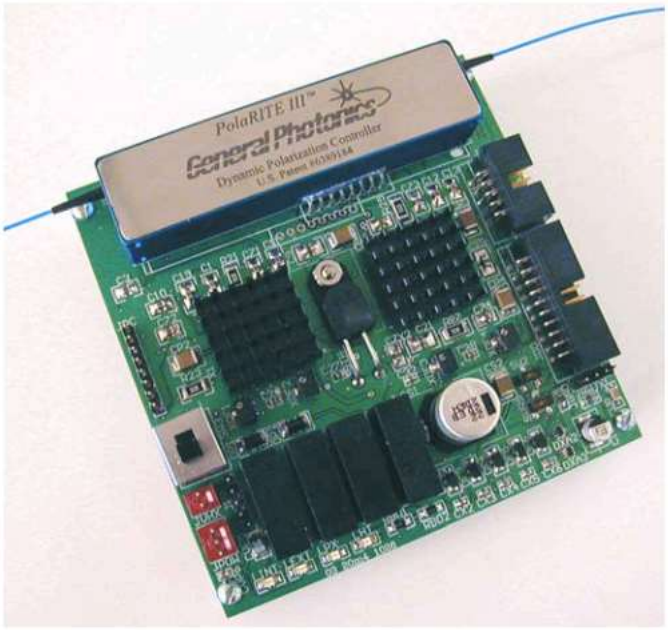
Making Light Work Lighter

General Photonics Corporation

MPD – 001/PCD – M02

Miniature Multi-Channel Piezoelectric Actuator Driver Card / Integrated PolaRITE™ II/III Polarization Controller

Operation Manual



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General Photonics Corp.
5228 Edison Ave.
Chino, CA 91710 USA

Ph: (909) 590-5473
Fax: (909) 902-5536
www.generalphotonics.com

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IMPORTANT SAFETY NOTE

The MPD-001 board can produce hazardous voltages and currents. The DC voltage on the board can reach 150 V. Use extreme CAUTION when operating the MPD-001. Never touch any part of the board or cable connectors when electric power is on. Make sure that the power is turned off when connecting or disconnecting cables.

CAUTION

The maximum peak current to each channel of the MPD-001 is 60 mA. However, the maximum current available to each channel will depend on operating conditions. Because the on board DC/DC converter output current rating is 80 mA, the sum of the currents to the four channels cannot exceed 80 mA. If each channel is operated sequentially, the current limit per channel is 60 mA. However, if all 4 channels are in operation simultaneously, the maximum continuous operation current rating for the PCD-M02 is 20 mA per channel. A severely distorted output waveform indicates that the unit is being operated at a current that exceeds the current rating. If a sinusoidal waveform is used as a driving source, the user should check Section 4 in this manual to make sure that the output voltage and driving frequency are within the designed safe operation range.

The driving limitations mentioned above depend on environmental conditions such as ambient temperature and ventilation. It is recommended that the board be mounted in a well-ventilated area for high frequency operation. High temperature operation will significantly decrease the current limit of the driver card. If high temperature operation is required, please contact General Photonics for details.

Section 1. Specifications:

Physical Features:

Dimensions	100 mm (W) × 100 mm (L) × 20 mm (H)
External analog input connector	10-pin AMP type with 0.1" pitch
External digital input connector	20-pin AMP type with 0.1" pitch
Input power connector	3-pin with 0.1" pitch
Number of output channels	4 channels

Max Ratings:

Max. output voltage	140 VDC
Max. output current	20 mA/channel all channels (continuous) 60 mA/channel single channel (continuous) 60 mA per channel (peak current limit)
Max Input Signal Voltage	5 V

Electrical Characteristics:

Input Analog Signal Voltage Range	0 to 5V
Input Resistance	≥20 kΩ
Digital input	TTL, 12-bit data, 4-bit control
140V Output Response Time	< 30 µs, rise/fall time without load < 400 µs, rise/fall time with PolaRite II
15V Output Response Time	10 µs, rise/fall time without load 40 µs, rise/fall time with PolaRite II
Output Voltage Range	0-140V DC
Output Impedance	50 ohms
External Input Gain	30 V/V ± 1%
Noise[1]	< 40 mV (RMS)
-3dB Bandwith[2]	16 kHz
Operating Temp.	0 to 40° C
Storage Temp.	-20 to 60° C

Required Power Supply:

Standard

+ 12V DC / 1.2A(continuous)

− 12 V DC / 0.1A

Note:

1. The noise is measured with the output set to 140V and an output capacitance of 0.18μF (capacitance of piezoelectric actuator used in PolaRITE II/III). It may decrease with higher output capacitance and increase with no output capacitance.
2. The bandwidth is measured at 140V output with no load. Any piezoelectric element added to the output may decrease the bandwidth. The –3 dB bandwidth is defined by the frequency at which the output peak-to-peak voltage drops from 140 V to 100 V (~ 0.707 × 140 V).

Section 2. Overview:

The MPD-001 is a precision, low noise, low drift, high voltage, multiple channel driver card for piezoelectric actuators. The card provides sufficient driving voltage to drive up to four (4) piezoelectric actuators. The output driving voltages are controlled by external analog or digital signals.

The MPD-001 is specially designed to drive General Photonics' polarization controllers (PolaRITE II/III) and commercial piezoelectric actuators with voltages up to ~150V. A PolaRITE II/III polarization controller can be mounted directly on the MPD-001 board to create an integrated polarization controller module (General Photonics product model PCD-M02). An 8-pin parallel connector is provided for driving other piezoelectric components. Figure 1 shows a top view of the MPD-001 and PCD-M02.

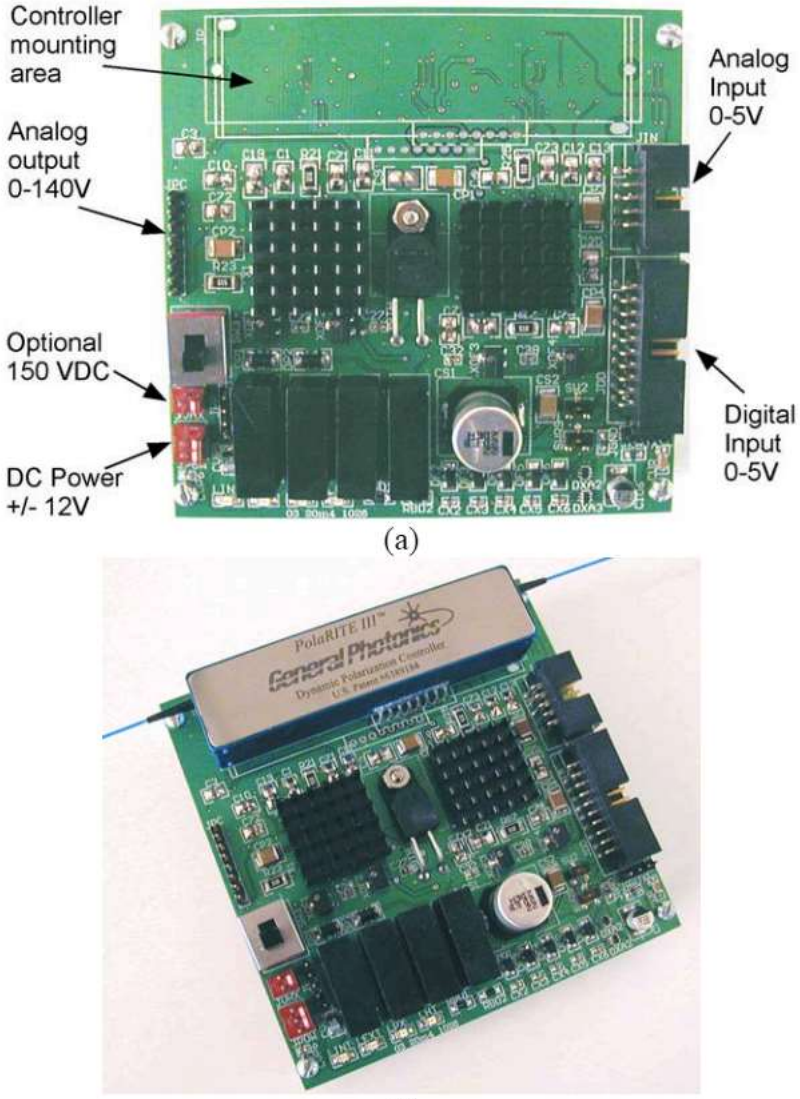


Figure 1 (a) MPD-001 standard board top view, and (b) PCD-M02 (PolaRITE™ III polarization controller is mounted on the board).

The MPD-001 board accepts both analog and digital control signals. It has a closed loop gain of 30V/V, so analog input voltages of 0-5V are sufficient to cover the full 150V control voltage range. The external analog control voltage can be supplied by any stable voltage source including function generators, DAC output, or DC supplies. For digital control applications, the MPD-001 board can be controlled by a 16-bit parallel TTL digital signal from any logic circuit. The digital signal controls each channel individually. An optional LabView program and a digital input/output card can be purchased from General Photonics.

One attractive feature of the MPD-001 board is that the standard board operates at ± 12V, which can easily be provided by commonly available laboratory or industrial power supplies.

2.1 Board descriptions

Analog and digital input connectors are mounted on the right hand side of the board, as shown in Figure 1. The analog and digital input connectors are a 10-pin and a 20-pin AMP type respectively. All connectors on the MPD-001 board have a standard 0.10 inch (2.54 mm) pin separation. The pinout diagram is shown in Figure 2.

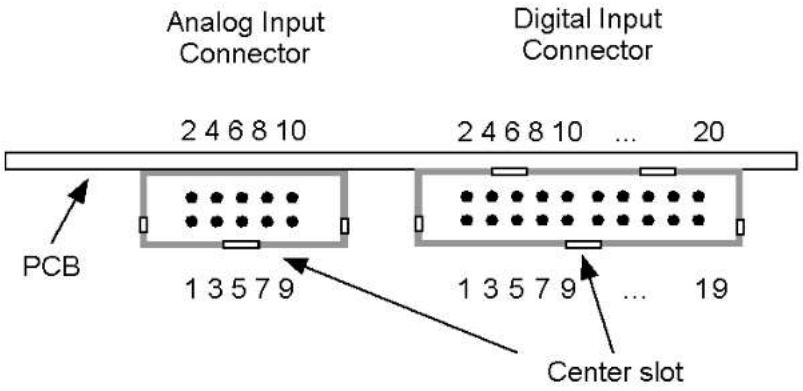


Figure 2 Analog and digital input connector configurations.

The pin assignments for analog and digital input connectors are summarized in Table 1 and Table 2, respectively. The analog input connector uses 5 independent connections, and the digital connector has 18 independent connections.

There are 4 mounting holes on the MPD-001 driver board. Their locations are shown in Figure 3. Also in Figure 3, the location and pin layouts for the DC power input connector (3-pin) and analog output connector (JPC: 8-pin) are illustrated. The pin assignments for DC power and analog output connectors are listed in Table 3 and Table 4.

Note: The analog output connection must be carefully checked to ensure that the orientation is correct. A reversed connection using a parallel cable will short the channel 3 and channel 4 outputs to ground, which may cause damage to circuit components if not corrected immediately.

Table 1: Analog input connector pin assignment list

Pin number	Assignment	Function
1	V_1	Channel 1 input
2	V_3	Channel 3 input
3	AGND	Analog ground
4	AGND	Analog ground
5	V_2	Channel 2 input
6	V_4	Channel 4 input
7	AGND	Analog ground
8	AGND	Analog ground
9	AGND	Analog ground
10	AGND	Analog ground

Table 2: Pin assignment for digital input connector

Pin number	Assignment	Function
1	RW	Read/Write
2	/CS	Chip select, negative active
3	/RESET	Asynchronous Reset Input, set DAC and input registers zero-scale (000H)
4	A0	Channel control bit 1
5	A1	Channel control bit 2
6	DB0	Digital signal least significant bit (LSB)
7	DB1	Digital signal bit 2
8	DB2	Digital signal bit 3
9	DB3	Digital signal bit 4
10	DB4	Digital signal bit 5
11	DB5	Digital signal bit 6
12	DB6	Digital signal bit 7
13	DB7	Digital signal bit 8
14	DB8	Digital signal bit 9
15	DB9	Digital signal bit 10
16	DB10	Digital signal bit 11
17	DB11	Digital signal most significant bit (MSB)
18	DGND	Digital ground
19	DGND	Digital ground
20	NC	NC

Table 3: DC power supply connector pin assignment

Pin number	Assignment
1	+12 V
2	AGND (analog ground)
3	-12 V

Table 4: Analog output connector (JPC) pin assignment

Pin number	Assignment	Function
1	AGND	Analog ground
2	AGND	Analog ground
3	AGND	Analog ground
4	V1	Channel 1 analog output, positive
5	V2	Channel 2 analog output, positive
6	V3	Channel 3 analog output, positive
7	V4	Channel 4 analog output, positive
8	AGND	Analog ground

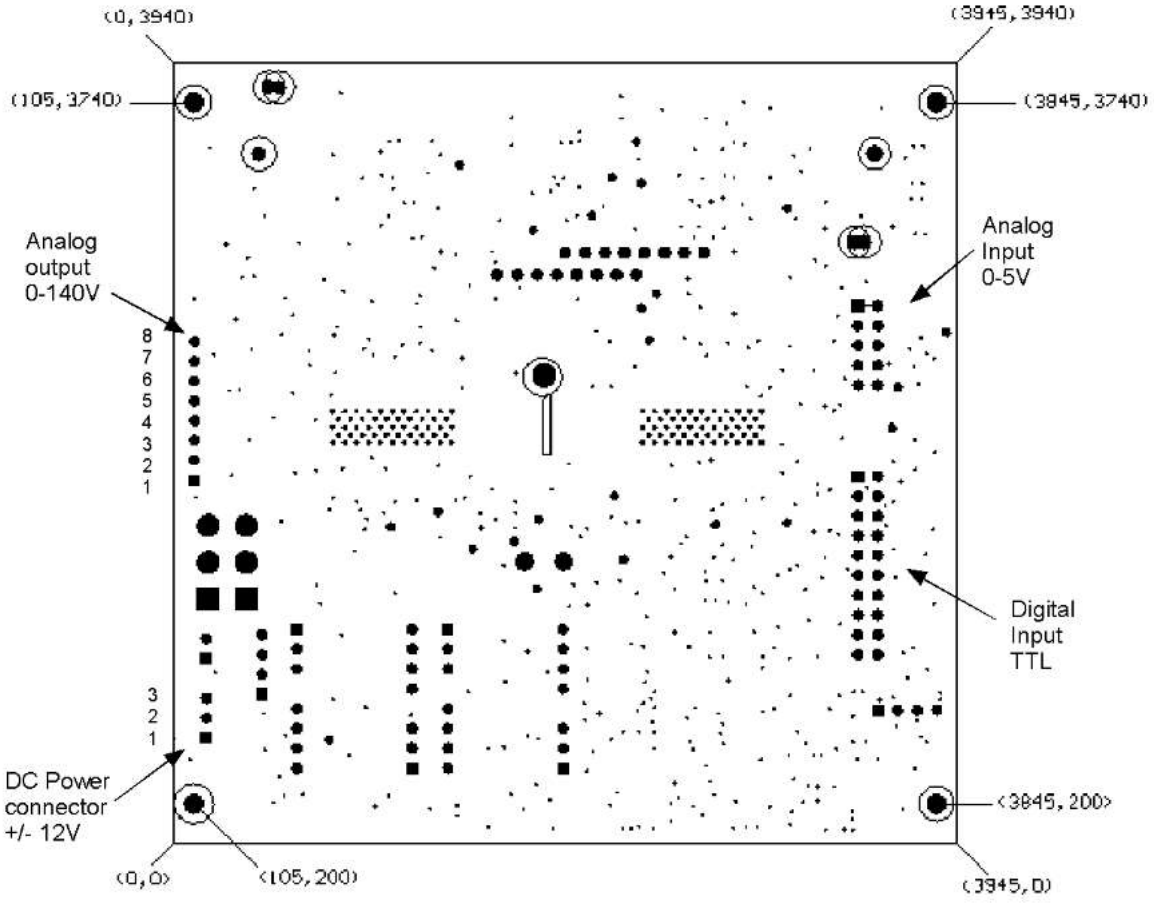


Figure 3 PCB layout showing mounting hole locations. All units are in mils. The analog output connector and ±12V DC power supply connector pin assignments.

Section 3. Operation Instructions:

Important Safety Notes

The MPD-001 board can produce hazardous voltages and currents. The DC voltage on the board can reach 150 V. Use extreme CAUTION when operating the MPD-001. Make sure that the power is turned off when connecting or disconnecting cables.

When using the MPD-001 as a custom piezoelectric actuator driver, users must check the maximum allowed voltage on their actuator to make sure that the output voltage from the MPD-001 does not exceed the limit of their device. The maximum output voltage from the MPD-001 is ~140 V.

The capacitor nature of piezoelectric actuators sometimes causes them to retain large amounts of charge that can cause electric shock to humans. To safely discharge a piezoelectric actuator, the user should set the input control voltage to 0 V.

Note: Do not place a negative voltage on a piezoelectric element. A high negative voltage can reverse the polarization direction of a piezoelectric element, causing the behavior of the device to change completely. If a negative voltage is applied to a piezoelectric element, the user should check with the supplier regarding the procedure to re-pole the device.

2.1 Getting started

Unpacking
The MPD-001 board or PCD-M02 module is shipped with a set of cables to facilitate user applications, as listed in Table 5. Please check the shipping package and the order

Table 5: MPD-001/PCD-M02 driver board and accessory list

Item	Part name	GP part number	Units	Note
1	MPD-001 board	MPD-001-(2-4)X	1	Standard board
2	Power cable (3-wire)		1	±12 V DC
3	Analog input cable		1	w/connector
4	Digital input cable		1	w/connector
5	PolaRITE II/III	PCS-4X-7-C/ MPC-4X-7-C	*1	Polarization controller option (on-board)
6	Analog output cable		*1	Piezo driver option
7	Digital I/O board		*1	Optional
8	DIO control program		*1	Optional
9	External 150 VDC input cable		*1	For non-standard MPD-001 version only
10	PWR-002 power supply		*1	Optional, non-standard MPD-001 version

* Optional features

Initial setup

1. Set a dual output power supply at 12 V. Turn off the supply and connect the power supply cable to the power supply using the connections specified in Table 3.
2. Before inserting analog or digital input connectors to the MPD-001 board, connect analog or digital input cable to the appropriate analog or digital control signal source.
3. If external piezoelectric actuator is used, connect analog output cable to external piezoelectric device. For PCD-M02 unit (integrated with a PolaRITE II/III polarization controller), skip this step.

2.2 Operation

The MPD-001 board can be operated under either analog or digital control modes. These two modes cannot be operated at the same time unless one of the control signal groups is set to zero. Typical analog applications include continuous piezoelectric actuation, slow speed polarization scrambling, etc.

2.2.1 Analog control mode operation

To operate the MPD-001 in analog control mode, a multi-channel (at least 4 channels) DC or AC signal generator is required. Typical signal sources are function generators, DC power supplies, digital-analog-converter output lines, computer controlled analog output boards, etc. Analog signals can be applied to all channels simultaneously.

1. After initial setup steps, connect the power supply cable to power connector JPOW (3-pin connector, refer to Figure 1).
2. Set the analog signal source at or near zero or their lowest output levels. Connect analog input connector cable to analog input connector JIN (10-pin connector, refer to Figure 1 and Figure 2).
3. When external piezoelectric elements or a remote PolaRITE II/III controller are used, check analog output connector and cable to make sure that the connection and polarity are correct according to Table 4.
4. Turn on the ±12V DC power supply. If the power supply has current readout, the steady state +12V current should be less than 0.3 A when input analog signals are set at zero.
5. Adjust voltage applied to the analog input connector to set voltage at the desired level. In general, the +12V current should be less than 1.0 A during continuous driving operation.
6. If a function generator is used, make sure that the applied signal frequency and amplitude do not overload the circuit. To avoid damage to the amplifier board, periodic analog inputs (such as from a function generator) should meet the following conditions:

    a. For one channel operating alone, or for two channels (channels 1 and 3 or 2 and 4) operating simultaneously, input conditions must satisfy:

BW = f * V < 2.5 kHz · V.
For example, if peak-to-peak input voltage V = 2V, input frequency f must be < 1.25 kHz

b. For three or 4 channels operating simultaneously, or if channels 1 and 2 or 3 and 4 are operating simultaneously, input conditions must satisfy:
BW = f * V < 1.25 kHz · V.
For example, if peak-to-peak input voltage V = 2V, input frequency f must be < 0.625 kHz.

7. In order to avoid an undesired floating offset from the digital output during analog control operation, it is recommended that the reset pin (pin 3 on the digital input connector (see fig. 1)) be tied to ground during analog control. This will force the digital output to zero.

8. Turn off the power supply when complete.

2.2.2 Digital control mode operation

Unlike the analog control mode, the digital control signals operate sequentially. The digital control signal is applied to one channel at a time. Of the 18 digital control signal lines, 16 are used for digital control signals, as listed in Table 2. Of the 16 control signals, 12 lines are used for loading 12-bit parallel voltage level control signals to a selected channel. The other 4 lines are for data traffic control. Therefore, a parallel output signal source hardware such as a digital input/output (DIO) board or computer parallel port is required to perform digital control. An initialization step is required when starting digital control mode operation.

1. Connect DC power cable and digital input connector to MPD-001 board after initial setup steps.
2. When external piezoelectric elements or a remote PolaRITE II/III controller are used, check analog output connector and cable to make sure that the connection and polarity are correct, according to Table 4.
3. Turn on ±12V DC power supply. If the power supply has current readout, the steady state +12V current should be less than 0.3 A when input analog signals are set at zero.
4. Launch an application program that generates appropriate digital control signals. A LabView control program is available at General Photonics for the optional control hardware.
5. An initialization step is required at the beginning of digital control. The initialization process sets the following lines:
   RW change from 0-1-0-1

DB0—DB11	from 0-1-0
A0, A1	from0-1-0
CS	from 0-1-0-1

The initialization process can be performed in parallel.

6. Digital control of output voltages:
   a. Change RW (reset) from 1 (default) to 0 (load data mode).
   b. Load data to DB0-DB11.
   c. Set A1, A0 to select output channel according to Table 6. The output voltage corresponding to the analog output connector pin position is also listed in Table 6.

Table 6: Output channel selection control assignment

Channel	A1	A0	Corresponding Analog output pin
1	0	0	4
2	0	1	5
3	1	0	6
4	1	1	7

   d. Change CS (chip select) from 1 (default) to 0 (select chip). This feature is very useful when multiple MPD-001 boards are in use. The user can apply the CS signal to select different boards and to share the data lines.
   e. Maintain RW at 0 and repeat steps (b) to (d) to operate another output channel.
   f. If reset is needed, change RESET from 1 (default) to 0, then back to 1.
   g. DGND pins are connected to ground.

7. Turn off power supply when complete.

Section 4. Application Notes:

4.1 Piezoelectric actuator driving current estimate

Step voltage waveform

The MPD-001 is a precision voltage amplifier designed specifically to drive piezo actuators. Since piezoelectric actuators can be modeled as a capacitor when not at their resonance frequencies, we can estimate their driving current based on the equation,

$$I(t) = C\, dV/dt \quad (1a)$$

or

$$I = C\, \delta V/\delta T \text{ (for a linear ramp)} \quad (1b)$$

For example, the instantaneous current required to drive a piezoelectric actuator with a capacitance of 0.18uF from 0 to 20V in 100μs is

$$I = 0.18\mu F \times 20V / 100\mu s = 36\ mA$$

Each individual driving channel in the MPD-001 board has a peak current limit set at 60mA; therefore it has sufficient current for this application.

Continuous sinusoidal waveform

When a biased sinusoidal waveform is applied to a specified channel on a MPD-001 board, the maximum output current can be expressed as

$$I_{max} = \pi \cdot C \cdot V_{pp} \cdot f_{max}, \quad (2)$$

and the continuous operation current

$$I_{RMS} \approx 0.707 \cdot \pi \cdot C \cdot V_{pp} \cdot f_{cont}. \quad (3)$$

For I_{max} = 60 mA and C = 0.18 μF, we have

$$V_{pp} \cdot f_{max} \approx 100\ V\text{-}kHz, \quad (4)$$

and for I_{RMS} = 20 mA, we have

$$V_{pp} \cdot f_{cont} \approx 50\ V\text{-}kHz. \quad (5)$$

Therefore, when the MPD-001 board is employed to drive a PolaRITE II/III polarization controller, we can use Eq. 4 to estimate the maximum output voltage-frequency product for single actuator operation. When the voltage-frequency product exceeds the limit set in Eq. 4, the output waveform will be severely distorted.

When all four output channels in a MPD-001 board are driven by the same sinusoidal waveform, the power supply limit of 80 mA (20 mA per channel) will require a driving condition specified by Eq. 5. For clarity, Eq. 4 and Eq. 5 are graphically illustrated in Figure 4.

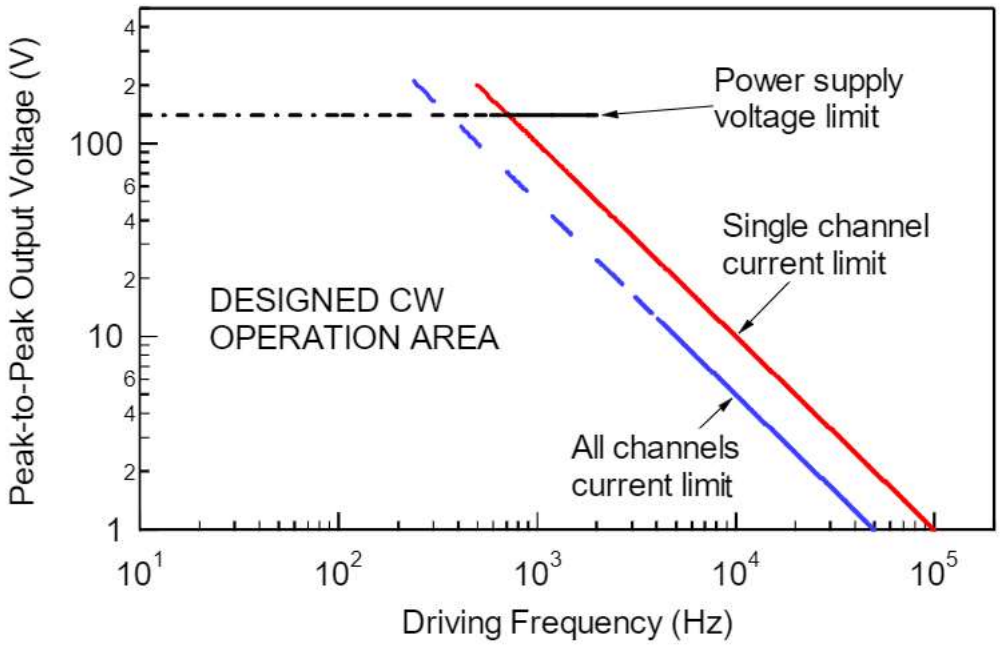


Figure 4 Current limit and power supply constraints on the peak-to-peak output voltage and driving frequency. The black horizontal line is the power supply high voltage limit. The red solid line is the single channel operation current limit. The blue broken line is the total current supply limit when all 4 channels are driven by a single sine frequency.

Rise time estimate when piezoelectric actuator is used as load

Under a step voltage driving condition, and assuming that the rise time of the driving signal is negligible, the rise time of the output waveform can be estimated from Eq. 1b and the current limit of 60 mA. Using C=0.18 μF, from the PolaRite II/III, as an example,

$$T_R = C \times \delta V / I_{max} = 3 \times \delta V \ (\mu s) \qquad (6)$$

Eq. 6 depicts a linear relationship between the rise time and the amplitude of the output voltage step under given current limit condition.

Note that the above estimates are for room temperature conditions.

4.2 Typical applications of the MPD-001/PCD-M02

In addition to functioning as a driver for external piezoelectric actuators, the MPD-001 can be used in various polarization control applications with an integrated PolaRITE II/III polarization controller (as the PCD-M02 integrated polarization controller module).

Dynamic polarization control

The PCD-M02 can be used to transform any arbitrary input polarization state to any arbitrary output polarization state. With the aid of a polarization detection device, the user can electronically control the voltage applied to each channel to adjust the output polarization state.

Polarization scrambling

The PCD-M02 can also be used as a low speed polarization scrambler to randomize the input polarization state. The control signal can be 4 random step voltages or 4 sine wave voltages with the following peak-to-peak voltage and frequency relationship:

$$V_{i,pp}=1.531V_{\pi,i},\ i=1\text{-}4; \tag{7}$$

$$nf_i \neq mf_j,\ m,\ n=\pm1,\pm2,\ \ldots,\ i,\ j=1\text{-}4,\ \text{and}\ i\neq j. \tag{8}$$

As mentioned in Section 4.1, the scrambling frequencies are limited by power supply constraints or circuit current limits. For a PolaRITE II/III in off-resonance mode, the maximum scrambling frequency is about 1kHz. The optional digital control program provides a function generation capability to facilitate slow speed scrambling. The extremely low polarization dependent loss (PDL) and the polarization scrambling capability are very useful in optical component PDL measurement.

For high frequency polarization scrambling, a resonant type scrambler, the PCD-003/4, is available at General Photonics. Please contact General Photonics for additional information.

Polarization stabilization

Using the appropriate feedback electronics and control algorithm, the PCD-M02 can be part of a polarization stabilization system. The feedback signal can be the maximum (or minimum) optical power output through a polarizer, or the maximum (or minimum) output voltage of a modulation signal. The stabilization speed depends on the algorithm, feedback loop time, detection approaches, system noise level, etc. For high-speed, reset free polarization stabilization, we recommend General Photonics' turn-key system POS-103A, which is microprocessor controlled and fully automatic. Please contact General Photonics for additional information.

Section 5. Technical Support:

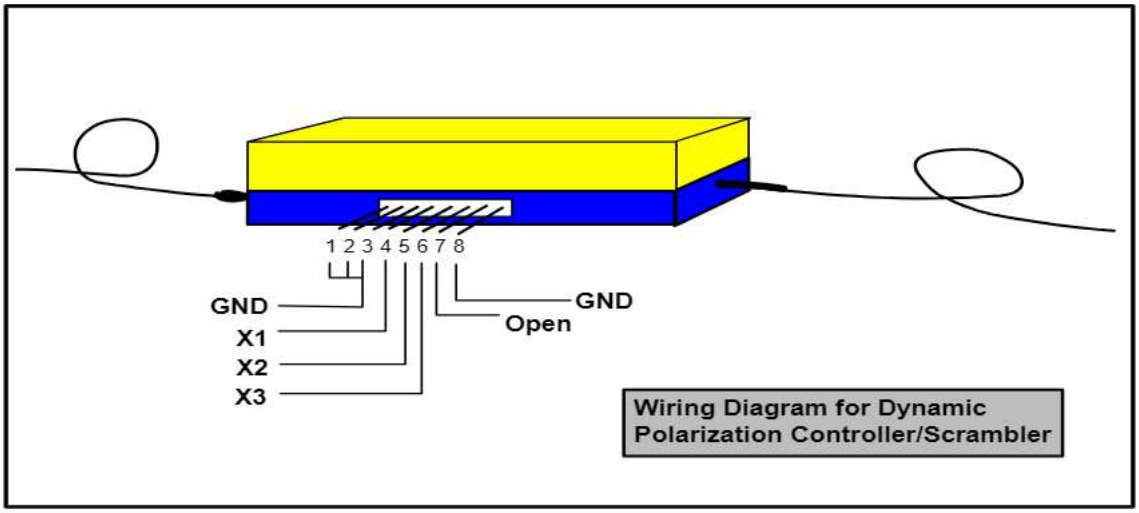
The MPD-001/ PCD-M02 has no user serviceable parts. Service should be performed only by manufacturer-authorized personnel.

General Photonics is committed to high quality standards and customer satisfaction. For any questions regarding the quality and the use of the MPD-001/PCD-M02, or future suggestions, please contact General Photonics Corporation at (909)-590-5473 (telephone) or (909)-902-5536 (fax), or by e-mail at info@generalphotonics.com. General Photonics will respond to all customer questions within 24 hours during regular business hours. You can also write to:

General Photonics
5228 Edison Avenue
Chino, California 91710
USA

Appendix A: Wiring Diagram of PolaRITE II/III on Board

3 channel PolaRITE II/III:



4 channel PolaRITE II/III: