Shear Piezoelectric Stack, ±200 V, 1.3 µm, Two End Plates, Two Copper Leads

PL5FBP3

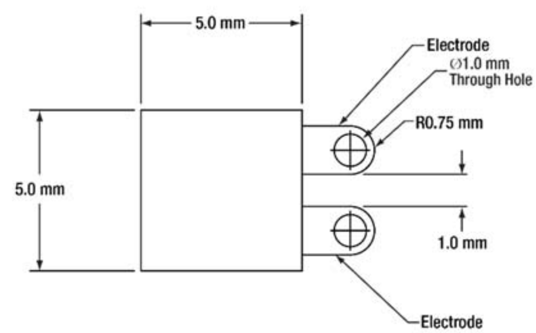
Description

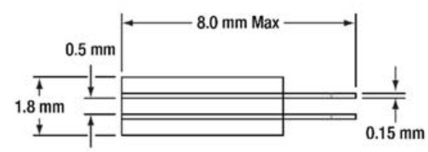
The PL5FBP3 is a shear piezoelectric chip functionalized with copper foils and end plates attached to the top and bottom surfaces via epoxy. Leads on the copper foils assist with making electrical connections to the chip, and the end plates facilitate the mounting. The PL5FBP3 provides a maximum lateral displacement of 1.3 µm ± 20% when driven from -200 V to 200 V. The green bar marking one side surface indicates the direction of lateral motion when a voltage is applied across the electrodes. The surface with the electrode that is positively biased translates over the side marked by the green indicator.

Specifications

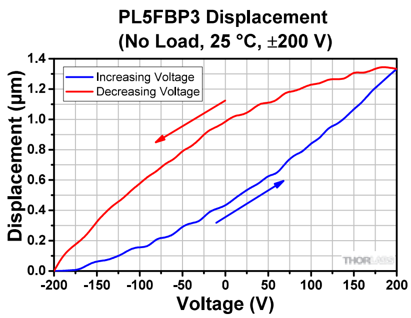
PL5FBP3[a]	
Drive Voltage Range	-200 V to 200 V
Displacement (Free Stroke)[b]	1.3 µm ± 20%
Hysteresis	<40% (See Graph Below)
Max Shear Load[c]	50 N (11.3 lbs)
Max Axial Load[d]	1000 N (225 lbs)
Resonance Frequency	1900 kHz (No Load)
Impedance at Resonance Frequency	20 Ω
Dissipation Factor	0.02 ± 15%
Capacitance	1.6 nF ± 15%
Operating Temperature	-25 to 130 °C
Curie Temperature	230 °C
External Electrodes	Chemically deposited Au on Ni with Copper Foil Leads
Dimensions	5.0 mm x 8.0 mm x 1.8 mm
Dimensional Tolerance	±0.1 mm

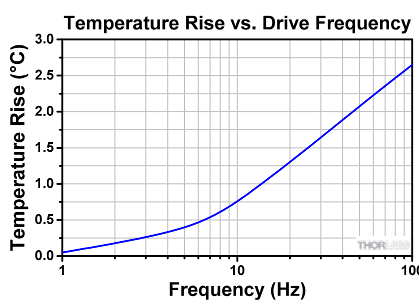
a. All specifications are quoted at 25 °C, unless otherwise stated.
b. With no Load and over the Full Driving Voltage Range
c. Max Allowed Load Applied in the Direction Normal to the Plane of the End Plates, towards the Piezo Element
d. Max Allowed Load Applied in the Lateral Direction, Resisting Lateral Displacement





Typical Performance Plots





The temperature increase was measured after a sine wave driving voltage was applied, under conditions of no load, at the specified frequency for 10 minutes. Driving voltage amplitude extrema were -200 V and 200 V.

Shear Piezo Operation

Electrical Considerations

The PL5FBP3 consists of a single PL5FB shear piezoelectric chip, with copper foils and alumina end plates bonded to the top and bottom surfaces via epoxy. Each copper foil is in electrical contact with a different gold electrode, which are located on the top and bottom surfaces of the chip. For easy access, the foils have copper leads extending beyond the footprint of the piezo chip. When a voltage (±200 V maximum) is applied across these electrodes, a shear strain is created in the piezo material. The deformation induced by the shear strain causes two parallel side surfaces to tilt in unison, which causes the top surface to translate laterally with respect to the bottom surface.

This lateral motion, which is characteristic of shear piezos, is a consequence of the applied electric field (E) being perpendicular the polarization (P) of the piezo material. The relationships among the polarization direction, the applied electric field, and the direction of the lateral displacement of the chip's surface is shown in Figure 1. When the electric field is applied so that the electrode on the top surface is positively biased, the top surface will translate over the side of the chip marked by the green bar; the top surface will move laterally in the direction indicated by the white arrow. Please note that using one 5 mm x 5 mm surface of the chip to translate a load requires the opposite surface to be mounted to a fixed surface. See the *Interfacing a Piezoelectric Element with a Load or Mating Surface* section below for more details.

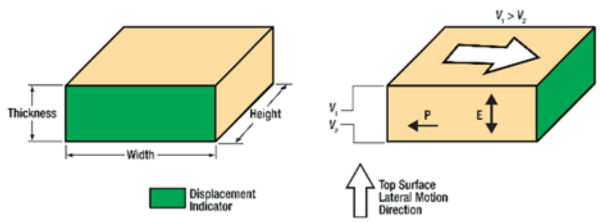


Figure 1 Shear piezos provide displacement in the lateral direction indicated by the white arrow. The positively-biased surface electrode is laterally displaced towards the side marked with the green bar. A diagram of the PL5FB Piezo is shown.

These shear piezo chips have identical electrodes on their top and bottom surfaces, and the induced shear strain is symmetrical. Therefore, these chips can be driven by bipolar symmetrical electrical supplies. We recommend Thorlabs' HVA200 High-Voltage Amplifier.

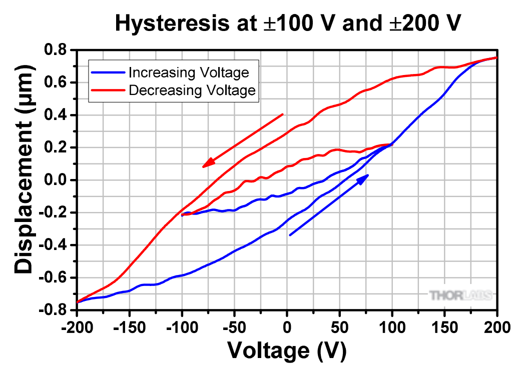


Figure 2 The stroke for a ±100 V driving voltage range is approximately 30% that for a ±200 V range. Relative hysteresis under both operating conditions is also shown.

Hysteresis and Lateral Displacement

The displacement of a piezo chip or stack depends on the instantaneous driving voltage as well as how the element was driven in the past. This hysteresis is a consequence of the intrinsic properties of the piezo element. The previous section's Displacement vs. Voltage graph shows the hysteresis exhibited the chip when the bottom surface is fixed and the driving voltage is varied from -200 V to 200 V. Hysteresis from the shear strain of piezo ceramics can be up to 40%, which is greater than that from the axial strain of piezos. This must be considered when driving shear piezo devices.

Reducing the driving voltage range from ±200 V to ±100 V decreases the total displacement to approximately 30% of the rated stroke. This is illustrated by the plot shown above.

Adding an Electrical Connection

Electrical connections to the external electrodes on the PL5FBP3 can be achieved by using mechanical contacts, soldering, gluing with electrically conductive glues, or wire bonding. The PL5FBP3 provides integrated copper foils with copper leads for electrical connections. If wire leads must be attached to the gold electrodes on the surface of the chip, a soldering temperature no higher than 370 °C (700 °F) should be used, and heat should be applied to each electrode for a maximum of 2 seconds. Solder the lead to the middle of the electrode (where the through hole is) and keep the region over which heat is applied as small as possible.

Caution: After driving, the piezo is fully charged. Directly connecting positive and negative electrodes has the risk of electric discharge, spark, and failure. A >1 kΩ resistor placed between the positive and negative electrodes is recommended to release the charge.

Interfacing the PL5FBP3 with a Load

As the top and bottom surfaces of shear piezo chips move relative to one another, one surface must be mounted to a fixed substrate to use the chip as an actuator. The shear piezo chips can be mounted either by mechanical clamping or gluing. The design of the PL5FBP3 includes inactive ceramic end plates bonded to and covering the copper foils. The end plates, which have a Mohs hardness of 9 and are also available separately (Item # PKFEP4), both facilitate mounting and help electrically insulate the surface electrodes. A polyimide film can also be used as an electrical insulator. The mating surfaces of both the actuator and the load or surface must be highly flat and smooth with surface roughness less than 10 µm and a Mohs hardness higher than 6. Ensure good parallelism between the two mating surfaces before applying pressure. The load should be centered on and applied uniformly over as much of the PN5FC3's mounting surface as possible. The direction of the loading should be normal to the mounting surface of the piezo.

When mechanically clamping the piezo in place, the axial stress must be well controlled. Too little pressure can lead to slippage whereas too much pressure can damage the ceramic. With the appropriate contact surface and in the case of low shear force, a pressure of 1 to 3 MPa is recommended. The stiffness of the loading mechanism in the actuation direction should be as low as possible in order not to hinder the movement of the piezo actuator. Correct and incorrect examples are provided below.

When gluing the PN5FC3 to a mounting surface or load, we recommend using an epoxy that cures at a temperature lower than 80 °C (176 °F). Recommended epoxies include Thorlabs' 353NDPK, TS10, or G14250 as well as Loctite® Hysol® 9340. Loads should be mounted only to the faces of the piezoelectric chip that translate. Mounting a load to a non-translating face may lead to the mechanical failure of the actuator.

Storage and Usage Advisories

- Do not store the device at temperatures above 80 °C.
- Do not store the device in humid environments. Relative humidity (RH) should be <40%.
- Do not immerse the device in organic solvents.
- Do not use the device around combustible gasses or liquids.