

# *User Guide*

*SIB416  
8 x 8 MPPC Sensor Interface Board  
Hamamatsu S11064*





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## **General Safety Precautions**

### **Use Proper Power Source**

The SIB416 is powered with a +5V power source directly from Vertilon's PhotoniQ multi-channel data acquisition systems. A separate -100V power source from the PhotoniQ is used to generate the high voltage bias signals for the S11064 MPPCs. Use with any other power sources may result in damage to the product.

### **Operate Inputs within Specified Range**

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

### **Electrostatic Discharge Sensitive**

Electrostatic discharges may result in damage to the SIB416. For this reason, the SIB416 board is intended to be operated in a user's conductive instrument enclosure.

### **Do Not Operate in Wet or Damp Conditions**

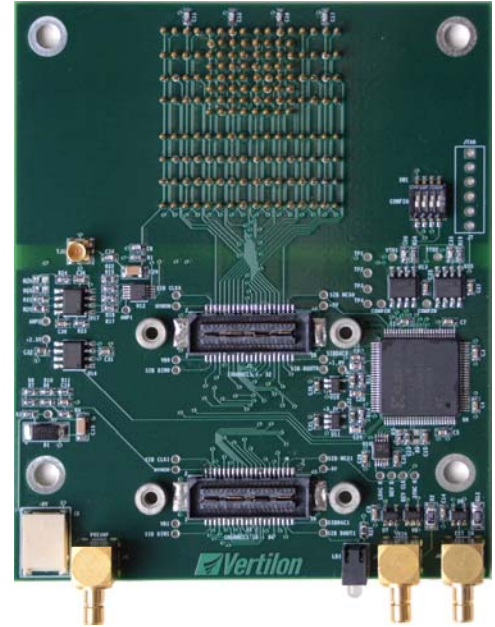
To avoid electric shock or damage to the product, do not operate in wet or damp conditions.

### **Do Not Operate in Explosive Atmosphere**

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

## Product Overview

- Interface board for Hamamatsu S11064 MPPC 4 x 4 arrays
- Supports up to four S11064 MPPC devices for a total of 64 channels
- Leading edge discriminator for event trigger and timing
- Adjustable gain and threshold for discriminator channel
- High voltage circuitry to bias the S11064 devices
- 100% compatible with Vertilon's PhotoniQ multichannel DAQs
- Simplified control through PhotoniQ graphical user interface



The SIB416 sensor interface board allows up to four Hamamatsu S11064 multi-pixel photon counter (MPPC) devices to easily interface to a Vertilon PhotoniQ multichannel data acquisition system. The devices, which are 4 x 4 silicon photomultiplier (SiPM) arrays, are inserted into receptacle pins on the bottom side of the printed circuit board where their cathode output signals are routed directly to two sensor interface board (SIB) connectors. The SIB connectors conform to Vertilon's standard, low-noise, multi-channel, cable interconnection system. Each connector mates to a micro-coaxial cable assembly that connects 32 device outputs to the PhotoniQ. Bias to MPPC arrays is provided on a high voltage cable by the PhotoniQ where it can be enabled and configured through the PhotoniQ graphical user interface. A special current-sense output from the bias interface circuitry is sent to a variable gain preamplifier on the SIB416 to represent the total AC charge signal measured by all four MPPC arrays. This signal, which is available to the user on an SMB jack, is fed into a user-programmable threshold leading edge discriminator. The discriminator generates a trigger signal on an SMB jack when an event exceeding a particular energy threshold is detected on any of the S11064 devices. The trigger output is typically connected to the trigger input on the PhotoniQ data acquisition system where it is used to initiate the collection of the charge signals from the sensor devices connected to the DAQ system's inputs. Alternatively, the trigger output can be sent to other external hardware that could perform coincidence detection or precise time-to-digital conversion. The full functionality and operation of the SIB416 is conveniently controlled through the PhotoniQ's graphical user interface. Intelligent software in the PhotoniQ constantly monitors the status of its SIB connectors to determine the type of sensor interface board attached to them. Once recognized, a dialog box specific to the recognized SIB is made available in the GUI through which the user has complete control over its operation.

The various functions on the SIB416 are described in greater detail on the following pages. When necessary, refer to the functional block diagram shown in Figure 1 below.



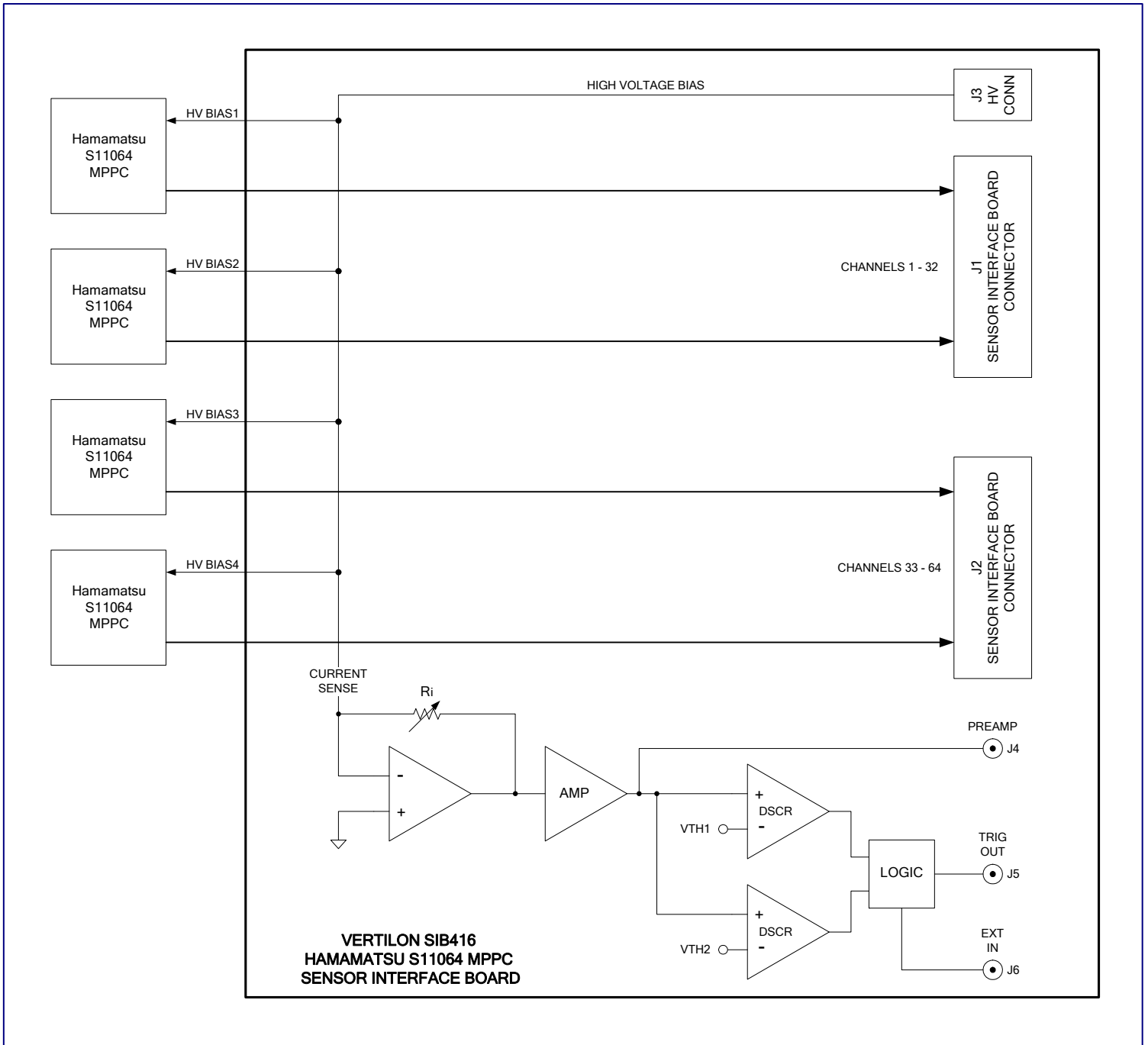


Figure 1: Functional Block Diagram

## Specifications

(T<sub>A</sub> = +25C, unless otherwise noted)

Description	Sym	Min	Typ	Max	Units	Notes
<b>INPUT CHANNELS</b>						
Quantity			64			64 direct coupled channels to PhotoniQ channels 1 to 64.
Cathode Bias Voltage	VB		+0.25		V	Detector cathode voltage supplied from PhotoniQ data acquisition system
<b>PREAMPLIFIER</b>						
Transimpedance (Low Gain)	R <sub>in</sub>		187		Ω	Gain selected through GUI interface.
Transimpedance (Med Gain)	R <sub>in</sub>		374		Ω	
Transimpedance (High Gain)	R <sub>in</sub>		750		Ω	
<b>LEADING EDGE DISCRIMINATOR</b>						
Threshold Adjustment Range	V <sub>th</sub>	0		2.5	V	Referenced to baseline level at discriminator input. Threshold (0 to 100%) controlled through GUI interface.
Threshold to Output Delay	t <sub>d</sub>		7		nsec	
<b>TRIGGER OUTPUT</b>						
Output Impedance			50		Ω	
Logic High Output Level	V <sub>OH</sub>	+4.3	+4.8		V	(I <sub>OH</sub> = -32mA)
Logic Low Output Level	V <sub>OL</sub>		+0.2	+0.6	V	(I <sub>OL</sub> = 32mA)
<b>DIMENSIONS</b>						
Width	W		84		mm	
Length	L		102		mm	(not including SMB connectors which extend past PCB edge)
Thickness	T		1.57		mm	(printed circuit board only)

Table 1: Specifications

## Typical Setup

A typical radiation detection setup using a SIB416 is shown below. Four Hamamatsu S11064 MPPCs in a 2 x 2 arrangement are attached to the SIB416 which is positioned in an optical assembly to detect incoming radiation. The 64 cathode outputs from the MPPC arrays are routed on the SIB416 to the SIB connectors that connect to a PhotoniQ IQSP482 or IQSP582 multichannel data acquisition system. The discriminator channel produces a trigger to the PhotoniQ whenever a radiation event is detected on any of the MPPCs. The energy level threshold for the radiation event is set by the user through the PhotoniQ graphical user interface. Charge signals from the 64 cathodes of the S11064 devices are acquired by the PhotoniQ for each trigger produced by the SIB416. Digitized output data from the PhotoniQ is sent through a USB 2.0 connection to a PC for display, logging, or real time processing. In the figure below, the PhotoniQ GUI is set to display an 8 x 8 image of the energy levels for each event captured.

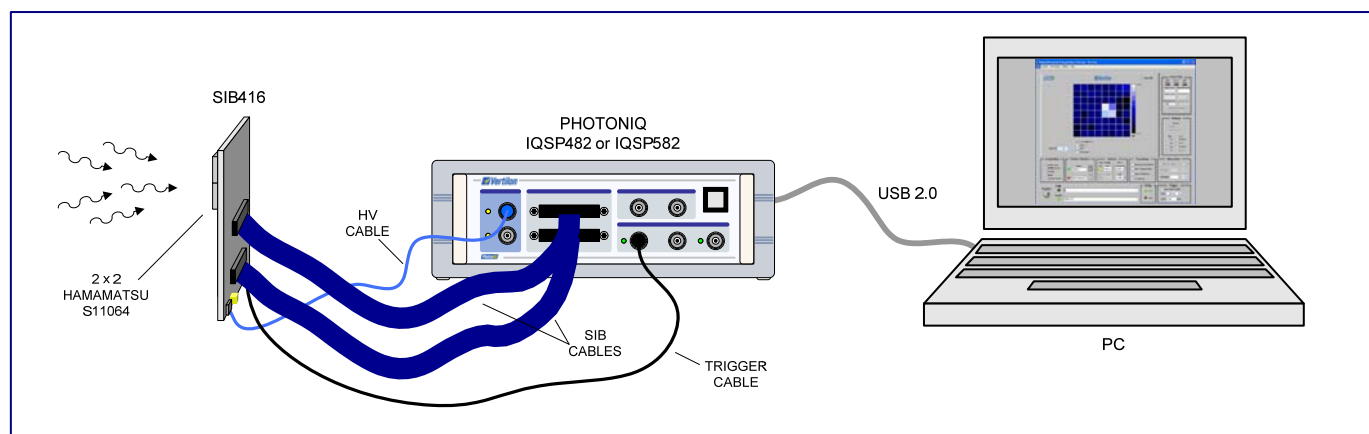


Figure 2: Typical Setup

## S11064 Detector Configuration

The SIB416 supports up to four Hamamatsu S11064 multi-pixel photon counter devices. The devices are attached to the SIB416 as shown in the figure on the following page. If one device is used, the MPPC is plugged into the receptacle pin pattern in the center of the board. When using four S11064s in a 2 x 2 configuration, the MPPCs are plugged into the four receptacle pin patterns symmetrically positioned around the center of the SIB416. Care should be taken to avoid bending the device pins when inserting the S11064 into the receptacle pins. The receptacle pins are sized for direct insertion of the S11064 without an additional socket. However a socket can be used but a large amount of insertion force may be required.

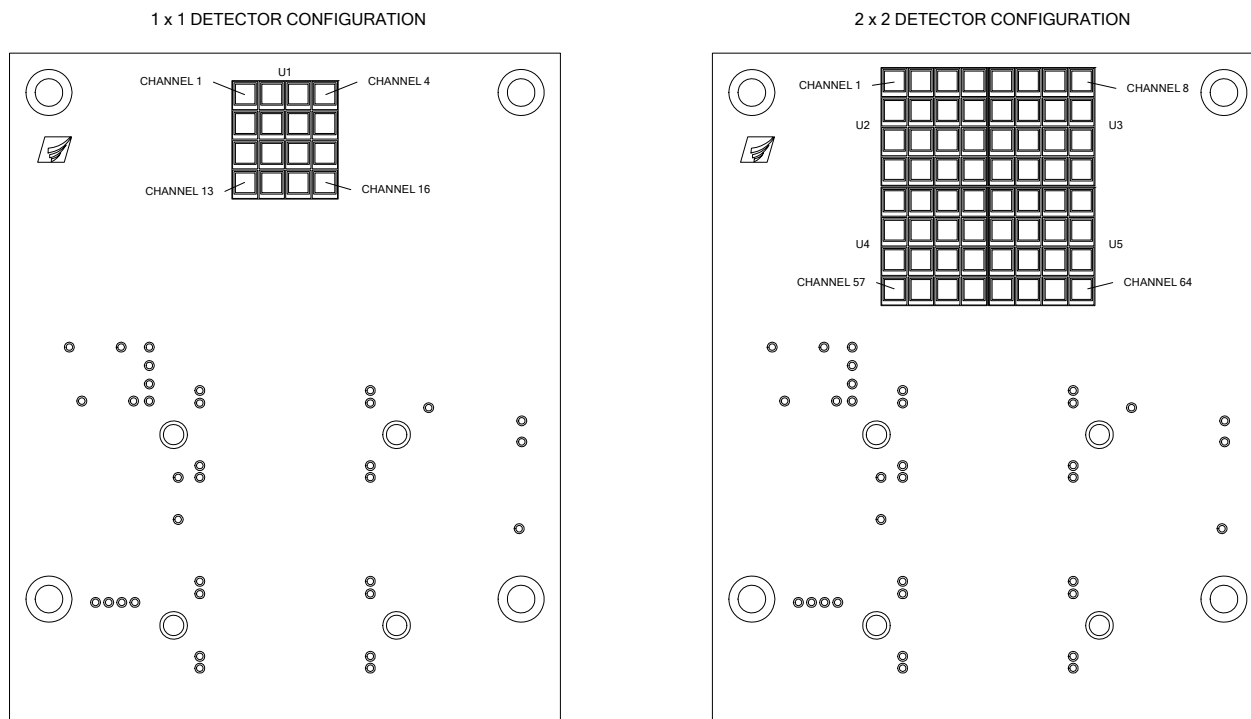


Figure 3: S11064 Detector Configuration

## Detector Channels

The 64 cathode signals from the S11064 devices are routed directly on the SIB416 to the SIB connector. These signals connect to channels 1 through 64 of a Vertilon PhotoniQ IQSP482 or IQSP582 charge integrating data acquisition system. For applications using either one or two S11064 devices, a 32 channel Vertilon DAQ such as the IQSP480 or IQSP580 can be used instead. The PhotoniQ utilizes DC-coupled high speed transimpedance amplifiers that maintain a DC bias voltage of +0.25 volts on each of its inputs. Because the S11064 devices are operated on the SIB416 in common anode arrangement, the current polarity to the PhotoniQ preamplifiers is *out of* the inputs. For this reason, the *Input Polarity* under the *Data Configuration* menu in the PhotoniQ GUI should be set to the default value of *positive*. See the PhotoniQ user's manual for more details.

## High Voltage Interface

The SIB416 employs the interface circuit shown below between the high voltage input connector, J3, and the anodes of the individual SiPMs on the S11064 devices. The monitor output (HVMON) allows the high voltage anode bias to the MPPCs to be indirectly monitored at a reduced voltage level. Voltage readings at the monitor point should be scaled by a factor of 100. Calibration of the scale factor may be required for very accurate measurements.

**Warning:** The high voltage section of the SIB416 contains signals at voltage levels that can exceed negative 100 volts. Never touch a component or signal in this area.

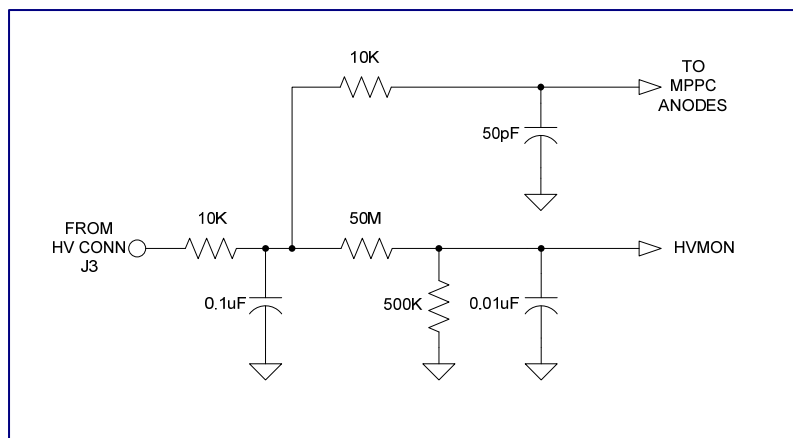


Figure 4: MPPC High Voltage Interface Circuit

## Preamplifier

Each anode the S11064 MPPCs is bussed together and connected to the input of a single current-sensitive preamplifier on the SIB416. The preamplifier generates a voltage signal in response to the current signal on its input from any of the 64 SiPMs from the 2 x 2 array of MPPCs. This voltage signal is available on an SMB output connector on the SIB416 and is also fed to the input of the discriminator. There are three settings for the preamplifier gain which are selected through the SIB416 configuration dialog box in the PhotoniQ graphical user interface shown below.

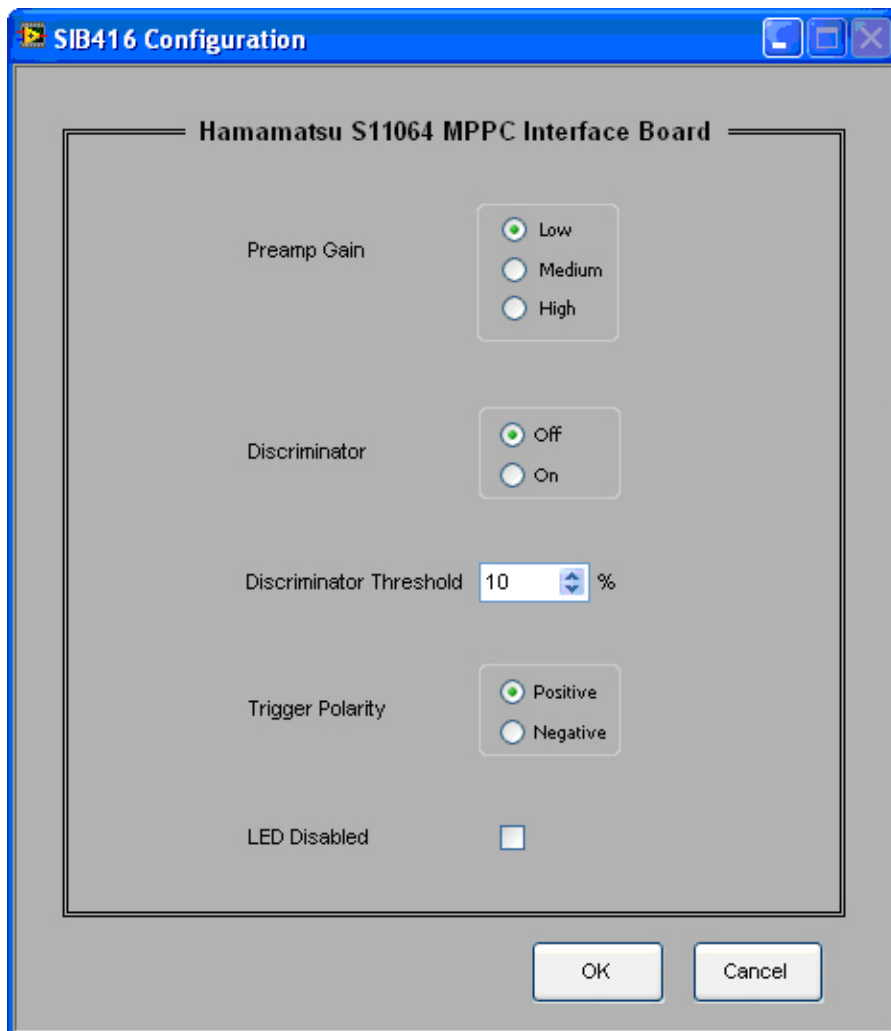


Figure 5: SIB416 Dialog Box

## Discriminator

The discriminator generates a logic signal when a pulse from the preamplifier exceeds a user-defined threshold. The SIB416 GUI dialog box allows the user to set this threshold between 0 and 100% where 100% is equal to the maximum possible signal amplitude in the discriminator channel. When a pulse is detected, the trigger output from the board becomes active. The polarity can be set to either *positive* or *negative*.

Figure 6 shows the operation of the leading edge discriminator. A positive-going current pulse into the preamplifier results in a negative-going pulse on its output. This pulse is compared to a threshold that is adjusted using the SIB416 configuration dialog box in the PhotoniQ GUI. A logic high (for *positive* polarity control) is generated after a small delay ( $t_d$ ) from when the pulse first crosses the threshold,  $V_{th}$ . The discriminator switches back to a logic low when the pulse crosses the threshold from the opposite direction as it returns back to the baseline level. The trigger LED blinks when a trigger signal is generated.

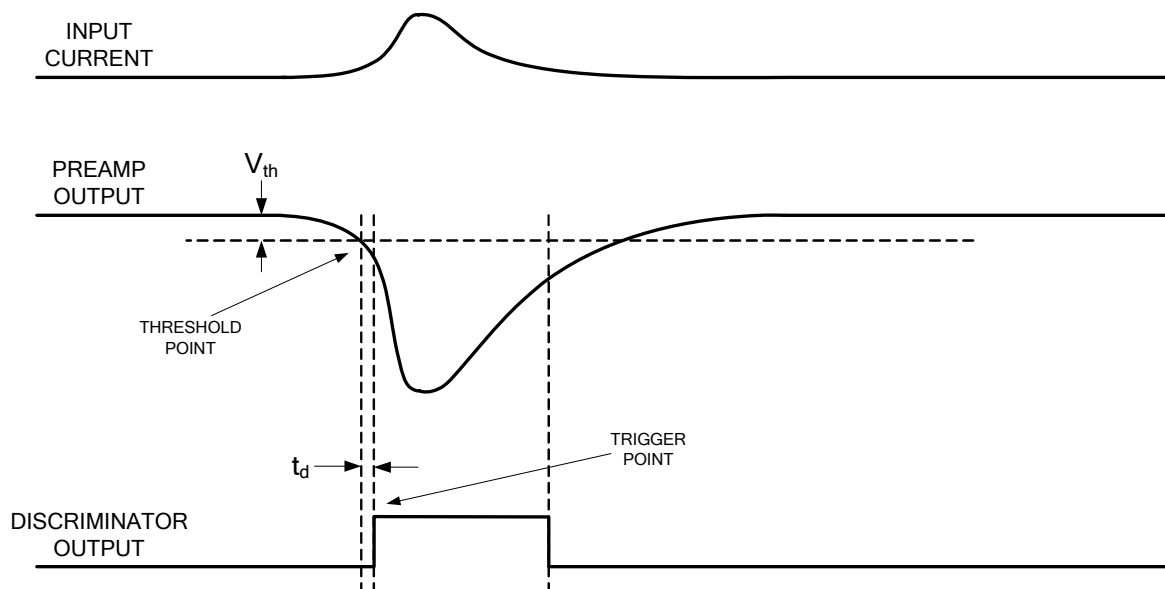


Figure 6: Leading Edge Discriminator Timing

Top View

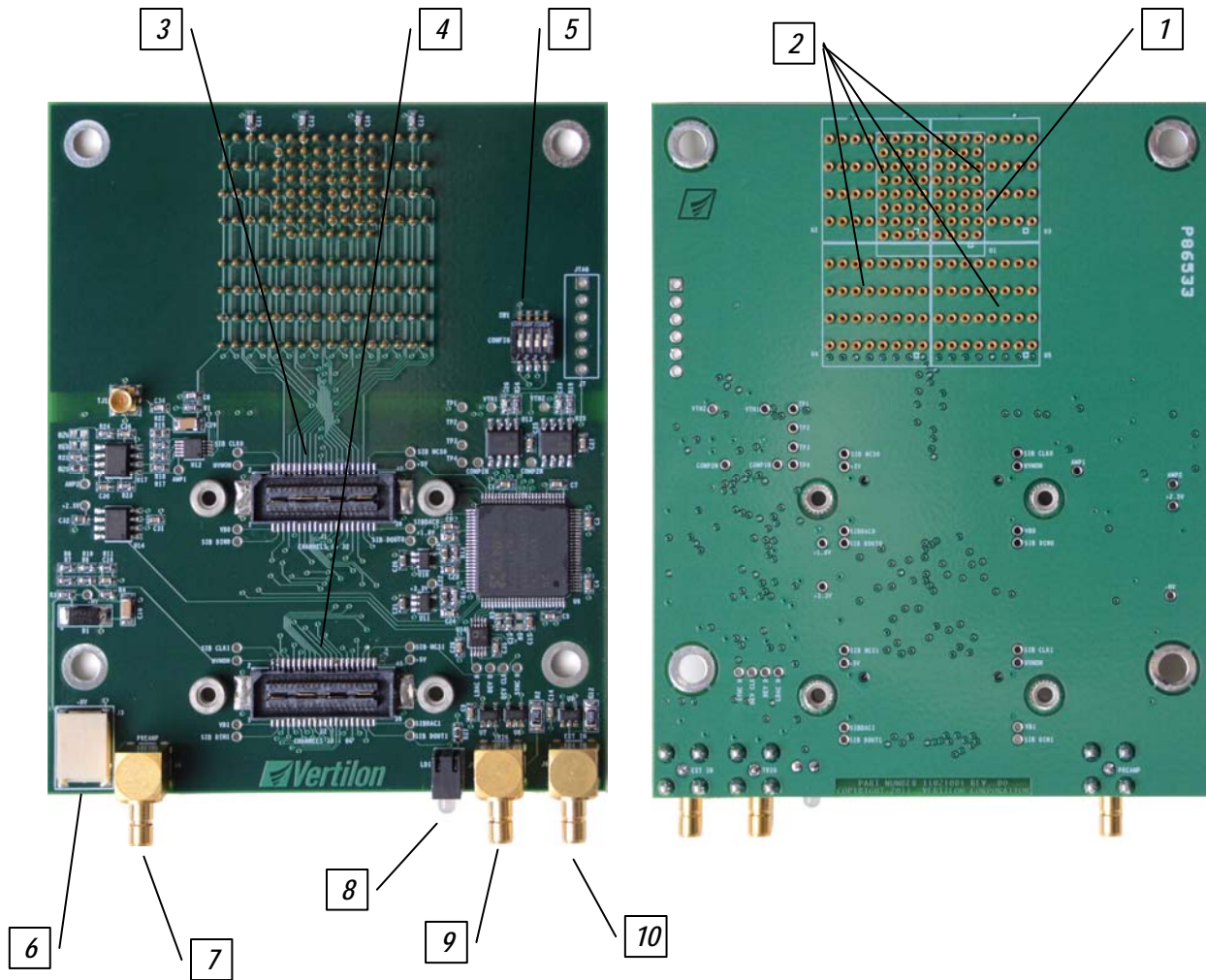


Figure 7: PCB Top and Bottom Views

- |  |  |
|--|--|
| 1. Connection Pins for S11064 (U1)       | 6. Negative High Voltage Bias Input (J3) |
| 2. Connection Pins for S11064 (U2 – U5)  | 7. Preamplifier Output (J4)              |
| 3. SIB Connector, Channels 1 to 32 (J1)  | 8. Trigger Status LED                    |
| 4. SIB Connector, Channels 33 to 64 (J2) | 9. Trigger Output (J5)                   |
| 5. Configuration Switches                | 10. External Input (J6)                  |



## Component Locations and Functions

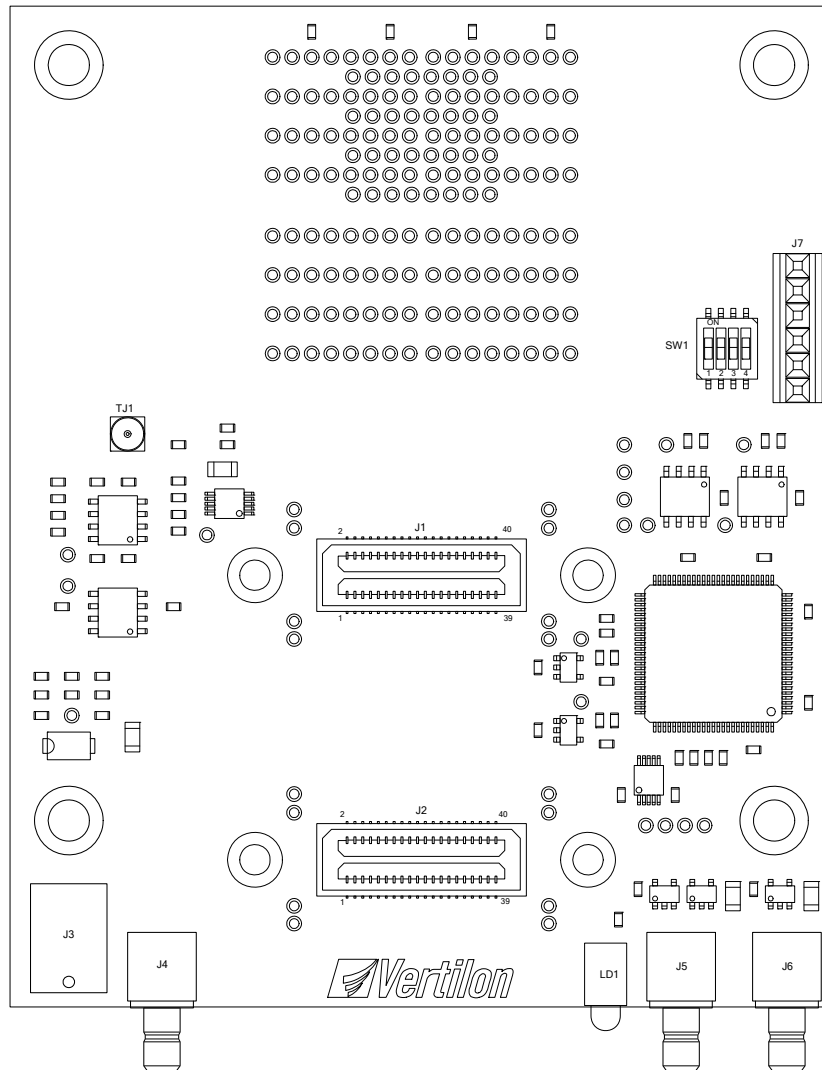


Figure 8: Component Locations and Functions

Name	Function	Description
J1	CHANNEL 1 - 32	Sensor interface board connector, cathodes 1 through 32 from S11064 devices
J2	CHANNEL 33 - 64	Sensor interface board connector, cathodes 33 through 64 from S11064 devices
J3	-HV	Negative high voltage bias input for the S11064 anodes
J4	PREAMP	Preamplifier output
J5	TRIG OUT	Trigger output
J6	EXT IN	External input (reserved)
J7	JTAG	JTAG interface
TJ1	TEST IN	Reserved

**Table 2: Connectors**

Name	Function	Description
LD1	TRIG OUT	Green LED indicator for trigger output
SW1: 1-2	DEV ADDR 1:0	Sets the device address for control by the PhotoniQ. Set both switches to "ON".
SW1: 3-4	DEV TYPE 1:0	Sets the device type for control by the PhotoniQ. Set both switches to "ON".

**Table 3: LEDs and Switches**

Name	Ref #	Description
+5.0V	P21	+5.0V power supply from the PhotoniQ
+3.3V	P25	+3.3V internal power supply
+1.8V	P24	+1.8V internal power supply
+2.5V	P34	Preamplifier baseline voltage, normally +2.5V
VB	P14	Bias voltage from PhotoniQ to MPPC cathodes. Normally at +0.25V when PhotoniQ set to positive input polarity.
HVMON	P15	High voltage monitor point
-HV	P6	Negative high voltage bias to MPPCs.

**Table 4: Test Points**

## SIB Connector Pinout

The SIB416 connectors and cables are fully compatible with all Vertilon PhotoniQ systems. For applications utilizing data acquisition systems other than Vertilon's PhotoniQ series, the pinouts for connectors J1 and J2 are provided in Table 5 as a reference.

J1				J2			
Signal Name	Pin #	Signal Name	Pin #	Signal Name	Pin #	Signal Name	Pin #
VB	1	HVMON	2	VB	1	HVMON	2
SIB_DIN0	3	SIB_CLK0	4	SIB_DIN1	3	SIB_CLK1	4
P16	5	P32	6	P48	5	P64	6
P15	7	P31	8	P47	7	P63	8
P14	9	P30	10	P46	9	P62	10
P13	11	P29	12	P45	11	P61	12
P12	13	P28	14	P44	13	P60	14
P11	15	P27	16	P43	15	P59	16
P10	17	P26	18	P42	17	P58	18
P9	19	P25	20	P41	19	P57	20
P8	21	P24	22	P40	21	P56	22
P7	23	P23	24	P39	23	P55	24
P6	25	P22	26	P38	25	P54	26
P5	27	P21	28	P37	27	P53	28
P4	29	P20	30	P36	29	P52	30
P3	31	P19	32	P35	31	P51	32
P2	33	P18	34	P34	33	P50	34
P1	35	P17	36	P33	35	P49	36
SIB_DOUT0	37	SIB_NCS0	38	SIB_DOUT1	37	SIB_NCS1	38
SIBDAC	39	+5V	40	SIBDAC	39	+5V	40

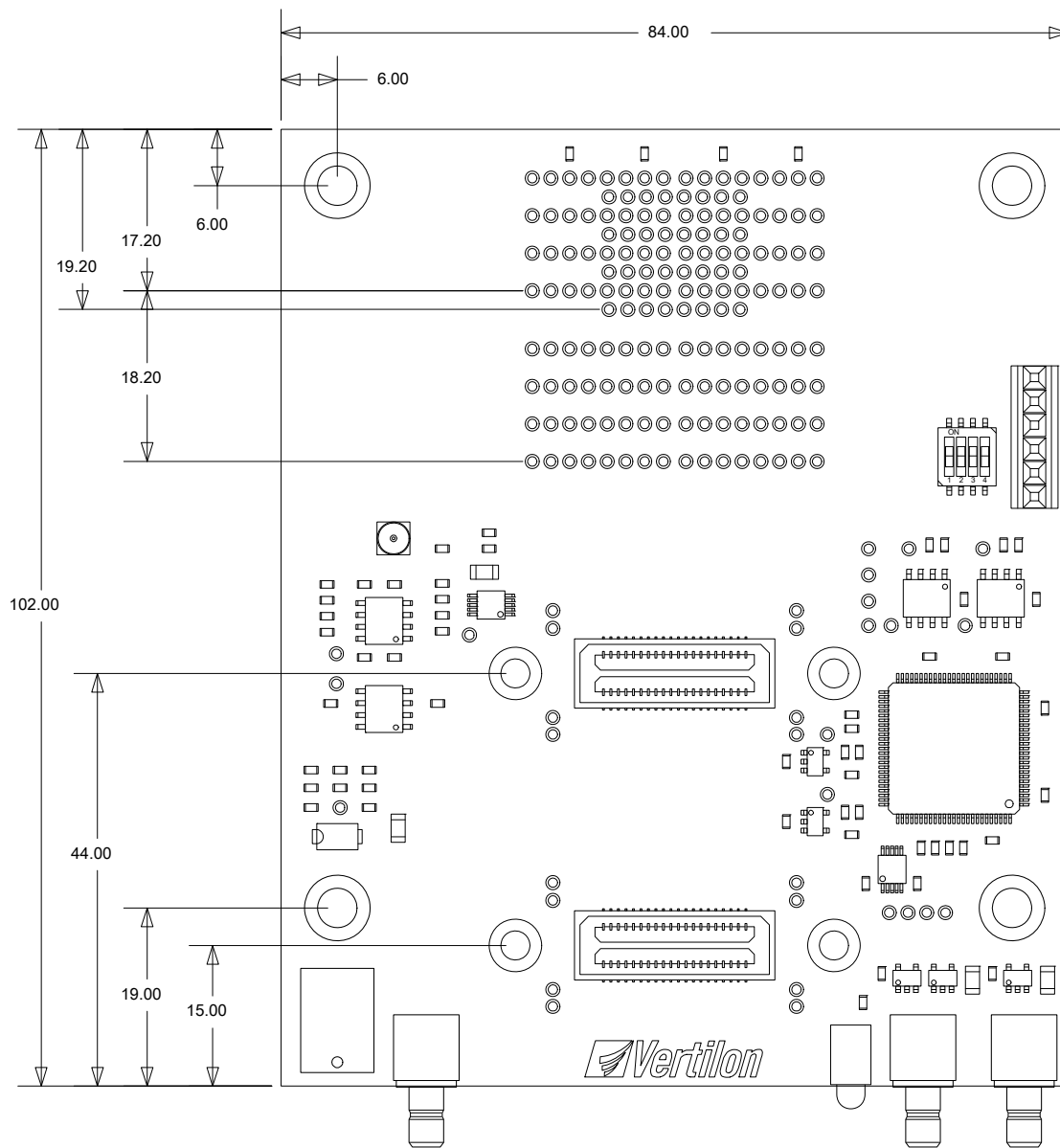
**Table 5: Sensor Interface Board (SIB) Connectors**

Power (+5V) supplied through pin 40 if PhotoniQ is not used

Pins 3, 4, 37, 38 used by PhotoniQ and should be left unconnected

Ground supplied through SIB cable shielding

## Mechanical Information



ALL DIMENSIONS IN MILLIMETER

Figure 9: SIB416 Printed Circuit Board Dimensions



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