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MDL – 002 OEM

Motorized Variable Optical Delay Line
with OEM controller board

<u>Operation Manual</u>

Version: 1.5

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Section 1. Specifications:

Operating Wavelength[1]	SM: 1260-1650 nm PM or double pass: 1310±50 or 1550±50 nm	1060±50nm
Optical delay range[2]	0 to 330 ps (single-pass) 0 to 560 ps (single-pass) 0 to 1120 ps (double-pass)	
Optical delay resolution[2]	0.3 μm or 1 fs per encoder count (single-pass) 0.6 μm or 2 fs per encoder count (double-pass)	
Position accuracy[2,3]	±3 μm (single-pass) ±6 μm (double-pass)	
Position repeatability[3]	±3 μm (single-pass) ±6 μm (double-pass)	

Delay varying speed[2,4]	10-speed levels selectable
	    From 0.01 ps/sec. to 256 ps/sec (single-pass)
	    From 0.02 ps/sec to 512 ps/sec (double-pass)	

Insertion loss	1.0 dB nominal (single-pass) 1.5 dB nominal (double-pass)	1.5 dB nominal (single-pass)
Insertion loss variation[2]	±0.3 dB over entire range for 330 ps model ±0.5 dB over entire range for 560 ps model ±0.7 dB over entire range for 1120 ps model	
PDL	0.1 dB for SM fiber	
Return loss	50 dB	
Extinction ratio	> 18 dB for PM model	
Optical Damage Power Threshold	300 mW	
Power supply	12VDC / 1A max.	
Control mode	RS-232 interface	
Operating Temperature	0 °C to 40 °C	
Storage Temperature	−20 °C to 60 °C	
Fiber type	SMF-28 or PM Panda fiber	Hi1060 or PM Panda fiber
Dimensions (Optical delay head)	4.37" (L) × 1.46" (W) × 0.7" (H) for 330 ps model 5.35" (L) × 1.46" (W) × 0.7" (H) for 560 ps or 1120 model	
Dimensions (Control board)	2.56" (L) × 2.56" (W) × 0.85" (H)	

Notes: Values in table are valid over a 1060±50, 1310 ± 50 or 1550 ± 50nm range for a device without connectors.
1. Other wavelengths may be available. Contact General Photonics for details.
2. The 1120 ps model is a double-pass device. Since input and output signals travel on the same pigtail, a circulator or PBS may be necessary to separate input and output signals for some applications. Double pass versions are not available for 1060nm. Output fiber type for double-pass models is SM.

3. Accuracy and repeatability specifications given for mechanical position of reflector at static position setting.

4. The delay change speed levels are as follows:

> Single-pass versions:
> Speed 0:   0.01   ps/second
> Speed 1:   0.25   ps/second
> Speed 2:   1   ps/second
> Speed 3:   4   ps/second
> Speed 4:   8   ps/second
> Speed 5:   16   ps/second
> Speed 6:   32   ps/second (default setting)
> Speed 7:   64   ps/second
> Speed 8:   128   ps/second
> Speed 9:   256   ps/second
>
> Double pass versions:
> Speed 0:   0.02   ps/second
> Speed 1:   0.5   ps/second
> Speed 2:   2   ps/second
> Speed 3:   8   ps/second
> Speed 4:   16   ps/second
> Speed 5:   32   ps/second
> Speed 6:   64   ps/second (default setting)
> Speed 7:   128   ps/second
> Speed 8:   256   ps/second
> Speed 9:   512   ps/second

> Please note that the speeds in the list above are steady state speeds. There will be an acceleration and deceleration period at the beginning and end of the travel.

Section 2. Overview:

General Photonics' motorized variable optical delay lines (MDL-002) provide precise, continuous optical path delay of up to 1120 picoseconds. They are driven by a DC motor with an integrated encoder, and have an extremely fine delay resolution of 0.3 μm, or 1 fs per encoder count for the single-pass versions, or 0.6 μm (2 fs) per encoder count for double-pass versions. These characteristics make them ideal for precision optical path length control or timing alignment. As shown in Figure 1, the MDL consists of a compact optical head and a separate control board. Major applications of these MDL devices include optical time division multiplexing (OTDM), optical Fourier spectrum analysis, interferometry, pulse alignment, and optical coherence tomography (OCT). They can also be used to vary the modulation phase of reflections for the testing of reflection effects on transmitters.

The MDL-002 family consists of 330 ps (10 cm), 560 ps (17 cm), and 1120 ps (34 cm) optical delay models. Single-pass models can have SM or PM fiber pigtails. Double-pass models have SM pigtails.
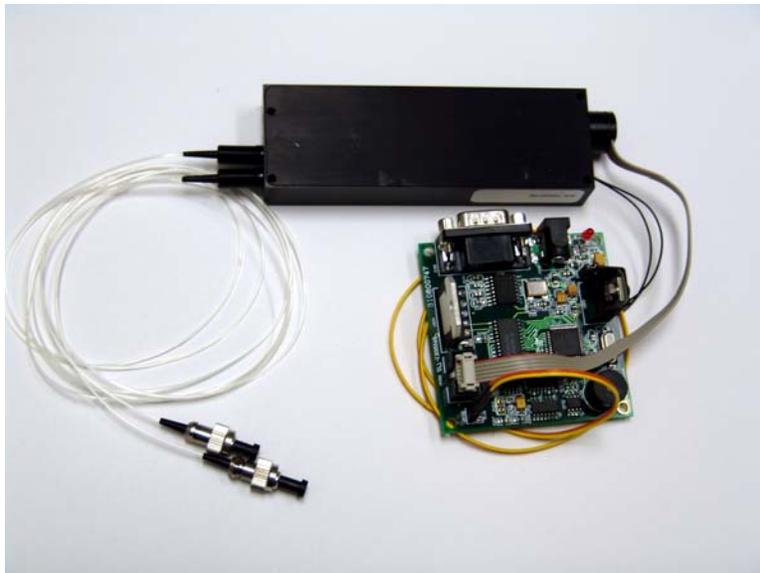

Figure 1 Miniature motorized variable optical delay line - MDL-002 with OEM controller board.

Section 3. Device Description:

3.1 General Description

This version of the MDL-002 motorized optical variable delay line (MDL) consists of two sub-modules: the variable optical delay module and the electronic controller board. The input/output optical signals are connected to the variable optical delay module via single mode or polarization maintaining optical fibers. A Faraday mirror is used in the double-pass versions. The electronic controller carries out the control commands and senses the delay state. A built-in RS-232 connector takes commands from a computer or a hand-held device when the MDL is operating and the communication between the PC and MDL is established.

3.1.1   MDL-002 package features

The optical head has one (for double pass) or two (for single pass) optical fiber pigtails to accommodate optical input and output on the left side of the unit, and two cables on the right side for connection to the control unit. The 6-wire cable carries motor information, and the 2-wire cable carries sensor information.

Dimensions for the MDL-002 optical heads are shown in Figure 2.
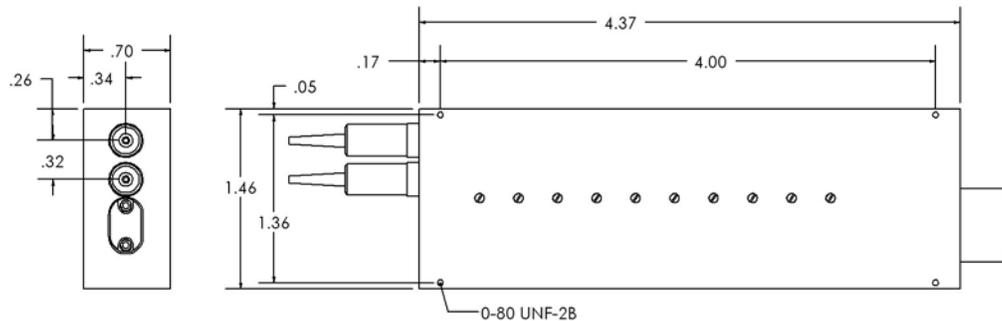
Figure 2 a) 330ps MDL-002 optical head dimensions
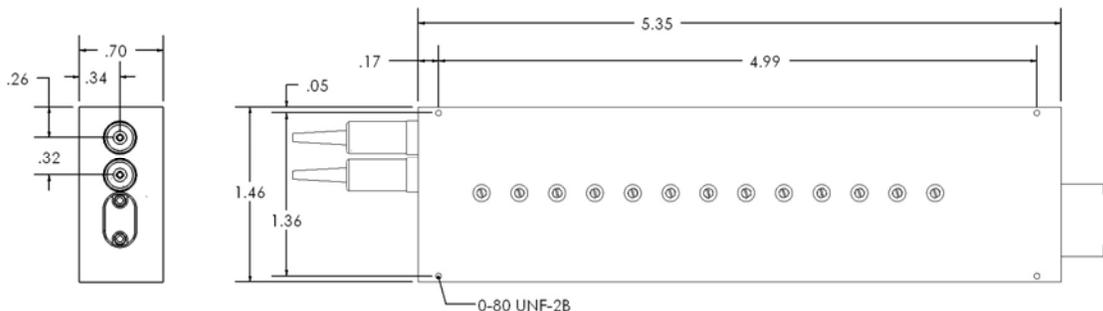
b) 560/1120ps MDL-002 optical head dimensions

The control unit is shown in Figure 3.
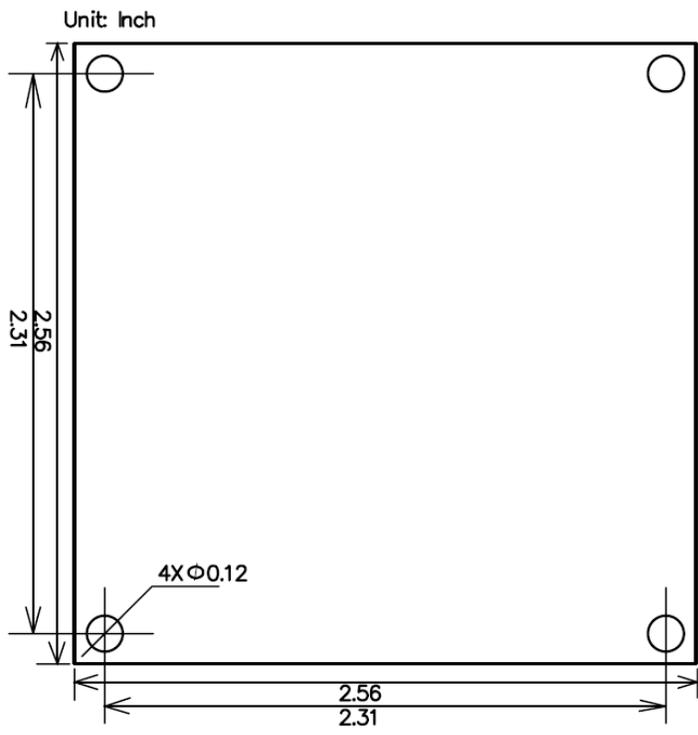
Figure 3 MDL-002 OEM controller board
a) dimensions
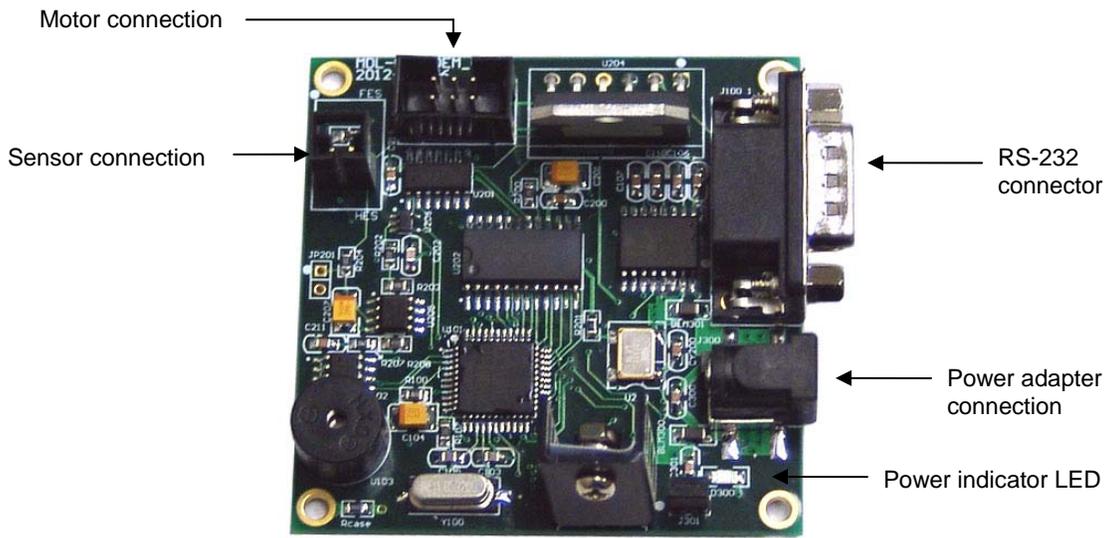

b) electrical/communication connections

RS-232 connector: standard DB-9 male connector.
sensor connector: 2-pin 2.54mm grid
power connector: barrel power jack 2.1X5.5mm SMD, part # PJ-002A-SMT

6-pin motor connection:
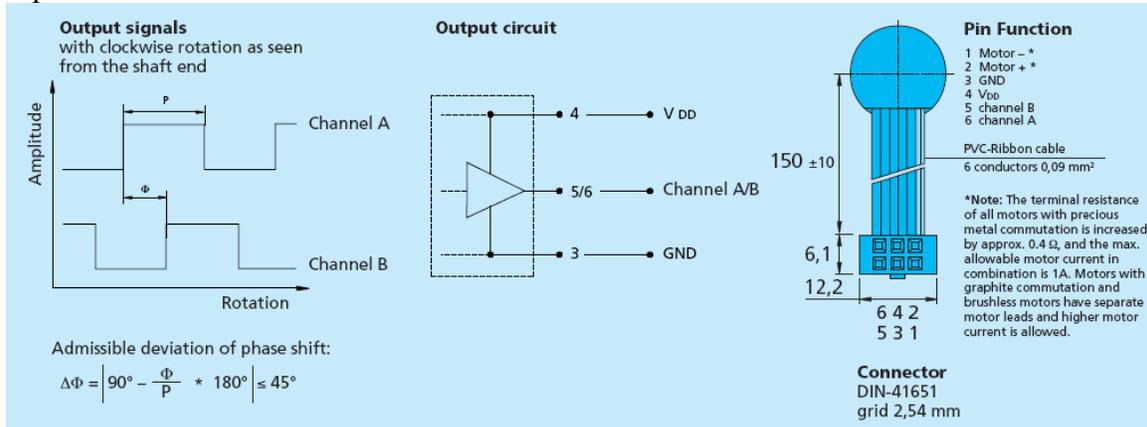
3.2 Polarization Properties

The MDL-002 employs free space optics to adjust optical path length; therefore, the polarization state will not change during delay adjustment. However, the standard single mode input/output fiber(s) may transform the input polarization state to a different state at the output.

3.3 Power Supply

The MDL devices require a 12V/1A DC power supply to operate. A standard AC/DC power supply adapter is shipped with the MDL-002. When using a DC power supply other than the one supplied with the MDL, make sure that the DC power supply connector has the correct polarity: the center pin is positive (+) and the outer contact is negative (−). Incorrect voltage and/or polarity will damage the control electronics of the MDL-002.

Section 4. Device Operation:

Electrical and optical connections are required during setup of the MDL-002. Follow safety precautions when making these connections.

4.1. Getting Started

Unpacking
Be careful when unpacking the MDL-002 from its original packaging.

Avoid applying any force to optical fiber pigtails, and do not let any free-drop of fiber connectors occur at any time. Excessive force to fiber pigtails may degrade device performance or damage the variable optical delay module.

Operation

Follow the steps below to operate the MDL-002.

1. Connect fiber pigtails to the optical path where delay adjustment is to be performed.

   The input and output travel on the same fiber pigtail of the double-pass MDL.

   To use a double pass model in a system with SM fiber, to separate input and output signals, connect the MDL's pigtail to port 2 of a 3-port SM circulator. The input should be connected to port 1 of the circulator, and the output to port 3.

   To use a double pass model in a system with PM fiber, to separate input and output signals, connect the MDL's pigtail to port 1 (common port) of a PBS with SM fiber on the common port. The input should be connected to port 2 of the PBS, and the output to port 3.

2. Connect 6-pin motor connection wire to the connector on the controller board (see Figure 3.) This connector is keyed and can only be inserted one way.
3. Connect 2-pin sensor connection wire to the connector on the controller board (see Figure 3). This connector is also keyed and can only be inserted one way.
4. Check the DC power supply output voltage (12 V DC) and polarity (center positive).
5. Connect power adapter to the power supply connector and plug it into the wall power supply. The power indicator LED will light, and the MDL will run through an initialization sequence.
6. See the next section for control instructions.

4.2 Remote Operation

The MDL-002 can be remote controlled via a built-in RS-232 communication port. Use a straight connection RS-232 cable to connect the control computer's RS-232 serial port to the MDL control unit.

Many programming languages support serial communications, including Visual Basic, LabVIEW and C. Any such program can be used to send ASCII string commands to the MDL through the RS-232 port.

The command sequence should be sent one command at a time. Wait for the command response before sending the next command.

4.2.1   Remote Control Command List

The ASCII commands for MDL remote control are summarized in Table 1, with more complete descriptions of their functions following the table.

Table 1 Remote control ASCII commands

Control Commands				
Command	Description	Range	Default	Response
idn$ or _IDN_$	Query device identification (model, firmware version and serial number)	n/a	n/a	For 330/560ps MDL: "MDL002OEMnnnV2.1 _01152015_xxxxx" xxxxx: serial number (00000 ~ 99999) nnn = 330/560 For 1120ps MDL: "MDL002OEM1120V2.1 _01152015_xxxx" xxxx: serial number(0000~ 9999)
_abs_xxx.xxx$ or _ABS_xxx.xxx$	Set delay to xxx.xxx, in selected units (ps or mm), with respect to relative zero position 0_R. Max = 330 ps (99 mm) 560ps (168mm), or 1120 ps (336 mm), depending on version.	(0 to max) -0_R	$0-0_R$	OK
_rel_xxx.xxx$ or _REL_xxx.xxx$	Set relative zero position 0_R, in selected units (ps or mm). Max = 330 ps (99 mm) 560ps (168mm), or 1120 ps (336 mm), depending on version.	0 to max	0	OK
_sc1_xxx.xxx$ or _SC1_xxx.xxx$	Set scan start position (T_1) in selected units (ps or mm)	(0 to T_2) -0_R	0	OK

Command	Description	Range	Default	Response
_sc2_xxx.xxx$ or _SC2_xxx.xxx$	Set scan end position (T_2) in selected units (ps or mm). Max = 330 ps (99 mm) 560ps (168mm), or 1120 ps (336 mm), depending on version.	(T_1 to max) -0_R	0	OK
_spd_x$ or _SPD_x$	Set scan speed setting <table><tr><td>x</td><td>Speed (ps/s) (330/560ps MDL)</td><td>Speed (ps/s) (1120ps MDL)</td></tr><tr><td>0</td><td>0.01</td><td>0.02</td></tr><tr><td>1</td><td>0.25</td><td>0.50</td></tr><tr><td>2</td><td>1</td><td>2</td></tr><tr><td>3</td><td>4</td><td>8</td></tr><tr><td>4</td><td>8</td><td>16</td></tr><tr><td>5</td><td>16</td><td>32</td></tr><tr><td>6</td><td>32</td><td>64</td></tr><tr><td>7</td><td>64</td><td>128</td></tr><tr><td>8</td><td>128</td><td>256</td></tr><tr><td>9</td><td>256</td><td>512</td></tr></table>	0 to 9	6	OK
org$ or _ORG_$	Reset delay position and origin to absolute zero position.	n/a	n/a	OK
sst$ or _SST_$	Start scan Note: Scan will time out after 10 minutes of continuous operation	n/a	n/a	OK
stp$ or _STP_$	Stop motor (while scanning or moving to a new position)	n/a	n/a	OK
mmu$ or _MMU_$	Set delay unit to mm 1 mm ≈ 3.333ps	n/a	n/a	OK
psu$ or _PSU_$	Set delay unit to ps 1 ps ≈ 0.333mm (default setting)	n/a	n/a	OK

Query Commands			
Command	Description	Range	Sample response
redabs$ or _REDABS_$	Query current delay, with respect to relative zero position	(0 to max) -0_R	ABS:xxx.xxxPS or ABS:xxx.xxxMM
redrel$ or _REDREL_$	Query relative zero position 0_R	0 to max	REL:xxx.xxxPS or REL:xxx.xxxMM
redsc1$ or _REDSC1_$	Query scan start setting T_1, with respect to relative zero position	(0 to T_2) -0_R	SC1:xxx.xxxPS or SC1:xxx.xxxMM
redsc2$ or _REDSC2_$	Query scan end setting T_2, with respect to relative zero position	(T_1 to max) -0_R	SC2:xxx.xxxPS or SC2:xxx.xxxMM

redspd$ or _REDSPD_$	Query steady-state speed, in ps/s. Possible responses:		SPD:64PS/S
	330/560 ps MDL	1120ps MDL	
	0.01 ps/s	0.02 ps/s	
	0.25 ps/s	0.50 ps/s	
	1 ps/s	2 ps/s	
	4 ps/s	8 ps/s	
	8 ps/s	16 ps/s	
	16 ps/s	32 ps/s	
	32 ps/s	64 ps/s	
	64 ps/s	128 ps/s	
	128 ps/s	256 ps/s	
	256 ps/s	512 ps/s	
redmode$ or _REDMODE_$	Query motor status: RUN = moving or STOP = stopped	n/a	EX: RUN or STOP
snr$ or _SNR_$	Query sensor status: OK = normal. E01 = far sensor not connected E02 = home sensor not connected E03 = far sensor triggered E04 = home sensor triggered		EX: E02

Remote Control Command notes:

1. Commands are case sensitive ASCII codes. The last character of each command ASCII string, $, is an end marker.
2. RS-232 port uses asynchronous framing, 8 data bits, no parity bit, and 1 stop bit.
3. RS-232 data rate: 9600 bps.
4. Only one command is allowed in each command string. Wait for "OK" or data response from the MDL before sending the next command.
5. While the MDL is scanning (the motor is moving), only the stop, motor status query, or position query commands will be received. Any other commands will receive a "NO" response.

The MDL will respond to the computer with an "OK" string (or, for a data query, with the requested data) when a command string is accepted. Any additional commands sent before the response string is returned will be ignored by the MDL, except for the stop command "_stp_$" or "_STP_$". If the format of the command sent to the MDL is incorrect, or input data is out of the allowed data range, for example: "aBS_123.456$" (mixed case), "_ABS_ 123.456$" (extra space before parameter), "_ABS_123.456" (no $ at end), or "_ABS_2723.456$" (delay data out of range), the MDL will respond with a "NO" string. *In user interface programs, please check for the response string before sending the next command unless sending the stop command, "_stp_$" or "_STP_$".* Please note that if the motor is moving, it must be stopped before changing other settings.

Control command descriptions:

(1). ABS

The _ABS_xxx.xxx$ command is used to set a static optical delay value, with respect to the relative origin or zero point 0_R. If the origin is set at 0 ps (default setting), then the delay value is the absolute delay defined by the MDL-002's internal position sensor. If a relative origin has been set, the delay value is referenced to the relative origin. Make sure that the delay value in the command is within the range of the MDL (referenced to the relative origin, if a relative origin is used). Also, make sure that the delay value is defined in terms of the selected unit (ps or mm). The default unit setting is ps.

Note: The MDL will not respond to any other command until it has finished executing this command (i.e. reached the set position).

(2). ORG

ORG$ is a reset command. When it receives this command, the MDL-002 performs a sensor position check routine and then resets the delay to the absolute zero point defined by the internal position sensor. It also resets the origin point to its default value of 0.000 ps. This is the same initialization process that it performs when it is first powered on. ORG can be sent at any time that the motor is not moving. The buzzer will sound when the absolute zero point is reached.

(3). Scan setup

Executing a scan requires a sequence of 4 commands:

_SC1_xxx.xxx$ sets the start position.
_SC2_xxx.xxx$ sets the end position.
_SPD_x$ sets the scan speed. (If a speed has already been set, the user can simply change the start and end positions to set up a new scan using the current speed setting.)
SST$ starts the scan.

For all of the setup commands, x denotes the command parameter (delay value for the scan endpoints and speed setting for the SPD command.

Make sure that the start and end positions are both within the range of the MDL (0-330 ps, 0-560 ps, or 0-1120 ps, depending on model). Also, make sure that the start and end positions are defined in terms of the selected unit (ps or mm). The default unit setting is ps.

The ranges for scan start and end points are determined by the range of the MDL, the relative origin setting, and the other scan terminus, if it has already been set. The scan end point must be greater than the scan start point.

Example:
> MDL range: 330 ps
> Relative origin set at 100 ps
> The range for the scan start point is −100 to 230 ps. If the scan start point is then set to 0 ps, the range for the scan end point becomes 0 ps to 230 ps.

The SPD command is used to set the steady-state scan speed. There are 10 speed settings available for selection.

The speed settings and corresponding steady-state speeds are:

Setting	Single-pass device (330 or 560 ps MDL)		Double-pass device (1120 ps MDL)	
SPD0 (Speed 0)	0.01	ps/s	0.02	ps/second
SPD1 (Speed 1)	0.25	ps/s	0.5	ps/second
SPD2 (Speed 2)	1	ps/s	2	ps/second
SPD3 (Speed 3)	4	ps/s	8	ps/second
SPD4 (Speed 4)	8	ps/s	16	ps/second
SPD5 (Speed 5)	16	ps/s	32	ps/second
SPD6 (Speed 6)	32	ps/s (default setting)	64	ps/second (default setting)
SPD7 (Speed 7)	64	ps/s	128	ps/second
SPD8 (Speed 8)	128	ps/s	256	ps/second
SPD9 (Speed 9)	256	ps/s	512	ps/second

Once the scan is started, the MDL-002 will continuously scan back and forth between the two terminus points until it receives a "stop" command. In scanning mode, only the STOP and position query commands are functional. The scan must be stopped before any other settings can be changed.

Note: After 10 minutes of continuous scanning, the MDL-002 will enter standby mode and stop scanning. This is a safety feature to prevent excessive heat generation from prolonged mechanical motion. To restart continuous scanning with the currently set scan parameters, re-send the "start" command _SST_$.

(4). STOP
The _STP_$ command is used to stop the motor during a scan.

(5). ps/mm
The _PSU_$ and _MMU_$ commands are used to set the delay unit to ps (picoseconds) and mm (millimeters), respectively. The default setting is ps.

(6). REL
The _REL_xxx.xxx$ command puts the MDL-002 into relative delay mode. In this mode, a zero offset function allows the user to set the origin to any delay setting within the total delay limit. All delay settings (single delay setting or scan start and end points) are then referenced to the new relative origin position. For example, if the delay setting is

_____

90 ps with the origin at its default position of 0.000 ps, then sending _REL_50$ moves the origin to 50 ps. The position setting now becomes 40 ps (90 – 50). The delay range is also offset by the amount set in the _REL_xxx.xxx$ command. In the current example, the range for a 330 ps device changes from 0 ~ 330 ps to –50 ~ 280 ps. Subsequent delay settings can be chosen within this range.

Query command descriptions:

The query commands allow the user to determine the current settings and status of the MDL. There are corresponding query commands for all control commands.

Notes:
  (1) _REDABS_$ returns the current position. It can be used either while the MDL is in a static position or during a scan.
  (2) Speed query: While the speed setting command _SPD_x$ sets the speed in terms of speed settings 0 to 9, the corresponding query command _REDSPD_$ does not return the speed setting code (0 to 9). Instead, it returns the steady-state speed in units of ps/s. For example, if the speed setting is 6, _REDSPD_$ will return SPD:32PS/S for a 330 or 560 ps model, and SPD:64PS/S for a 1120ps model.

Warning:

When using a relative origin, please make sure that the delay value setting is within the allowed range (i.e. the MDL's original range shifted by the relative origin position).

Section 5. Technical Support:

General Photonics is committed to high quality standards and customer satisfaction. For any questions regarding the quality and use of the MDL-002, 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. General Photonics can also be contacted by mail at:

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