



# OZ Optics

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## OPTICAL DELAY LINES

### Features:

- Low loss
- Sub-picosecond resolution
- Wide wavelength range
- Over 300 psec delay range
- Polarization insensitive
- Singlemode and polarization maintaining fiber versions
- Electrically controlled versions available
- **New miniature style version**

### Applications:

- PMD compensation in high speed communications networks
- Interferometric sensors
- Coherent telecommunications
- Spectrum analyzers

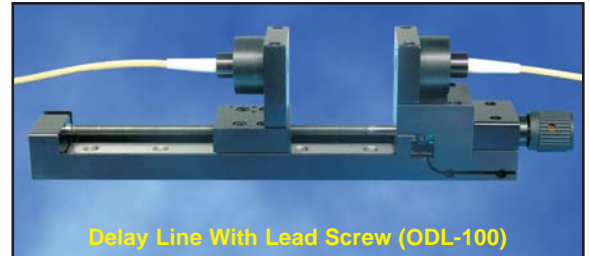
### Product Description:

Fiber Optic Delay Lines (ODL) consist of an input and output fiber collimator to project the light into free space and collect it again into a fiber. The distance the light travels in free space is precisely controlled, either by controlling the separation between the input and output optics, or by reflecting the light off a movable reflector. In either case, by varying the distance the light travels, one can control the delay time through the device.

Delay lines are offered using singlemode, multimode or Polarization Maintaining (PM) fibers. In general, OZ Optics uses polarization maintaining fibers based on the PANDA fiber structure when building polarization maintaining components and patchcords. However OZ Optics can construct devices using other PM fiber structures. We do carry some alternative fiber types in stock, so please contact our sales department for availability. If necessary, we are willing to use customer supplied fibers to build devices.

Delay lines are offered in both manual or electrically controlled versions. Manual delay lines utilize either a lead screw or a micrometer to adjust the spacing. Electrically controlled versions utilize a servo motor with encoders to monitor the motion. With this device submicron resolution ( $<0.003$  ps) is achieved. The delay line is easily controlled by a computer via an RS-232 interface or manually using some simple TTL input signals. These devices are calibrated to provide the delay in picoseconds. Home and end position sensors prevent accidental damage to the device.

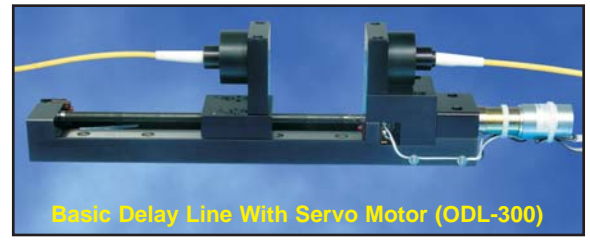
A new, miniature style delay line provides up to 13 picoseconds delay in a miniature package. The unit takes up little more space than an ordinary patchcord connection, and is easily adjustable and lockable.



Delay Line With Lead Screw (ODL-100)



Delay Line With Micrometer (ODL-200)



Basic Delay Line With Servo Motor (ODL-300)



Reflector Style Delay Line With Lead Screw (ODL-600)



Electrically Controlled Delay Line (ODL-650)



Miniature Delay Line (ODL-700)

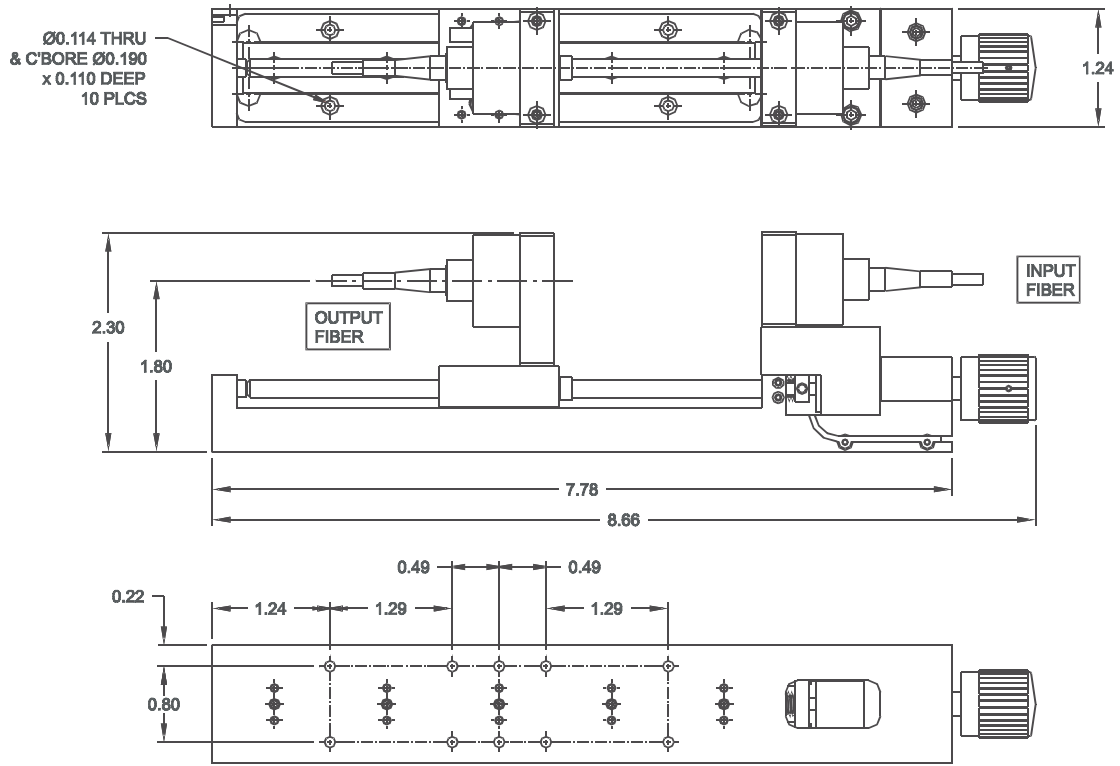


Figure 1: Dimensions of ODL-100 Model

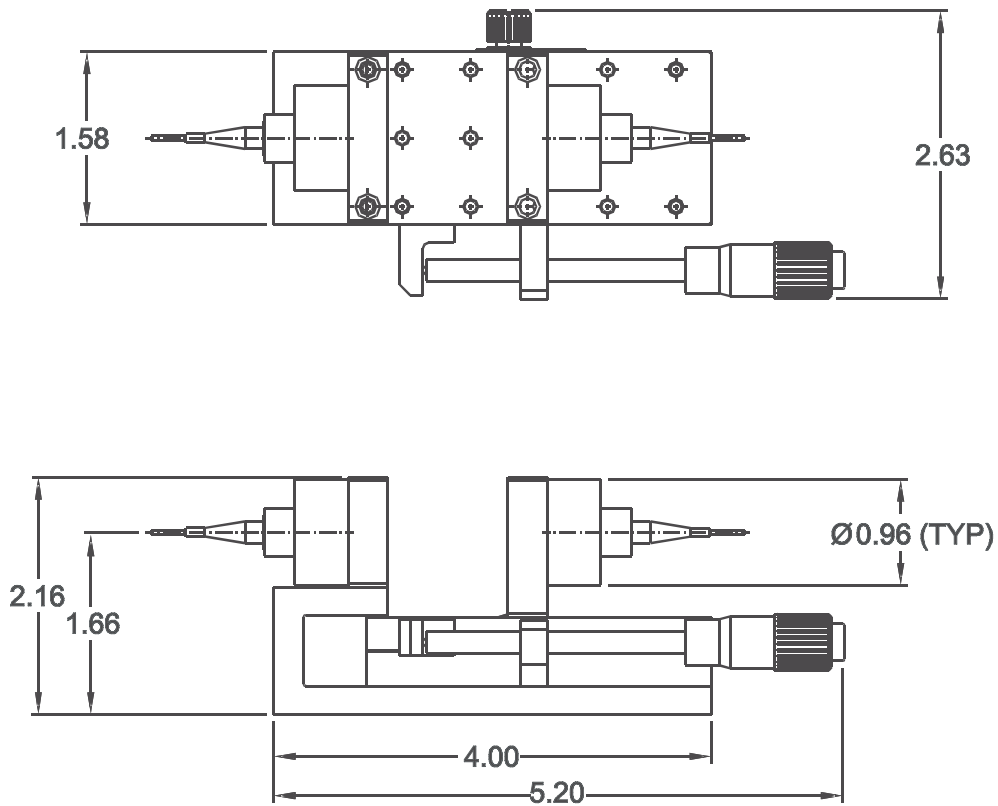


Figure 2: Dimensions of ODL-200 Model

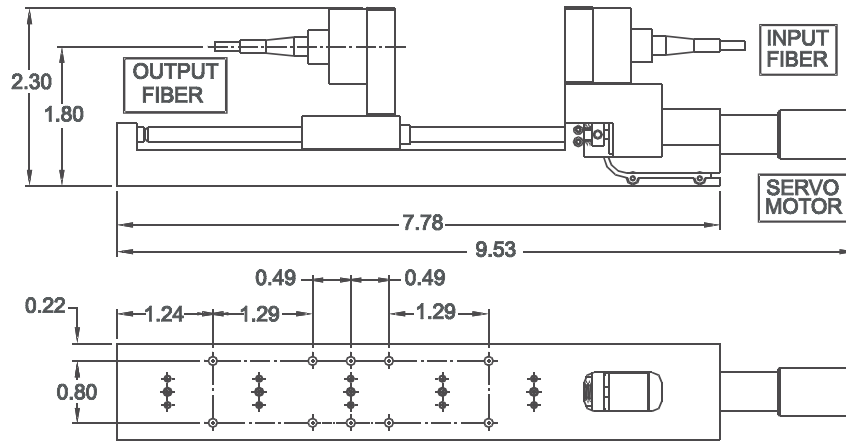
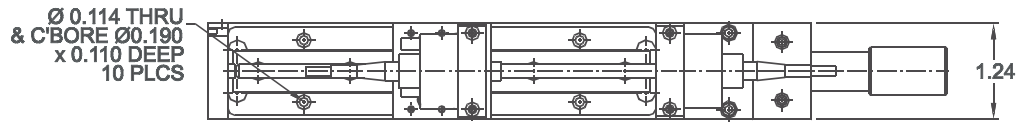


Figure 3: Dimensions of ODL-300 Model

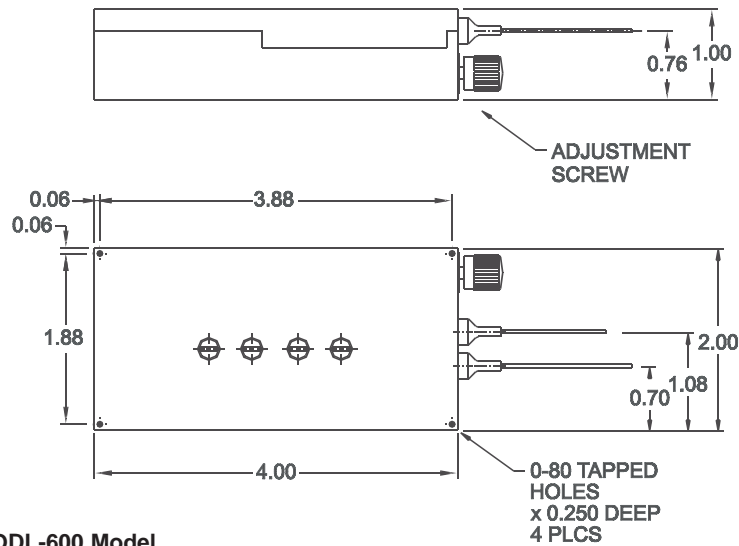


Figure 4: Dimensions of ODL-600 Model

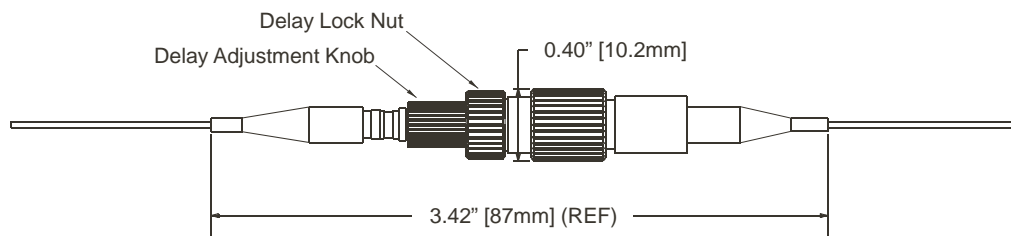


Figure 5: Dimensions of ODL-700 Model

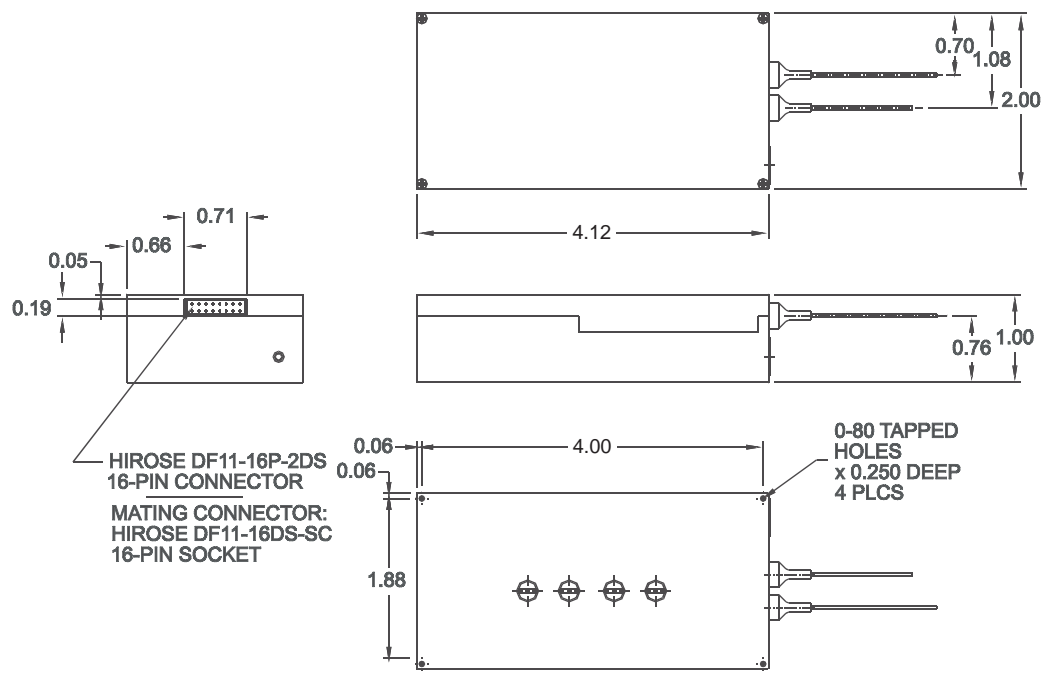


Figure 6: Dimensions of ODL-650 Model

#### Ordering Information For Standard Parts:

Bar Code	Part Number	Description
8457	ODL-100-11-1550-9/125-S-40-3S3S-3-1	Variable Fiber Optic Delay Line for 1550nm, with manual lead screw and 40dB return loss. Pigtails are 1 meter long, 3mm OD PVC cabled 9/125 SM fibers, Super FC/PC connectors.
9432	ODL-100-11-1550-9/125-S-60-3A3A-3-1	Variable Fiber Optic Delay Line for 1550nm, with manual lead screw and 60dB return loss. Pigtails are 1 meter long, 3mm OD PVC cabled 9/125 SM fibers, FC/APC connectors.
12823	ODL-100-11-1550-9/125-S-60-XX-1-1	Variable Fiber Optic Delay Line for 1550nm, with manual lead screw and 60dB return loss. Pigtails are 1 meter long, 0.9mm OD tight buffered 9/125 SM fibers, no connectors.
13753	ODL-100-11-1550-8/125-P-40-3S3S-3-1	Variable Fiber Optic Delay Line for 1550nm, with manual lead screw and 40dB return loss. Pigtails are 1 meter long, 3mm OD PVC cabled 8/125 PM fibers, Super FC/PC connectors.
13421	ODL-100-11-1550-8/125-P-60-3A3A-3-1	Variable Fiber Optic Delay Line for 1550nm, with manual lead screw and 60dB return loss. Pigtails are 1 meter long, 3mm OD PVC cabled 8/125 PM fibers, FC/APC connectors.
8375	ODL-200-11-1550-9/125-S-40-3S3S-3-1	Variable Fiber Optic Delay Line for 1550nm, with manual micrometer and 40dB return loss. Pigtails are 1 meter long, 3mm OD PVC cabled 9/125 SM fibers, Super FC/PC connectors.
8933	ODL-200-11-1550-8/125-P-40-3S3S-3-1	Variable Fiber Optic Delay Line for 1550nm, with manual micrometer and 40dB return loss. Pigtails are 1 meter long, 3mm OD PVC cabled 8/125 PM fibers, Super FC/PC connectors.
10468	ODL-200-11-1550-8/125-P-60-3A3A-1-1	Variable Fiber Optic Delay Line for 1550nm, with manual micrometer and 60dB return loss. Pigtails are 1 meter long, 8/125 PM fibers, protected with 0.9mm OD hytrel tubing, and with FC/APC connectors.
13754	ODL-600-11-1550-9/125-S-60-3A3A-1-1	Reflector Style Variable Fiber Optic Delay Line for 1550nm, with manual lead screw and 60dB return loss. Pigtails are 1 meter long, 0.9mm OD tight buffered 9/125 SM fibers, FC/APC connectors.
13755	ODL-600-11-1550-8/125-P-60-3A3A-1-1	Reflector Style Variable Fiber Optic Delay Line for 1550nm, with manual lead screw and 60dB return loss. Pigtails are 1 meter long, 8/125 PM fibers, protected with 0.9mm OD hytrel tubing, and with FC/APC connectors.
13756	ODL-650-11-1550-9/125-S-60-3A3A-1-1-MC/RS232	Electrically Controlled Reflector Style Variable Fiber Optic Delay Line for 1550nm, with 60dB return loss. Pigtails are 1 meter long, 0.9mm OD tight buffered 9/125 SM fibers, FC/APC connectors, RS232 Interface
13757	ODL-650-11-1550-8/125-P-60-3A3A-1-1- MC/RS232	Electrically Controlled Reflector Style Variable Fiber Optic Delay Line for 1550nm, with 60dB return loss. Pigtails are 1 meter long, 8/125 PM fibers, protected with 0.9mm OD hytrel tubing, and with FC/APC connectors, RS232 Interface

## Ordering Examples For Standard Parts:

A customer is building a polarization mode dispersion compensator using a polarization maintaining electrically controlled delay line and computer interface. The delays in their system are 50 picoseconds or less. His system is sensitive to both insertion losses and return losses, so a low return loss device is needed.

Bar Code	Part Number	Description
13757	ODL-650-11-1550-8/125-P-60-3A3A-1-1-MC/RS232	Electrically Controlled Reflector Style Variable Fiber Optic Delay Line for 1550nm, with 60dB return loss. Pigtailed are 1 meter long, 8/125 PM fibers, protected with 0.9mm OD hytrel tubing, and with FC/APC connectors, RS232 Interface

## Standard Product Specifications:

Model	ODL-100	ODL-200	ODL-300	ODL-600	ODL-650	ODL-700
Travel Mechanism	Manual Lead Screw	Manual Micrometer	Servo Motor	Manual Lead Screw, mirror	Servo-motor, Mirror	Manual Adjustment Screw
Travel Range (mm)	100	25	100	25x2=50mm	25x2=50mm <sup>4</sup>	4
Resolution (microns) <sup>1</sup>	318 per turn	10 per division	1.4 per encoder pulse	635 per turn	0.8 per encoder pulse	210 per turn
Delay Range (psec)	330	83	330	167	167 <sup>4</sup>	13
Delay Resolution (psec) <sup>1</sup>	1 psec per turn	0.033 psec per division	0.0047 psec per encoder pulse	2 psec per turn	0.0028 psec per encoder pulse	0.67 psec per turn
Max. Insertion Loss (dB) <sup>2,3</sup>	<1.5	<1.0	<1.5	<1.0	<1.0	<1.5
Loss Variation over travel range (typical)(dB) <sup>3</sup>	0.5	0.1	0.5	0.15	0.15	0.5
Size (LxWxH) (mm)	230x30x60	145x60x55	242x30x60	102x51x25	105x51x25	87x10.2 (Diameter)
Return Loss (dB)	-35 for multimode fiber versions, -40, -50, -60 for singlemode fiber versions					-50
Speed (mm/sec)	N/A	N/A	2.9	N/A	1	N/A
Input Supply Voltage	N/A	N/A	6V to 8V	N/A	6V to 8V	N/A
Input Supply Current	N/A	N/A	400mA	N/A	180mA	N/A

<sup>1</sup>Theoretical, based on thread pitch and motor/encoder resolution. The MC/RS232 versions of the ODL-300 and ODL-650 can generate two counts per encoder pulse, effectively doubling the resolution.

<sup>2</sup>Includes variation of insertion loss over the entire travel range.

<sup>3</sup>For 1550nm wavelengths singlemode or PM fibers, at room temperature.

<sup>4</sup>A custom unit, with 110mm of travel, 350 psec delay range is also available.

## Environmental Specification for ODL-650 Systems:

Operating Temperature (°C)	-10°C to +60°C
Temperature Dependent Loss (Measured over the Entire Scanning Range)	<1dB from +10°C to +40°C <2dB from -10°C to +60°C
Operating Lifetime	Over 5000 hours, continuous operation

## Ordering Information For Custom Parts:

OZ Optics welcomes the opportunity to provide custom designed products to meet your application needs. As with most manufacturers, customized products do take additional effort so please expect some differences in the pricing compared to our standard parts list. In particular, we will need additional time to prepare a comprehensive quotation, and lead times will be longer than normal. In most cases non-recurring engineering (NRE) charges, lot charges, and a 1 piece minimum order will be necessary. These points will be carefully explained in your quotation, so your decision will be as well informed as possible. We strongly recommend buying our standard products.

### Questionnaire For Custom Parts:

1. What Delay Range (in psec or mm) do you need?
2. What Resolution (in psec or mm) do you need?
3. Do you need a readout of the position?
4. Do you need electrical control?
5. Do you need computer control? What Interface will you use?
6. Do you intend to make your own drive circuit?
7. What wavelength will you be using?
8. What fiber type are you using? Singlemode, Multimode or Polarization Maintaining?
9. What is the worst acceptable return loss?
10. What kind of fiber connectors are you using?

## ODL-A-11-W-a/b-F-LB-XY-JD-L(-I)

**A** = Version:

- 100 = Standard Style, with lead screw
- 200 = Standard Style, with micrometer
- 300 = Standard Style, with DC servo motor
- 600 = Reflector Style, with lead screw
- 650 = Reflector Style, with Servo motor
- 700 = Miniature Style

**W** = Wavelength: Specify in nanometers  
(Example: 1550 for 1550nm)

**a/b** = Fiber core/cladding sizes, in microns,  
9/125 for 1300/1550nm SM fiber sizes  
8/125 for 1550nm PM fiber sizes  
See Tables 1 to 5 of the Standard Tables data  
sheet for other fiber sizes

**F** = Fiber type: M=Multimode  
S=Singlemode  
P=Polarization maintaining

**LB** = Backreflection level: 35, 40, 50, or 60dB  
60dB is available for 1300 and 1550nm only  
Multimode devices are only available with  
35dB

**I** = Interface (ODL-300 & 650 models only)  
MC/RS232 for Intelligent RS232 Interface  
with built-in manual TTL control lines  
PC for direct connections to the motor,  
encoder and limit switches (no driver).

**L** = Fiber length, in meters, on each side of  
the device  
Example: To order 1 meter of fiber at the  
input and 7 meters at the output, replace the  
L with 1,7

**JD** = Fiber Jacket type:  
1 = 900 micron OD hytel jacket  
3 = 3mm OD kevlar reinforced PVC  
cable  
See Table 7 of the Standard Tables for other  
jacket sizes

**X,Y** = Input & Output Connector Codes:  
X = No connector  
3S = Super NTT-FC/PC  
3U = Ultra NTT-FC/PC  
3A = Angled NTT-FC/PC  
8 = AT&T-ST  
SC = SC  
SCA = Angled SC  
LC = LC  
LCA = Angled LC  
MU = MU

### Ordering Examples For Custom Parts:

A customer building an interferometer needs a manual delay line for 1300nm, using singlemode fiber. He needs pigtails 1 meter long on one side, and 10 meters long on the other side, and does not need connectors. Because he is fusion splicing, he prefers uncabled fiber. While he does not require to read the exact delay, he does need as long a travel range as possible. Return losses do need to be as low as possible, to prevent additional interference effects.

Part Number	Description
ODL-100-11-1300-9/125-S-60-XX-1-1,10	Variable Fiber Optic Delay Line for 1300nm, with manual lead screw and 60dB return loss. Pigtails are 1 meter long on the input, 10 meters long on the output, 0.9mm OD tight buffered 9/125 SM fibers, no connectors.

### Frequently Asked Questions (FAQs):

**Q:** How do I convert travel in mm to delays in picoseconds?

**A:** The delay is equal to the distance divided by the speed of light in air. 1mm corresponds to 3.33psec of delay. Note that in the ODL-600 and ODL-650 models, the light travels the distance twice, so the delay is twice the motion of the optics.

**Q:** Is the minimum delay zero picoseconds?

**A:** No, there is a minimum delay, due to the minimum separation between the optics, and the length of the attached fibers. A one meter long fiber produces a 4.9nsec delay. The minimum separation of the optics induces between 30psec and 150psec delay, depending on the model. The delay range specified in the tables is for relative delay.

**Q:** Are the units calibrated?

**A:** The ODL-200 models have a micrometer, to give the direct readout of the motion, in mm. The ODL-300 with controller and ODL-650 also give a readout of the delay in picoseconds. The other models do not have any calibration. Note that these are relative readouts, not absolute (see the previous question).

**Q:** What are the advantages and disadvantages of the inline version versus the reflector style?

**A:** Generally the inline version gives the largest travel ranges versus the reflector style, and thus can produce the greatest delays. However the reflector style unit has the advantage that the fibers themselves do not move. This makes the reflector style the best choice for commercial applications as opposed to lab use.

**Q:** Do I need special software to run the ODL-300 or ODL-650 delay lines?

**A:** Both units are operated with simple text commands that can be sent via terminal programs such as Windows™ Hyperterminal™. Active X™ control and Labview™ driver, as well as a direct Windows interface program are also provided.

**Q:** What voltages and currents do the motor driven delay lines use?

**A:** The ODL-300 requires an input voltage between 6 to 8 Volts, and can draw up to 400mA of current when the motor is turning. The ODL-650 also requires 6 to 8 Volts, and can draw up to 180mA of current when operating. If necessary, the ODL-650 can be set up to work with a 5V supply voltage. However, that will limit the speed. If necessary, OZ Optics can provide a 12V version of the ODL-650 style delay line, which will accept supply voltages from 6V to 12.25V. This option will provide slightly greater speed. However it will consume more current than the standard model, and would have to be custom built.

## Application Notes:

**Example Application:** Polarization mode dispersion (PMD) is an important issue in the quest to build high speed (10GBs, 40GBs, and higher) communication networks. An input signal travelling along a single mode fiber normally has some distortion, due to polarization mode dispersion. The signal effectively has been split into two arbitrary, yet orthogonal polarizations, and one polarization is leading the other. A delay line is a crucial element in building compensators for PMD.

The figure below shows how to use a delay line to compensate for polarization modes dispersion. The light from the singlemode input is split into two using a polarizing beam splitter. A polarization controller installed just before the splitter is used to convert the arbitrary polarizations that the signal has been split into S and P polarization. The faster S polarization is routed through the delay line while the slower P polarization is sent straight into the combiner. The combined signals then reach the receiver. A control system monitors the quality of the signal at the receiver, and dynamically adjusts the polarization and the delay to get the two signals to match up again. Thus the PMD is the system can be corrected in real time.

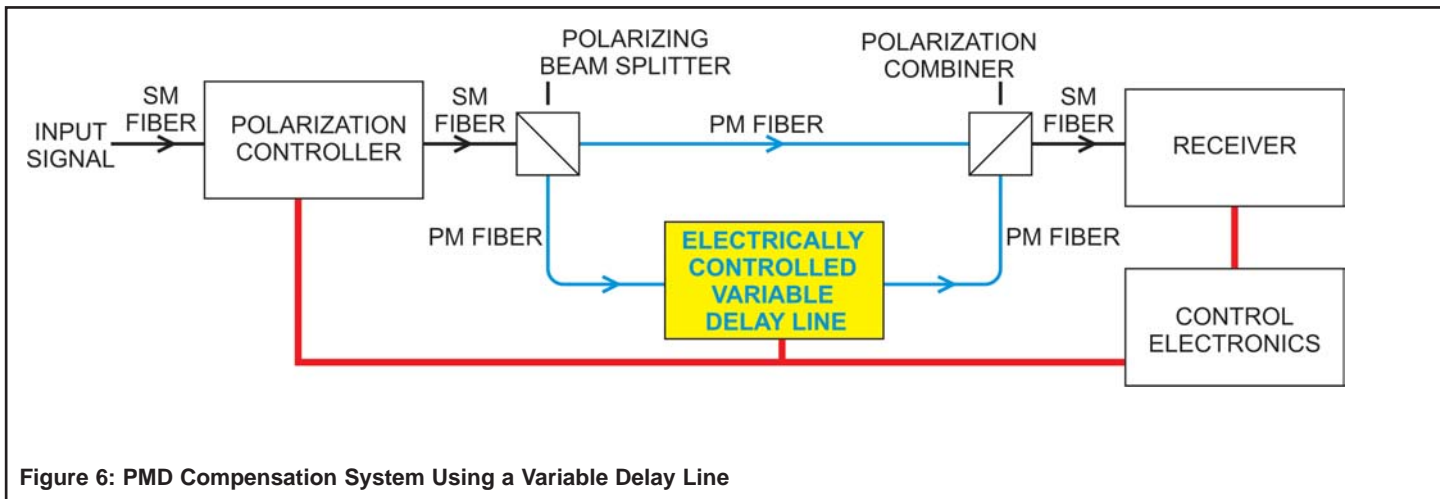


Figure 6: PMD Compensation System Using a Variable Delay Line

**Mounting:** The base of the delay lines have mounting holes for attachment to a rack or printed circuit board. For best results, the mounting surface should be rigid and free of vibration. Do not over-tighten the mounting screws and use screws that thread in no more than 2mm. Tightening the mounting screws too much will warp the base and potentially increase losses either temporarily or permanently

**Electrical Connections:** The ODL-650 unit has a Hirose DF11-16P-2DS16-pin connector. The pin designations are given below:

Pin	Name	Function	Comment
1	GND	Common Ground	
2	GND	Common Ground	
3	Select	Select TTL interface	For TTL interface, Input Active Low
4	Vin	Input DC supply voltage; (Min +6V Max +8V)	For ODL-300 Max 400mA For ODL-650 Max 180mA
5	Reverse	Move the motor in reverses	For TTL interface, Input Active Low
6	Rx	RS232- Receive input line	
7	Forward	Move the motor forward	For TTL interface, Input Active low
8	Tx	RS232- Transmit output line	
9	N/A	Do not connect	Factory use
10	N/A	Do not connect	Factory use
11	Reset	Hardware Reset line	Active Low, Min 100mS
12	N/A	Do not connect	Factory use
13	End	End limit switch	TTL output, active low
14	N/A	Do not connect	Factory use
15	Home	Home limit switch	TTL output, active low
16	N/A	Do not connect	Factory use

(1) (3) (5) (7) (9) (11) (13) (15)  
(2) (4) (6) (8) (10) (12) (14) (16)

Hirose 16-pin connector

When you first connect the wire harness to the 16-pin port, make sure that the power is off. Before turning the power on, make sure that your connections have the correct voltage levels and polarity (given above). If you have ordered an RS-232 interface, the harness comes terminated with a DB9 connector that plugs directly into your computer's serial port. For special applications, the harness is left without a connector and must be terminated by the user for the communications type of their choice.