

# Wiring Guidelines

We recognize the need to perform FEA and modeling to predict and design a piezoelectric transducer. This article provides resources on our material properties.

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## Attaching Leads to Bare Piezo

Piezoceramic electrodes will be either fired silver or nickel. Silver electrodes are flat white in color while nickel electrodes are grey. Electrical connections are usually made to these electrodes by soldering, but one may also use conductive adhesive, or clips to attach wires. Soldering materials in our kit (<https://piezo-systems.myshopify.com/collections/kits/products/solder-flux-kit>) are for soldering to nickel electrodes unless specifically requested otherwise. Silver electrodes are not recommended for high electric field DC applications where the silver is likely to migrate and bridge the two electrodes. It is often used in AC applications. Silver used as an electrode is in the form of flakes suspended in a glass frit. It is generally screened onto the ceramic and fired. The glass makes the bond between the ceramic and the silver particles. Silver is soluble in tin and a silver loaded solder should be used to prevent scavenging of silver in the electrode. Nickel has good corrosion resistance and is a good choice for both AC and DC applications. It can usually be soldered to easily with

tin/lead solder. Electroless nickel, used for plating piezoceramic, contains phosphor. Sometimes the phosphor content in a plating run can make it hard to solder. Vacuum deposited nickel electrodes are usually very thin, making soldering tricky.

Choice of the correct flux (to remove surface oxidation) makes soldering to electrode surfaces easy even under adverse conditions.

A wire is attached to the center shim if the element is used in parallel operation. Generally, the center shim layer of a 2-Layer piezoelectric bending elements is either .004" (.1mm) thick brass or stainless steel. Shims are soldered to in the same way as the nickel electrode.

## Tools & Materials for Soldering

- Soldering iron set ~ 660°-650° F
- 60 Sn / 40 Pb Solder
- Supersafe # 67 DSA Liquid Flux
- Wires (preferably #32 gauge or smaller)
- Pencil eraser and paper clip

## Procedure for Soldering

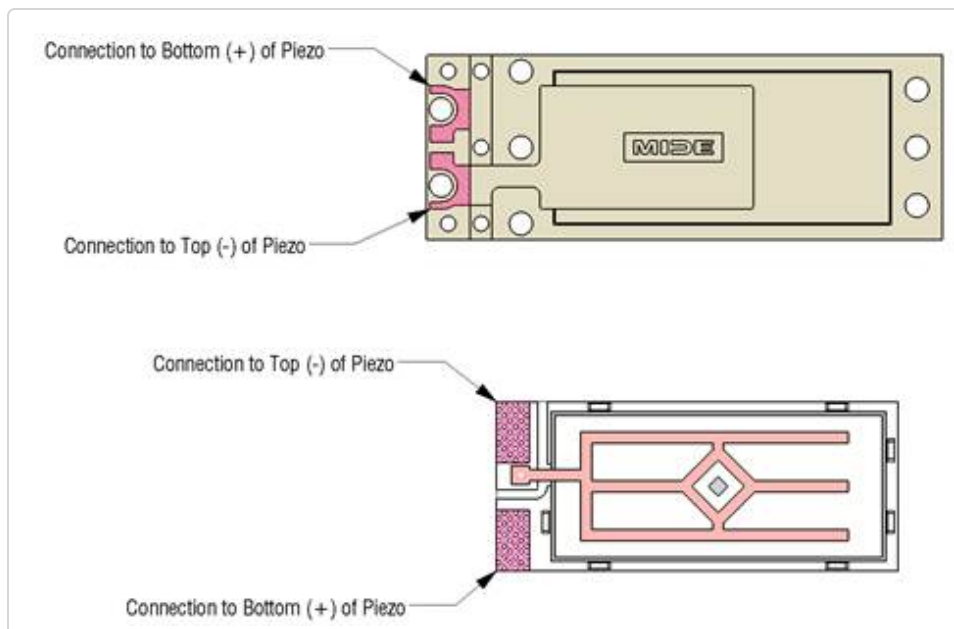
1. Clean surface to be soldered with an abrasive (pencil eraser) and wipe with alcohol. This step can usually be skipped when using the proper flux.
2. Dip the tip of a paper clip into the flux and apply a small dot of Supersafe Liquid Flux to the electrode area to be soldered.
3. Apply small amount of solder to iron tip and transfer solder to the piezoceramic electrode by touching iron tip to flux dot. A good solder joint should flow rapidly ( $\leq 1$  second) and look shiny. Metal shims take longer due to the increased thermal mass (~2 seconds).
4. Apply another small dot of Supersafe Liquid Flux to the solder dot on electrode.
5. Position pre-tinned wire on solder dot and apply soldering iron to the wire until the solder melts. Remove iron quickly after the solder melts and hold the wire still until the solder solidifies. A #32 gauge wire or smaller is recommended to minimize strain on the solder joint during wire handling.

6. Remove Supersafe Liquid Flux residue with clean running water. This flux residue is electrically conductive and must be removed for proper functioning of a piezo device. Any rosin residue may be removed with alcohol.
7. Wherever feasible, the wire-solder joint should be strain relieved with a drop of adhesive.

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## Sealed Piezo Polarity & Connecting Multiple Piezos

Each of the standard PPA products have only two electrical connection points for ease of use as highlighted below. Most of these products are poled so that the positive voltage is in the direction of the side with the Midé logo (the side with the copper connection pads). -1803YBs are poled in the opposite direction. If a positive signal is applied to the “Bottom (+)” pad (in line with the poling direction) the piezo wafer will compress in the thickness direction and thus bending upward, toward the side with electrical connection. In applications where the piezo is being used as a sensor or harvester, compressing the piezo through the thickness (bending upward, “out of the page”) will result in a positive voltage to the “Bottom (+)” pad. The opposite is true if applying a negative voltage.



For bimorph products the bottom wafer is poled in the opposite direction as the wafer on top, away from the center of the pack. The electrical connections are then made with the two wafers connected in parallel; but in such a way where the two wafers always act in the opposite direction of one another (one compresses, while the other extends). This is the desired configuration for when using these

products as benders. The quadmorph wires the four piezos similarly to the bimorphs but as two sets of pairs. The first two wafers act in unison but in the opposite direction as the bottom two wafers which act in unison with one another.

Admittedly, the polarity direction can be confusing. Piezo.com recommends to do a few bench top tests upon receipt of these products to gain a better understanding of this directionality.

Piezos can be connected to one another in either series or parallel. Series connection will double the open-circuit voltage compared to a single wafer, and the effective capacitance will be 1/2 the single-wafer capacitance (assuming each wafer is the same capacitance). Parallel connection will double the current compared to a single wafer, and the effective capacitance will be double the single-wafer value. For most applications, parallel connection is recommended. Regardless of series or parallel connection, the power generated by the harvester will be the same.

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## Soldering to Sealed Piezos

The recommended electrical connection method is to solder directly to the two copper pads on the pack for most of these products. Please note that the PPA-1001 has steel pads which are not designed for soldering. Please practice safe soldering techniques and be sure to apply some electrical tape or insulating epoxy over the connections to prevent them from shorting to one another or person.

### Warning

Risk of eye injury; always wear safety goggles when working with hot solder. Risk of lung irritation; avoid direct inhalation of solder fumes. Always solder in well ventilated areas. Risk of severe burns; soldering iron tips become very hot when used. NEVER touch the iron tip.

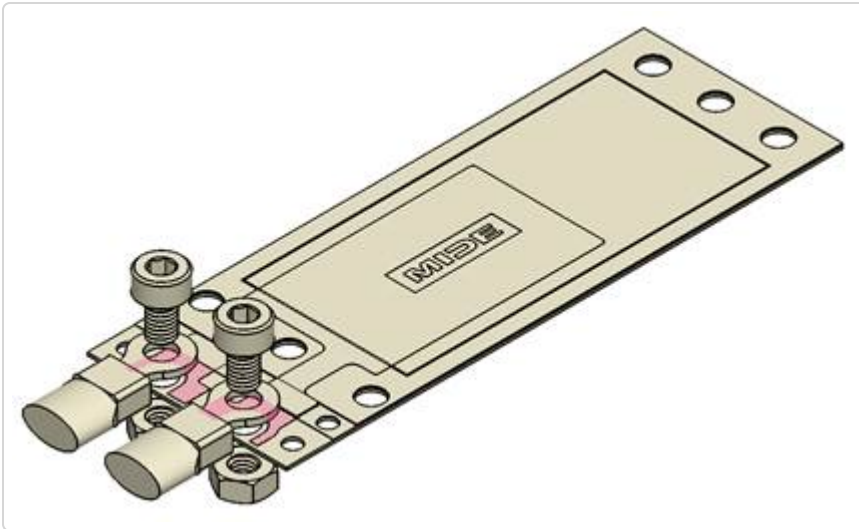
When connection to the piezo is being made by soldering there are countless forms of cabling to use. Piezo.com typically uses bare cable but here are two options that have worked well: Header Pin Receptacle to Solder Pins (<http://www.digikey.com/product-search/en?vendor=0&keywords=A9BAG-0208F>), and BNC Connector to Bare Wire ([https://www.jameco.com/webapp/wcs/stores/servlet/ProductDisplay?storeId=10001&productId=2097555&CID=CAT151PDF&langId=-1&catalogId=10001&krypto=kMYYrBxGZ%2FJcfaX9kvnXQccS%2BP4zc75V%2FP8SOwNmJck%3D&ddkey=https:CookieLogon](https://www.jameco.com/webapp/wcs/stores/servlet/ProductDisplay?storeId=10001&productId=2097555&CID=CAT151PDF&langId=-1&catalogId=10001&krypto=kMYYrBxGZ%2FJcfaX9kvnXQccS%2BP4zc75V%2FP8SOwNmJck%3D&ddkey=https:CookieLogon))).

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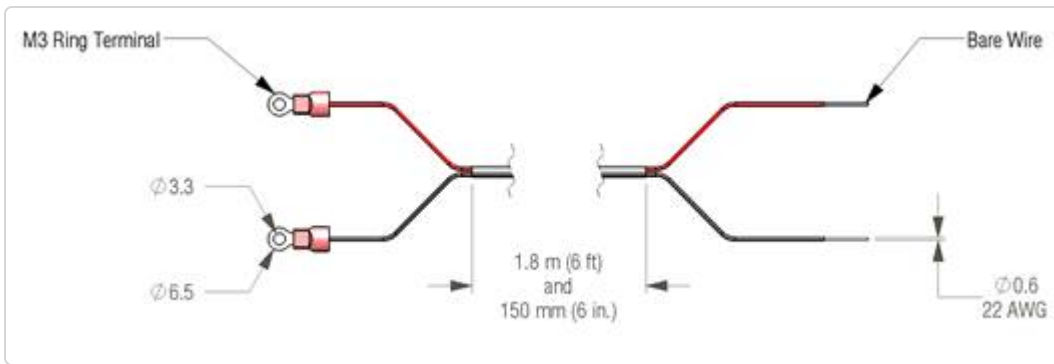
# Cables & Connectors

## Ring Terminals

The sealed products were designed for using a M3 Ring Terminal connection as shown below. Refer to the product drawing and/or 3D model for exact location of these holes; they are spaced 10.5 mm apart.



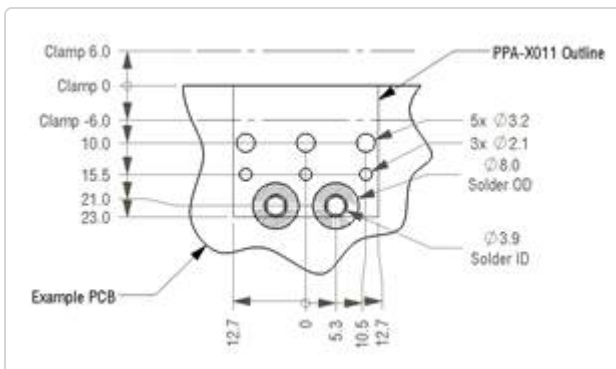
A cable can be made from two bare wires to two M3 ring terminals. This cable uses two ring terminals purchased through Digi-Key: WM9606-ND (<http://www.digikey.com/product-detail/en/0193240002/WM9606-ND/3884467>). The cabling is 22 gauge and also purchased through Digi-Key: E1002S-1000-ND (<http://www.digikey.com/product-detail/en/E1002S.30.10/E1002S-1000-ND/618468>). Any M3 nut and bolt will work to secure the terminals to the copper pads; but Piezo.com uses two from McMaster: 90128A187 (<http://www.mcmaster.com/#90128a187/=zkg0jt>) and 90591A121 (<http://www.mcmaster.com/#90591a121/=zkg0cv>). Proper mounting torque of 1 N-m (8.85 in-lb) should be used.



Be sure to apply some electrical tape or insulating epoxy over the connections to prevent them from shorting to one another or person.

### Conductive Hardware directly to PCB

Conductive hardware can be used in place of ring terminals when the piezo beam is directly placed on a PCB. Two brass M3 bolts can be used to connect the piezo pack to a PC board if large pre-tinned pads (shown as shaded rings in Figure 58) are on the underside of the board. In this configuration the piezo pack would lay on top of the PCB with the brass bolts bringing connection down through the PCB to the underside of the board where a conductive nut would be used to secure the bolt. This nut would electrically connect to the large pads on the underside of the board. Proper mounting torque of 1 N-m (8.85 in-lb) should be used. When mounting directly to the PCB use the PPA-5004 clamp or similar for accurate clamping and operation.



Be sure to apply some electrical tape or insulating epoxy over the connections to prevent them from shorting to one another or person.

### Spring Loaded Contacts

All of the piezo products can be connected to with spring loaded contacts, or pogo pins. There are a number of products on the market that work well but Piezo.com has had good experience with the products made by Mill-Max. ([https://www.mill-max.com/new\\_products/detail/103](https://www.mill-max.com/new_products/detail/103)) It is recommended to apply some insulating potting compound around the contacts to protect them in long term operation and against shock and vibration.

## IC Hook and Alligator Clips

IC hooks can be used for quick connection to all of these products but the hook can become disconnected rather easily. The PPA-1001 product has raised bumps that enables connection with an alligator clip. Alligator clips are difficult to connect with for the other products.



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## Custom Connectors

Piezo.com can include a connector with each unit but this involves a custom design. Some of Midé's previous QuickPack and Vulture products had connectors similar to these Flat Flex Cable Connectors (<http://www.digikey.com/product-detail/en/66226-002LF/609-2176-ND/1002491>).

Piezo.com has also utilized the flex circuit to design in a flat flex cable to be plugged directly into a ZIF connector. If a built in connector or some other alternative electrical termination method is desired, a custom solution can be designed. There will be an NRE of over \$2K for such a design. See our custom solutions (<https://support.piezo.com/article/115-custom-solutions>) for more information.

