPS701)

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

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

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

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

[3] Voltage adjustment resolution is 100mV in GUI

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

Cable Handling Notice

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

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