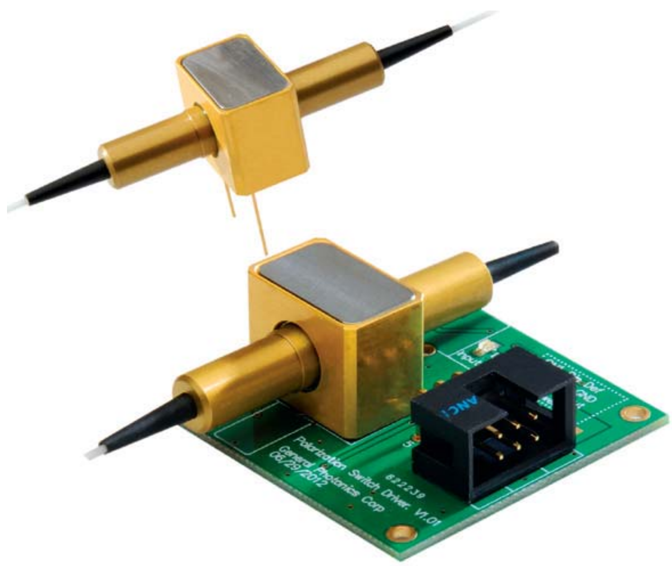
PSW-002

Fiber Optic Polarization Switch



User Guide

Version: 1.1
Date: June 30, 2015

General Photonics Corporation is located in Chino California.
For more information visit the company's website at:
www.generalphotonics.com
or call 909-590-5473

SAFETY CONSIDERATIONS

The following safety precautions must be observed during operation of this product. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the product. General Photonics assumes no liability for customers' failure to comply with these requirements.

Before operation, the user should inspect the product and review the manual carefully.

Use only in a safe work environment in terms of temperature, humidity, electrical power and risk of fire or shock. The product is designed for indoor use. Avoid exposure to liquids or water condensation. Provide adequate ventilation for cooling.
Operate the product on a stable surface. Avoid excess vibration.
Standard laser safety procedures should be followed during operation.

Never look into the light source fiber connector when the light source is turned on. THE OUTPUT LIGHT FROM A HIGH POWER LASER IS HARMFUL TO HUMAN EYES. Follow industry standard procedures when operating a high power laser source.

Section 1.0 Overview

The PSW-002 is a miniature polarization switch that rotates the input polarization state by a fixed angle, either 45° or 90°. It is available with either single mode (SM) fiber or polarization maintaining (PM) fiber pigtails. The switching of the polarization state is achieved using an external control current supply. The PSW-002 is compact and can be mounted on a PCB Applications include polarization diversified detectors and sensors, polarization multiplexing, polarization modulation, polarization metrology, polarization mode dispersion (PMD) monitoring, coherent optical communications, and other polarization related applications.

Figure 1 PSW-002 polarization switch

1.1 Principle of Operation

The PSW-002 performs polarization state transformations on a signal traveling in optical fiber. Using Poincaré sphere representation, the PSW-002 transforms the input polarization state along the equi-ellipticity contours that are represented by latitude lines. The 90° and 45° PSW-002 devices rotate the polarization state by a half (1/2) circle or quarter circle (1/4 circle), respectively, along the latitude line on which the input polarization state falls. Figure 2a shows the two output SOPs of a 90° PSW resulting from different input polarization states. In the first case, the input SOP is linear (on the equator); the two output SOPs will be 180° apart on the circle defined by the equator (points A and B in the diagram). In the second case, the input SOP is elliptical; the two output SOPs (points C and D) will be 180° apart on a smaller circle corresponding to the latitude line on which the input SOP falls. If the input polarization state is circular (north or south poles of the sphere), the latitude circle collapses to a point, so the output SOP will still be circular.

Figure 2b shows a similar example for a 45° PSW-002. In this case, points A and B and points C and D are 90° from each other on their respective circles.

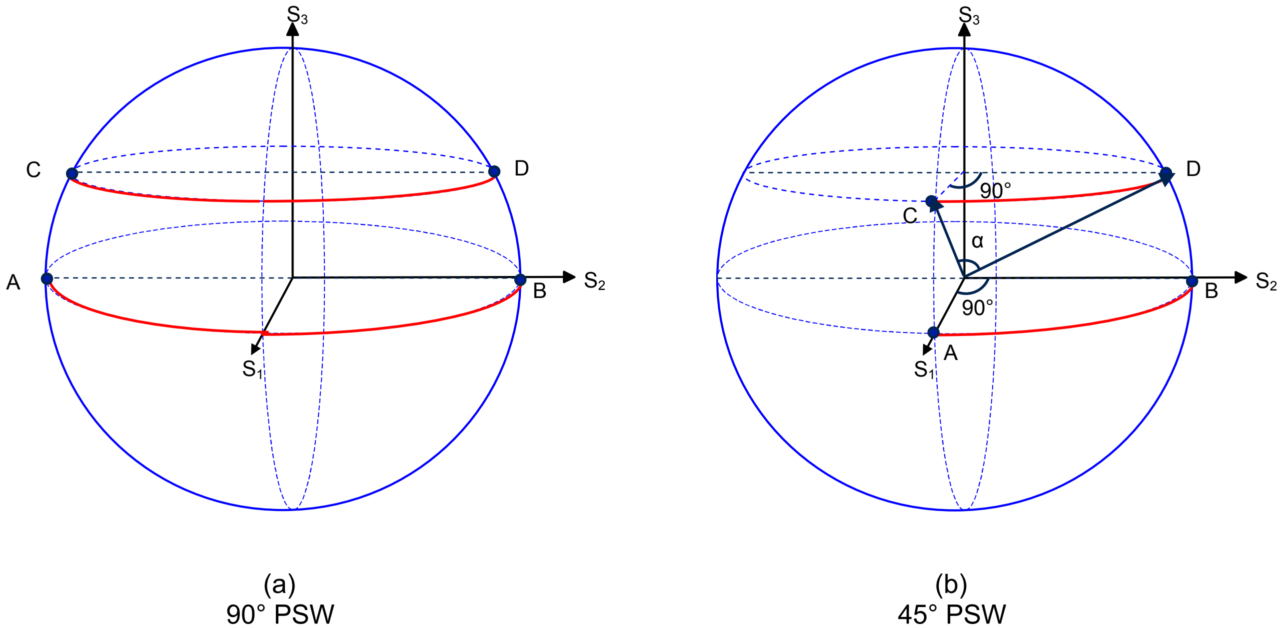


Figure 2 Examples of Poincaré sphere representations of output polarization states of 90° and 45° PSW-002s for 2 different cases:
Case 1: Linear input SOP →output states A and B
Case 2: Elliptical input SOP →.output states C and D

Please note that the rotation angle with respect to the S_3 axis is generally not the same as the solid angle with respect to the origin of the sphere unless the rotation is on the equator (S_3 = 0). In Figure 2b, both sets of output states (points A and B and points C and D) are rotated 90° from each other with respect to the S_3 axis; however, the solid angle between points C and D with respect to the origin of the sphere is not 90°. Instead, it is some angle α, whose value depends on the S_3 coordinate of the input SOP.

For a PSW-002 with PM fiber pigtails, an input state aligned to either the slow or fast axis of the input fiber will result in a polarization transformation on the equator of the Poincaré sphere. With a slow-axis aligned input, a 90° PM PSW-002 switches the output polarization state between alignment with the slow and fast axes of the output PM fiber. With a slow-axis aligned input, a 45° PM PSW switches the state of its output light between slow-axis aligned and 45° from the slow axis at the point where it launches into the output PM fiber.

Section 2.0 Features

2.1 Optical Features

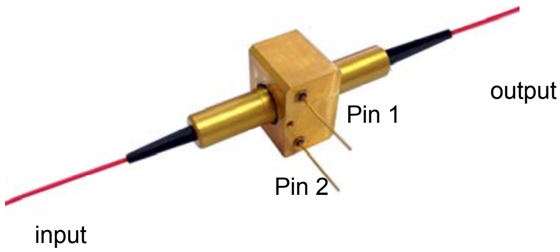


Figure 3 PSW-002 input and output pigtails

Figure 3 shows the input/output pigtails for the PSW-002. For devices with SM fiber pigtails, the input and output pigtails are interchangeable. Devices with PM fiber pigtails should be used with the designated input/output configuration. There is also an option to add a slow-axis aligned polarizer at the PSW input port to improve output PER and rotation angle accuracy. Devices with the polarizer included will not work as a polarization switch if the pigtails are reversed.

Fiber connectors can be FC/PC, FC/APC, SC/PC, or SC/APC per customer specification. Before each connection, fiber connectors should be cleaned using industry standard fiber connector cleaning methods. For PM pigtailed PSW-002s, the input connector alignment is also very important. For devices without an input polarizer, any connector misalignment to the input connector can affect output PER and rotation angle accuracy.

Fiber pigtails should be handled carefully. Excessive force on fiber pigtails may degrade performance or damage the device.

2.2 Electrical Features

The PSW-002 requires a bipolar electrical current to perform polarization state switching. Without a drive current, the PSW-002 will not rotate the input polarization state, and its insertion loss will be slightly higher. In laboratory applications, the PSW-002 can be driven by a function generator or a DC power supply. The PSW-002 has two electrical connection pins for the electrical control signals. Its electrical equivalent circuit is shown in Figure 4, where L_c is an inductor and R_c is a resistor.

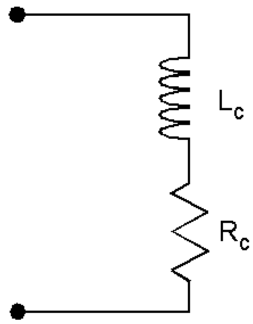


Figure 4 PSW-002 equivalent electrical circuit

Voltage/Current Guidelines:

The PSW-002 requires a certain level of current and voltage to switch from one output state to another (switching voltage/current), but once it has switched, it can maintain its state with a lower voltage/current (latching voltage/current).

	Voltage	Current
Switching	2-3 V	<130 mA
Latching	1.5-2V	<80 mA

A typical drive signal might look like:

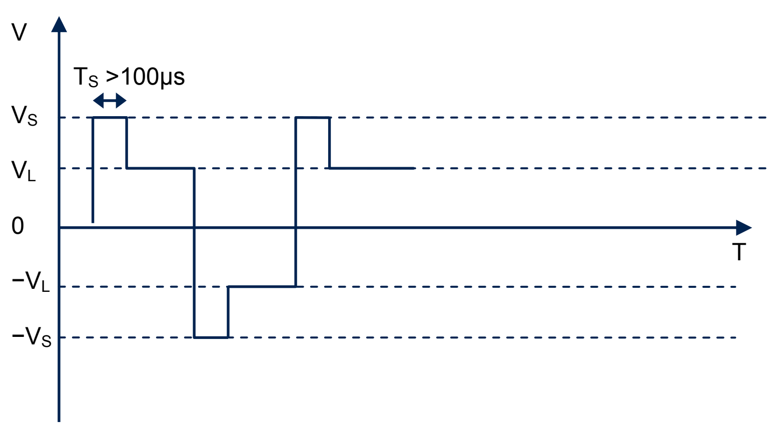


Figure 5 Drive signal diagram
V_S = switching voltage
V_L = latching voltage
T_S = time switching voltage is applied

Lowering the control voltage to the latching voltage to maintain the current output state improves the stability of the output state because it reduces device heating, which can affect the rotation angle. It is generally recommended to use a drive signal pattern like the one shown in Figure 5, especially if the PSW-002 is to remain in one state or the other for relatively long periods of time.

The output SOP depends on the polarity of the voltage between the two pins. For a PM fiber PSW-002 with a slow-axis aligned input, the correspondence is as follows.

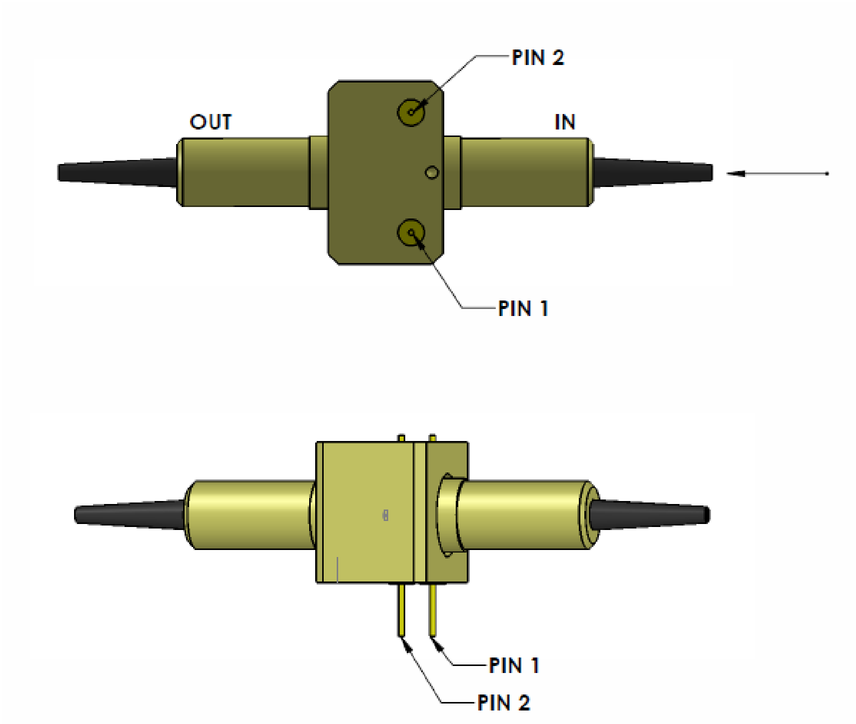


Figure 6 PSW-002 pinout

PIN1	PIN2	Output SOP
−	+	Fast axis (90° PM PSW) 45° from slow axis (45° PM PSW)
+	−	Slow axis

2.3 Switch Timing

A typical switching response is shown in Figure 7, where the upper trace is the synchronization output waveform from a function generator, and the lower trace is the PSW-002 output power after a polarizer. A function generator with output voltage set at ±2V is used as the PSW-002 driver. The time scale (horizontal axis) is 50 μs/division.

As shown in Figure 7, when a step function waveform voltage is applied to the PSW-002, there is an initial delay of ~75 μs. The rise time (10%-90%) of the switch is also on the order of a few 10s of μs. The total switching time is ~100μs.

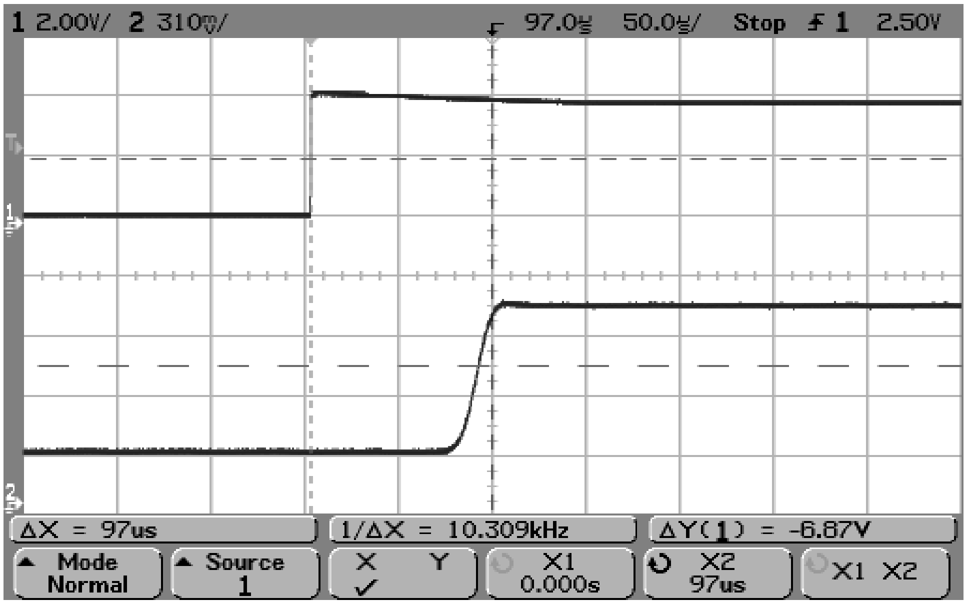


Figure 7 Switching speed of PSW-002 under a −2 to +2V voltage step

2.4 Dimensions and Mounting Holes

The PSW-002 has one mounting hole on its bottom surface, between the electrical pins. Package dimensions and electrical pin and mounting hole locations are given below.

Electrical pins are 0.5mm in diameter.

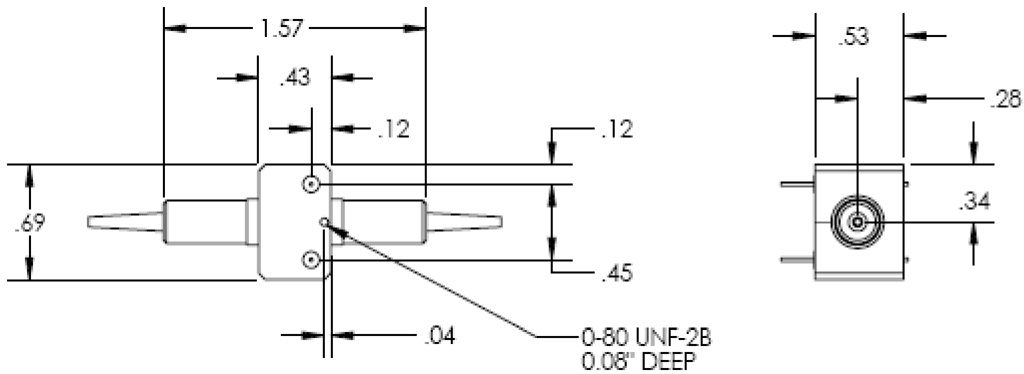


Figure 8 Dimensions and mounting hole information
All dimensions given in inches.

Section 3.0 Operation Instructions

3.1 Unpacking

Inspect PSW-002 for any physical damage due to shipping and transportation. Contact carrier if any damage is found. Check the packing list to see if any parts or accessories are missing.

Packing List

Item #	Description
1	PSW-002
2	User Guide
3	Electrical cable (only for devices with driver board)

3.2 Operation

1. Make optical connections. For PM PSWs, do not reverse input and output connectors.
2. Connect the two electrical leads to an electrical driver such as a function generator, analog output board, or DC power supply, as shown schematically in Figure 9. Make sure that the electrical driver is capable of driving an inductive load.
3. Power on the driving circuit.

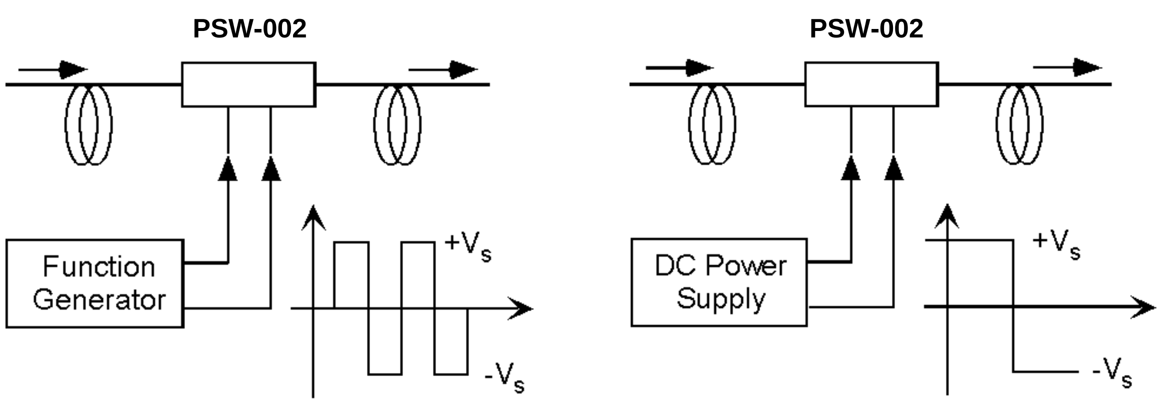


Figure 9 Examples of basic driver setups. A function generator can be used to drive the PSW for periodic switching, while a DC power supply may be sufficient for occasional switching. Note that this diagram shows only switching voltages. Once the device has switched state, the voltage can be lowered to the latching voltage to maintain the output state.

Section 4.0 Specifications

Optical

Operating Wavelength	1550 ±30nm or 1310±30nm
Polarization Rotation (at λ_c, 23° C)	45 ± 0.5° or 90 ± 0.5°
Polarization Rotation (all wavelengths, all temps)	45 ± 5° or 90 ± 5°
Rotation Angle Temperature Dependence	−0.1 degree/°C for 45° version −0.2 degree/°C for 90° version
Switching Time	100 μs typical
Insertion Loss	<0.5 dB
Return Loss	>55 dB
Extinction Ratio[1]	> 18 dB for PM model
Optical Power Handling	300 mW

Note: Values referenced without connectors.
1. Both output states of 90° PM PSW with input polarizer at 23°C.

Electrical

Switching Current	<130 mA
Switching Voltage	2.5 V
Latching Current	~ 80 mA
Latching Voltage	1.5 to 2 V

Physical and Environmental

Fiber Type	PM Panda, SMF-28 or compatible
Operating Temperature	0 °C to 50 °C
Storage Temperature	−40 °C to 85 °C
Dimensions	1.57” (L) x 0.69” (W) x 0.53” (H)
Weight	30g typical

Appendices

Appendix 1.0 Driver Board (Optional)

General Photonics offers an optional driver board to simplify use of the PSW-002. The board generates the recommended switching/latching voltages (see Figure 5), allowing the user to control the output state using simple TTL levels.

Note that the control signal for the board is TTL levels, not pulses. For a PM fiber PSW-002 with a slow-axis aligned input, the correspondence is as follows.

TTL Level	PIN1	PIN2	Output SOP
High	−	+	Fast axis (90° PM PSW) 45° from slow axis (45° PM PSW)
Low	+	−	Slow axis

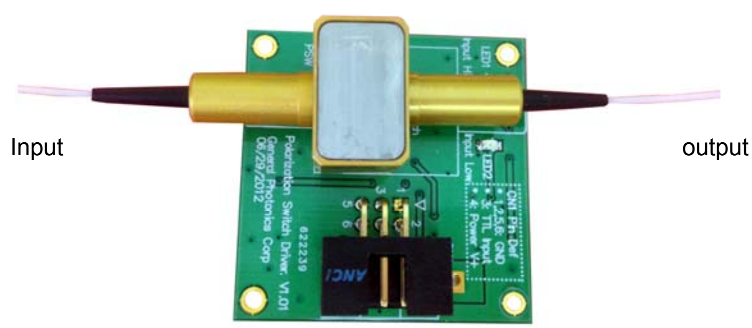
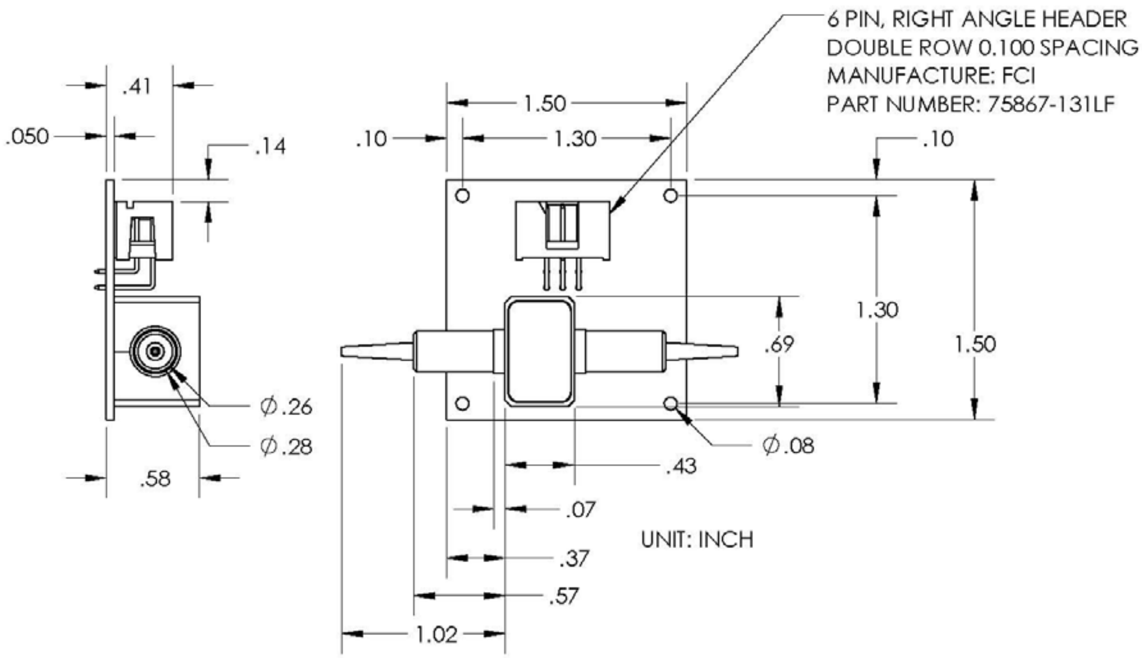


Figure 10 PSW-002 on driver board

<u>Driver Board Specifications</u>

Electrical connector	IDC 6-pin connector (2x3 pins), cable provided
Power supply	+8~+15VDC/0.2A
Control signal	TTL logic level 0-5V
Maximum switching rate	1 kHz (1ms per state)
LED indicators	Drive logic high (red) and low (green)
Dimensions	1.50” (L) x 1.50” (W) x 0.58”(H)
Mounting holes	4x ∅2mm

Board Diagram



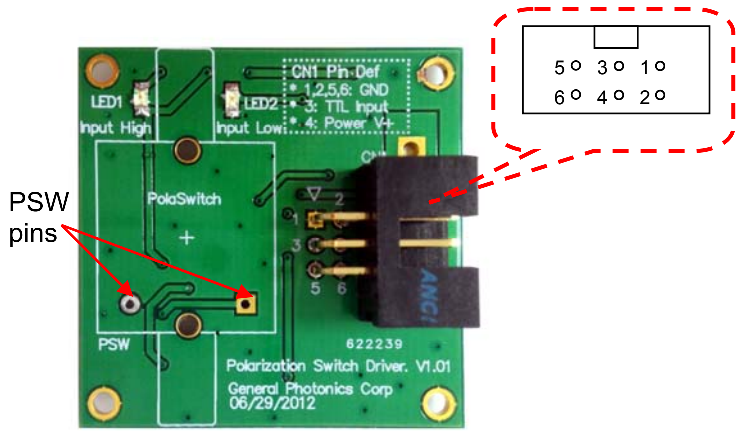


Figure 11 PSW driver board dimensions and pinout

The PSW driver board has 4 mounting holes located at the corners of the board, as shown above.

A 6-pin electrical connector is used to connect the power supply and control signal. A connection cable is provided. The connector pinout and corresponding connection cable color code are as follows:

Table 1 PSW driver board cable pinout

Pin #	Symbol	Wire Color	Function	Description
1	GND	Brown	Board ground	
2	GND	Red	Board ground	
3	PS	Orange	Polarization switching	Logic signal, TTL compatible Low = polarization state A High = polarization state B
4	PWR	Yellow	Power input	8~15VDC/200mA
5	GND	Green	Board ground	
6	GND		Board ground	

The connection cable is shown below.

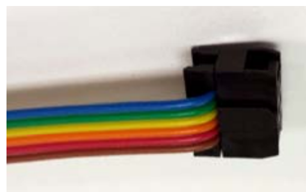


Figure 12 PSW driver board electrical cable

Setup

1. Connect optical input and output to PSW-002.
2. Connect electrical cable to board.
3. Make sure power supply voltage and current are set at appropriate levels (8 to 15VDC/200 mA).
4. Connect control signal.
5. Power on power supply.

Power Supply/Control Signal Guidelines

Power Supply

The PSW-002 driver board will accept a power supply voltage anywhere between 8 and 15V, but it is generally better to use a lower voltage if possible (i.e. closer to 8V).

Control Signal

Voltage ranges:

TTL Level	Nominal	Range
High	5V	3-5V
Low	0V	0-1V

Current requirement: <1μA

Maximum switching rate: 1kHz (1 ms per output state)