

## How to Drive Optiphase Fiber Stretchers

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This application note discusses how to drive Optiphase PZ1, PZ2, and PZ3 piezoelectric based fiber stretchers using voltage based sources. Also provided are third party driver vendors.

## PZ1 series fiber stretchers

These fiber stretchers are provided with flying wire leads (which are not shown in the photograph of the PZ1 device on the product data sheet data sheet). Shown below is a photograph of the “back-side” of a PZ1 device, where the lead wires are clearly exposed.



The drive voltage is applied across the two wire leads. All of the critical factors relating to the electronic device parameters of the PZ1 series devices are found on the first page of the data sheet as shown below and explained in more detail.

SPECIFICATIONS		
	SMF-28 FIBER	PM FIBER
Operational Wavelengths	1260 to 1625 nm	1550 nm [C band]
Modulation Constant	1 radian/V @ 1300 nm [see charts]	Typical 0.2 rad/V
Frequency Range	dc to 80 KHz, 120 to 160 KHz, see charts	dc to 80 KHz, 120 to 160 KHz, see charts
Optical Loss	≤ 0.5 dB, typical 0.2 dB [excluding connectors]	≤ 0.5 dB, typical 0.2 dB [excluding connectors]
Maximum Voltage Range	± 500V [off resonance, 1000V P-P]	± 500V [off resonance, 1000V P-P]
Impedance [off resonance]	Capacitance 2 nF, floating	Capacitance 2 nF, floating
Wire Lead	18 inches, flying leads, #30	18 inches, flying leads, #30
Fiber Type	SMF-28e	Corning PM 15-U25A
Fiber Length	12.3 meters [includes 1 m leads]	Approximately 4.6 meters plus end to end
Fiber Wind	4-layer wind	The 1-layer design preserves a high polarization extinction ratio reducing the modulation constant

**PZ1 Maximum Voltage Range:** This is the maximum value one can drive the piezoelectric element without causing failure. Although this limit is extremely high, the majority of applications for PZ1 family devices only require only few volts or less. Such applications typically involve providing a dither signal for a fiber based interferometer.

When voltage requirements are only a few volts, there will be no need to implement specialized and costly high voltage drivers, and standard electronic components such as op-amps, laboratory function generators, DAQ cards, etc. may be used to drive PZ1 elements family.

### **PZ1 Impedance (off resonance) = Capacitance 2 nF, floating**

Piezoelectric elements when implemented at frequencies below its mechanical resonance have an electrical (load) impedance of that of a capacitor. For the PZ1 series, this capacitance is 2 nF (or 2000 pF, or 0.002 uF). This holds for a range from dc to 40 KHz. At higher frequencies, the impedances become more complex due to the mechanical resonance.

When voltage requirements for fiber stretch applications only a few volts, there will be no need to implement specialized and costly high voltage drivers, and standard electronic components such as op-amps, laboratory function generators, DAQ cards, etc. may be used to drive PZ1 elements family.

Floating impedance: The specification for the impedance of the PZ1 is “floating.” This means that the device has no-pre-determined ground or case connection reference, and if desired it can be driven without attaching any of the wire leads to ground. When electronic drives are configured to provide a ground, either of the two leads can be connected to ground, and is the designer’s choice.

### **PZ1 Wire Leads      18 inches flying leads**

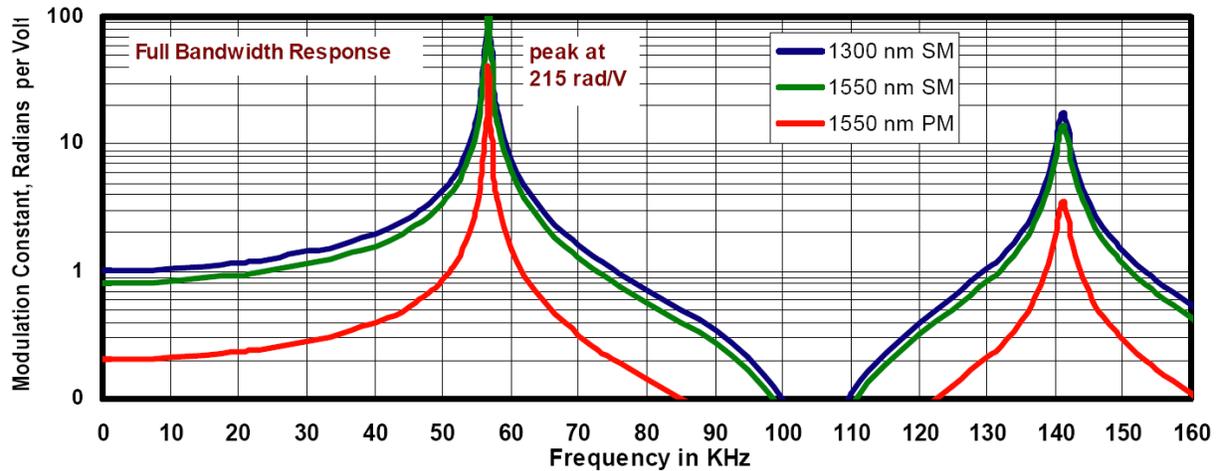
The electrical connection to the PZ1 series fiber stretchers are made through two wire leads. These are defined as floating leads, meaning that neither of them is tied to ground or the case of the PZ1 device. This allows the PZ1 device to be driven with a true-differential drive or a conventional “single-ended” drive, where one of the two leads may be connected to ground (or the drive signal common).

Reversal of the leads is also allowed. The effect here is reversal of the stretch direction with the applied voltage.

## PZ1 Full frequency Response

The response curve below is an excerpt from the PZ1 series data sheet showing the frequency response for PZ1 elements configured with SM and PM fibers. Note that past 40 KHz, the response is highly non-linear which follows the mechanical operation of the particular types of piezoelectric elements used in the PZ1 series design.

**PZ1 Modulation Constant Over Frequency**

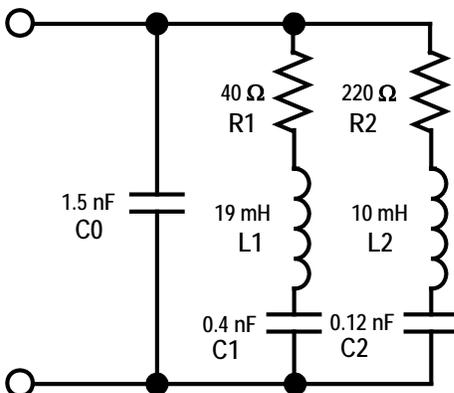


## Equivalent Circuit for driving PZ1 devices over the full frequency range

This is complex high order circuit, as shown below. Please note the following

1. This is an approximate circuit.
2. This circuit represents the load impedance of the PZ1 for frequencies up to 160 KHz. It does not represent the modulation constant transfer function (above).
3. Low frequency impedance (out to 30 KHz) is  $C0 + C1 + C2$  (2 nF)

**PZ1 Series Equivalent Impedance**  
*approximate*



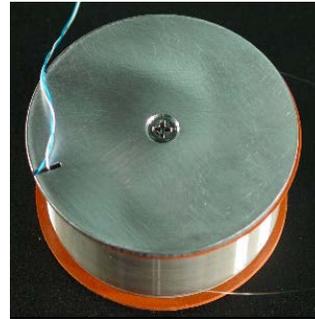
Low Freq: =  $C0 + C1 + C2$

First Resonance:  $C1 \& L1$

Second Resonance:  $C2 \& L2$

## PZ2 / PZ3 Series Fiber Stretchers

PZ2 / PZ3 Fiber Stretchers are available with SM, commercial PM [PANDA or Bowtie] or RC [SM Reduced Cladding] fiber types. Fiber stretchers with connectors are housed in an enclosure, making set-up and use quick and easy. They are also available as bare devices with a mount kit. These fiber stretchers are unique in that they do not require proprietary drivers. For most low voltage applications ( $< \pm 15V$ ) our stretchers can be driven by standard electronics such as signal generators, op-amps or other laboratory equipment without modification.



**PZ2/PZ3 Maximum Voltage Range is +/- 400V:** This is the maximum value one can drive the piezoelectric element without causing failure. Although this limit is extremely high, the majority of applications for PZ2/ PZ3 family devices only require only few volts or less. Such applications typically involve providing a dither signal for a fiber based interferometer.

When voltage requirements are only a few volts, there will be no need to implement specialized and costly high voltage drivers, and standard electronic components such as op-amps, laboratory function generators, DAQ cards, etc. may be used to drive PZ1 elements family.

### **PZ2/PZ3 Impedance (off resonance) = Capacitance 92 nF / 42nF, floating**

Piezoelectric elements when implemented at frequencies below its mechanical resonance have an electrical (load) impedance of that of a capacitor. For the PZ2/PZ3 series, this capacitance is 92 nF for the PZ2 and 42 nF for the PZ3. This holds for a range from dc to 15 KHz. At higher frequencies, the impedances become more complex due to mechanical resonances.

Floating impedance: The specification for the impedance of the PZ2/PZ3 is “floating.” This means that the device has no-pre-determined ground or case connection reference, and if desired it can be driven without attaching any of the wire leads to ground. When electronic drives are configured to provide a ground, either of the two leads can be connected to ground, and is the designer’s choice.

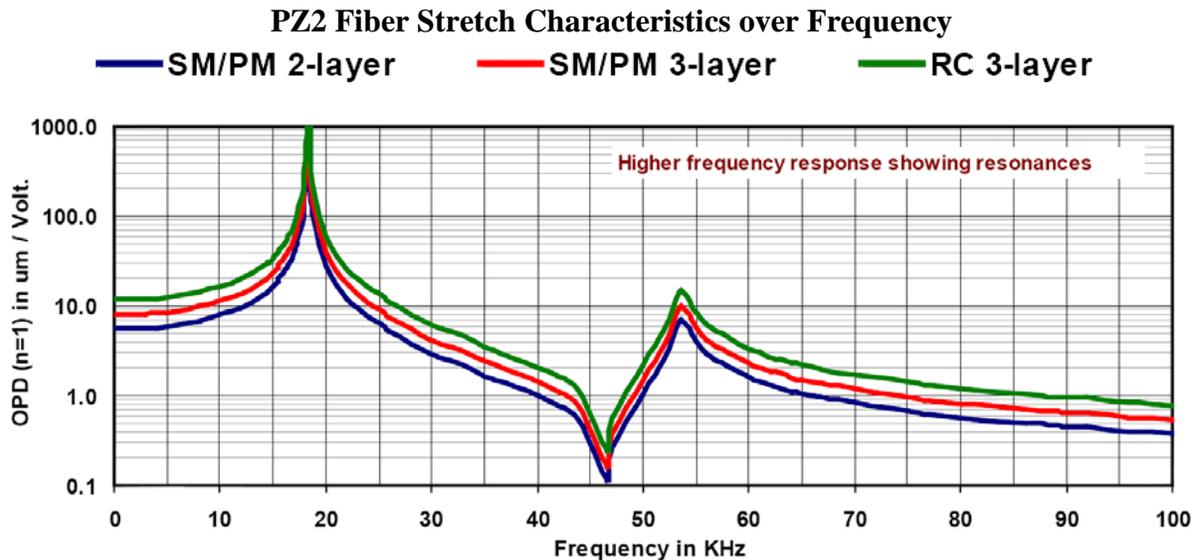
### **PZ2/PZ3 electrical Interfaces**

The electrical connection to the PZ2 / PZ3 series fiber stretchers are made through a floating wire pair or a floating BNC (enclosed mount). These are defined as floating leads, meaning that neither of them is tied to ground or the case of the PZ1 device. This allows the PZ1 device to be driven with a true-differential drive or a conventional “single-ended” drive, where one of the two leads may be connected to ground (or the drive signal common).

Reversal of the leads is also allowed. The effect here is reversal of the stretch direction with the applied voltage.

## PZ2 Full frequency Response

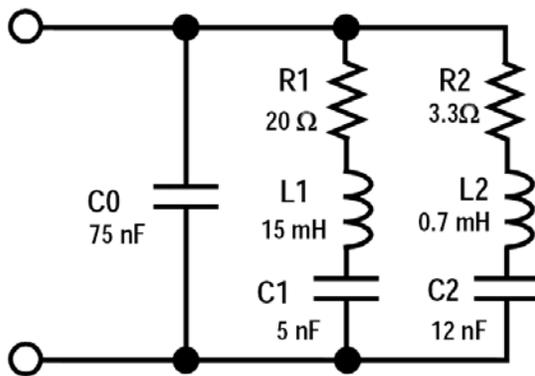
The response curve below is an excerpt from the PZ2 series data sheet showing the frequency response for PZ2 elements configured with SM and PM fibers. Note that past 15 KHz, the response is highly non-linear which follows the mechanical operation of the particular types of piezoelectric elements used in the PZ2 series design.



## Equivalent Circuit for driving PZ2 devices over the full frequency range

This is complex high order circuit, as shown below. Please note the following

1. This is an approximate circuit.
2. This circuit represents the load impedance of the PZ2 for frequencies up to 100 KHz. It does not represent the modulation constant transfer function (above).
3. Low frequency impedance (out to 15 KHz) is  $C_0 + C_1 + C_2$  (92 nF)

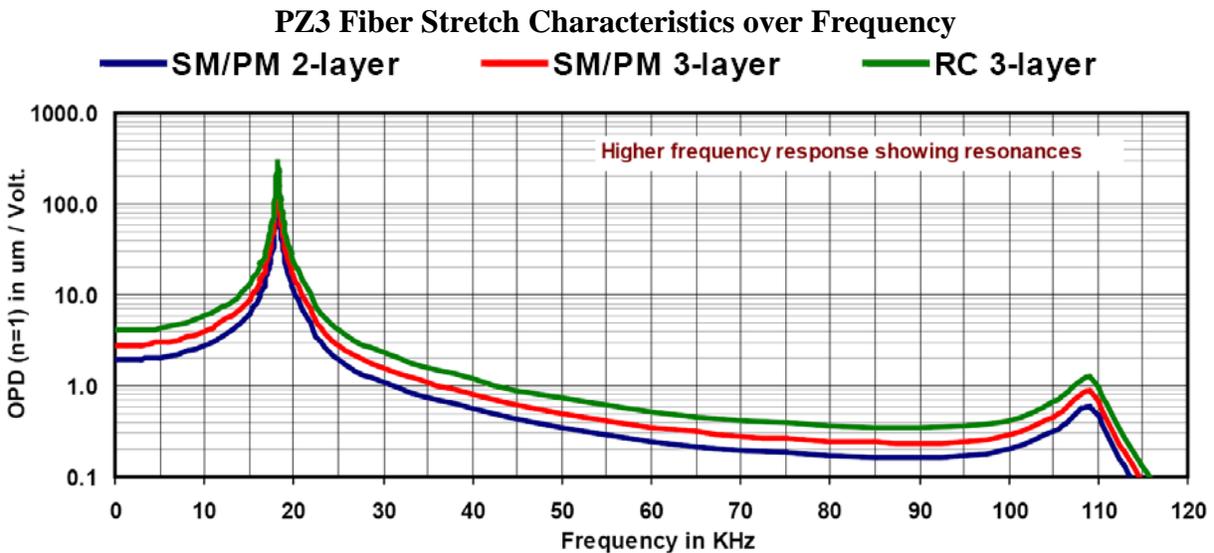


First Resonance (18 KHz) defined by R1, C1, L1

Second Resonance (110 KHz) defined by R2, C2, L2

## PZ3 Full frequency Response

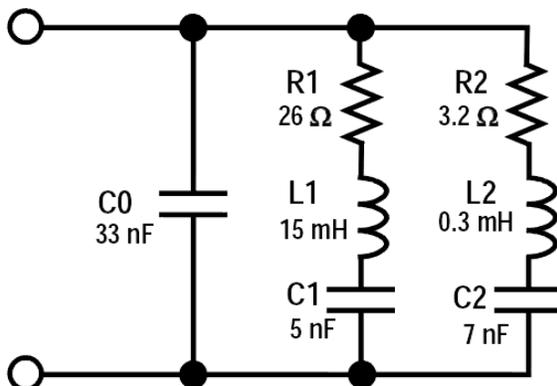
The response curve below is an excerpt from the PZ3 series data sheet showing the frequency response for PZ3 elements configured with SM and PM fibers. Note that past 15 KHz, the response is highly non-linear which follows the mechanical operation of the particular types of piezoelectric elements used in the PZ3 series design.



## Equivalent Circuit for driving PZ3 devices over the full frequency range

This is complex high order circuit, as shown below. Please note the following

1. This is an approximate circuit.
2. This circuit represents the load impedance of the PZ3 for frequencies up to 120 KHz. It does not represent the modulation constant transfer function (above).
3. Low frequency impedance (out to 15 KHz) is  $C_0 + C_1 + C_2$  (42 nF)



First Resonance (18 KHz) defined by R1, C1, L1

Second Resonance (110 KHz) defined by R2, C2, L2

## PIEZO DRIVERS

Optiphase does not manufacture PZT drivers. Below are some commercially available high voltage amplifiers suitable for driving Optiphase, Inc. piezoelectric Fiber Stretchers. Suitability to PZ1, PZ2, or PZ3 needs to be determined by the customer related to their specific application needs.

Vendors who make drivers for piezo elements which may be suitable for your application are listed below.

### TREK, INC.

11601 Maple Ridge Road  
Medina, New York 14103 USA  
(585) 798-3140 ; Fax: (585) 798-3106  
Website: <http://www.trekinc.com/>  
Link to amps: [http://www.trekinc.com/products/amp\\_piezo.asp](http://www.trekinc.com/products/amp_piezo.asp)

### PIEZO SYSTEMS, INC.

65 Tower Office Park  
Woburn, MA 01801 USA  
Tel: 781-933-4850 Fax: 781-933-4743  
Website: <http://www.piezo.com/>  
Link to Amps: <http://www.piezo.com/prodelect0nav.html>

### PiezoDrive

Newcastle Innovation Limited  
Industry Development Centre  
University Drive  
CALLAGHAN, NSW 2308 AUSTRALIA  
Website: <http://www.piezodrive.com>  
Link to Amplifiers: <http://www.piezodrive.com/products.html>

### Noliac (various sales locations)

Website: [http://www.noliac.com/Piezo\\_drivers-8521.aspx](http://www.noliac.com/Piezo_drivers-8521.aspx)

### AA Lab Systems

U.S.A office:  
9 Blossom Drive, Kennett Square, PA19348  
Tel: (302) 478-2881, Fax: (610) 444-5544  
Website: <http://www.lab-systems.com/>  
Link to Amps: <http://www.lab-systems.com/products/amplifier/amplifier.html>

## Other Possibilities for HV drive

TEGAM (HV amps, most with low current however)

<http://www.tegam.com/category.asp?categoryID=27>

POWER AMPLIFIERS <a href="#">Request A Catalog</a> <a href="#">30 Day Trial Offer</a>						
1	Viewing 1-6 of 6 Total					
	Product	Output Voltage	Output Current	Bandwidth	Channels	Price
	2340 <a href="#">View details</a>	400 Vp-p	40 mA	DC to 2 MHz	1	\$2,495 <a href="#">QUOTE</a>
	2340S-100-2K <a href="#">View details</a>	400 Vp-p	40 mA	DC to 2 MHz	1	\$2,495 <a href="#">QUOTE</a>
	2348 <a href="#">View details</a>	50 Vp-p	750 mA	DC to 2 MHz	1	\$2,995 <a href="#">QUOTE</a>
	2350 <a href="#">View details</a>	400 Vp-p	40 mA	DC to 2 MHz	2	\$3,495 <a href="#">QUOTE</a>
	2350S-020-2K <a href="#">View details</a>	400 Vp-p	40 mA	DC to 2 MHz	2	\$3,495 <a href="#">QUOTE</a>
	2375 <a href="#">View details</a>	150 Vp-p	20 mA	DC to 5 kHz	4	\$6,495 <a href="#">QUOTE</a>

## Design your own Driver using HV OP-Amps

### Apex Microtechnology(Cirrus Logic)

5980 N. Shannon Road

Tucson, AZ 85741 USA

Phone: 520.690.8600 Fax: 520.888.3329

Website: <http://www.apexanalog.com/>

App note: [http://www.apexanalog.com/wp-content/uploads/2012/08/Apex\\_AN44U\\_2.pdf](http://www.apexanalog.com/wp-content/uploads/2012/08/Apex_AN44U_2.pdf)