Sealed Piezo Fan User Guide

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This document will guide you through the background & operation of our sealed piezo fans (https://piezo.com/collections/piezoelectric-fans).

In this Article

Overview

Our sealed piezo fans offer highly reliable active cooling solutions. Many applications cannot use standard axial fan due to the reliability issues with the rotating bearings. These piezo fans (sometimes referred to as "blades") offer a solid-state solution which drastically improves reliability while also being non-magnetic, low profile and quiet. Axial fans tend to get louder as they age, piezo fans will have the same low noise levels throughout their entire lifetime. Axial fans are often limited to operating temperature ranges from -40 to 60 C, PIEZO.com fans can operate in temperature between -60C to 120C, and higher temperatures are available with different epoxies.

The PIEZO.com fan technology is based on the unique properties of piezoelectric materials. These piezoelectric materials are transducers and convert electrical energy into mechanical energy. A piezo fan uses this property to drive a cantilevered beam at resonances creating a fan element.

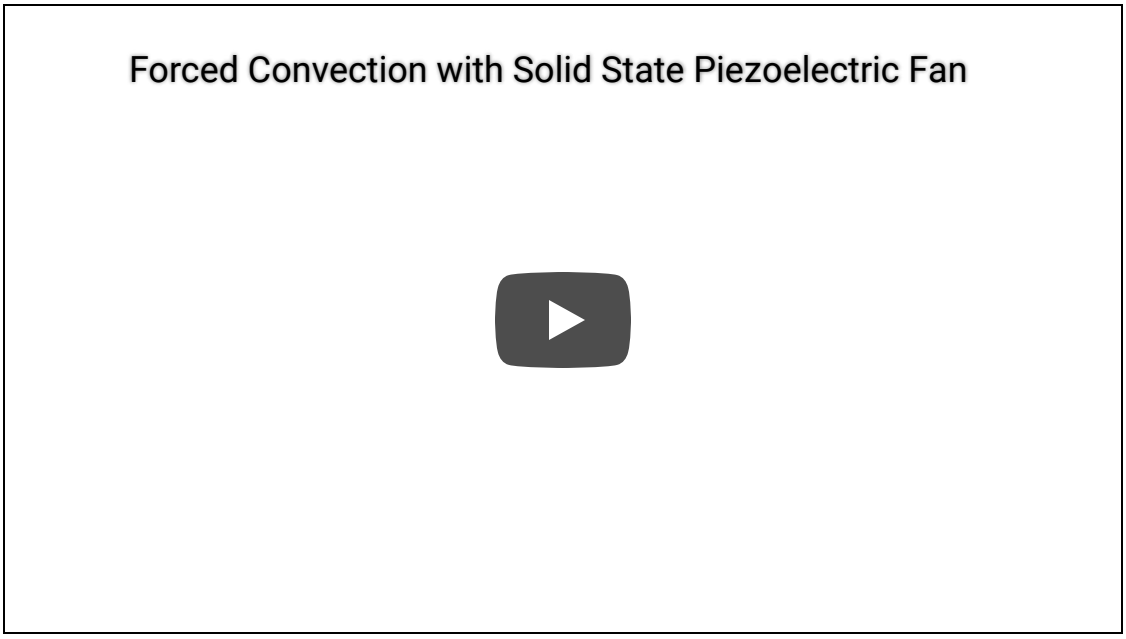
Reliability is the key advantage of piezo fans. The reliability of piezo fans is based on two fundamental properties, solid-state actuation (no rotating parts) and a patented protective packaging process for the piezoelectric element. Piezoelectric materials are ceramics and when in tension they can be brittle. The packaging process is critical for reliable performance because it strengthens the normally brittle piezoelectric material as well as offers important protection from the environment. Other piezoelectric fan products that don't have this packaging process will not be able to offer the reliable performance that our products can offer. The PIEZO.com fan technology has undergone rigorous reliability testing including highly accelerated life testing, humidity testing, and corrosion testing amongst others. Other products using the patented piezoelectric packaging process (https://piezo.com/pages/our-piezo-advantage) have been operating in the field for over 20 years

These piezo fans were developed to integrate into heat sinks, and add airflow to normally passive heat sink solutions. They can also directly cool critical components on electronics boards. They excel as an active cooling solution in applications where: reliability is critically important; use of magnetic-based fan technology is not permitted; a thin form factor is required; a dusty or extreme temperature environment is expected; or where audible noise needs to be kept to a minimum.

Airflow, Static Pressure and Cooling Performance

PIEZO.com fans do not operate the same way as standard axial fan products (simple inlet and outlet). The flow generated by a piezo fan is more complex. The structure around the piezo fan (inlet and outlet) will have a large impact on the airflow. There has been work done in industry and academia around optimizing airflow for piezoelectric fan devices. Due to this complexity, we recommend custom developments for all larger volume applications to optimize performance.

The following video demonstrates how air is pulled into and pushed through an example heat sink.

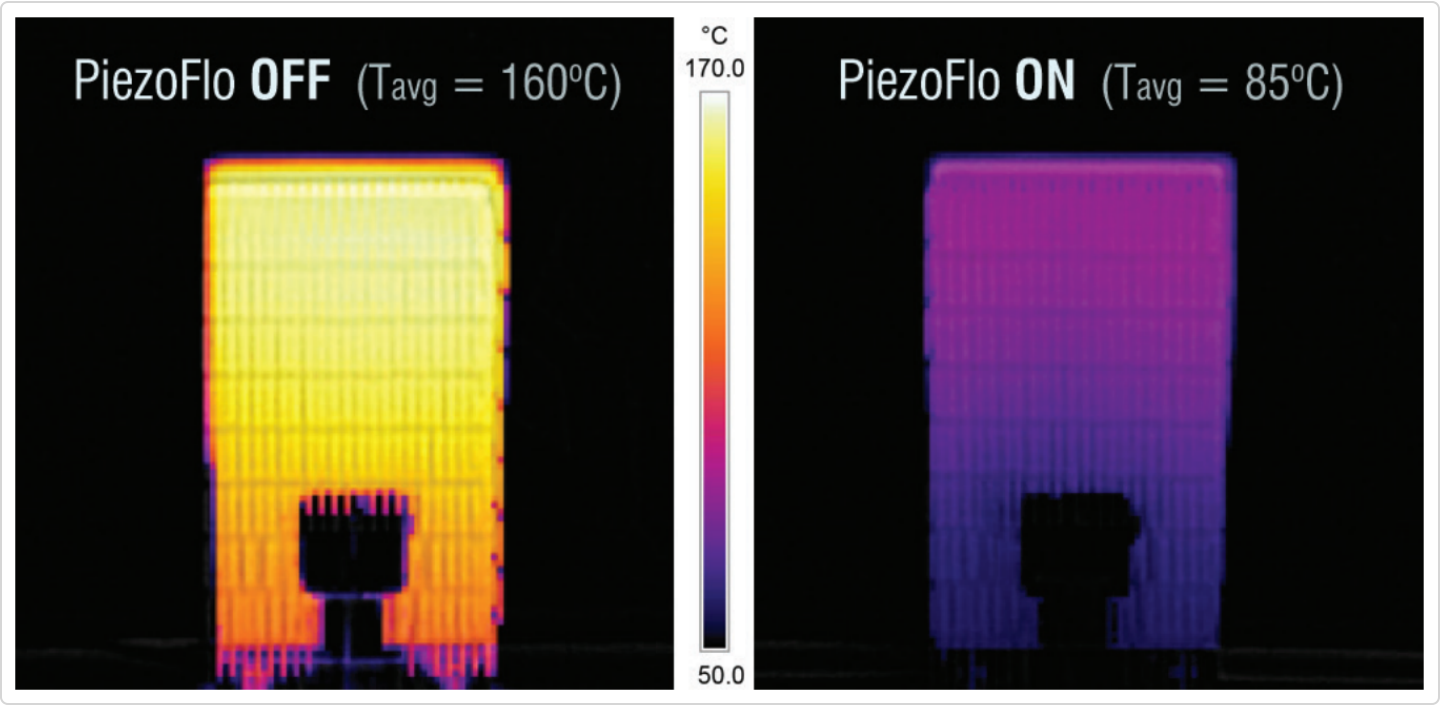


There are some general rules of thumb to ensure high airflow and cooling performance:

- Ensure that the PiezoFlo device does not mechanical impact any structure during its actuation
  - An audible noise will be heard if the device impacts a structure
- Do not block the intake area of the piezo fan device
- Where possible mount heat sinks vertically to assist natural convection better
  - Horizontal mount will still be benefited by a piezo fan

The structure surrounding the piezo fan will have a drastic influence on the airflow and static pressure performance. The primary important structural design features are to leave one side of the piezo fan completely open and completely block the opposite side. For the blocked side, the actuating beam should have as small a gap between the beam and the structure as possible, less than 0.5 mm or 0.020 in is recommended. The walls around the piezo fan in the actuating direction should have some distance between the actuating beam and the wall, 6.5mm or 0.25 in is recommended. If this wall is too close it inhibits the deflection of the beam. However, it has been shown that at the tip of the beam the wall should come very close to the beam to enable the best flow and pressure performance.

The flow generated by piezo fans is more complex than standard fans. Many factors will influence the power dissipation potential including the surrounding structure and heat sink design. Using the standard product, a single fan was able to dissipate 70 watts of power from a standard heat sink (Alpha Novatec LT70130-40W) with an input power of 100W. The heat sink was mounted vertically in a room temperature ambient condition and reduced the average temperature from 160C to 85C. An infrared image of the heat sink before and after turning on the piezo fan is pictured below.



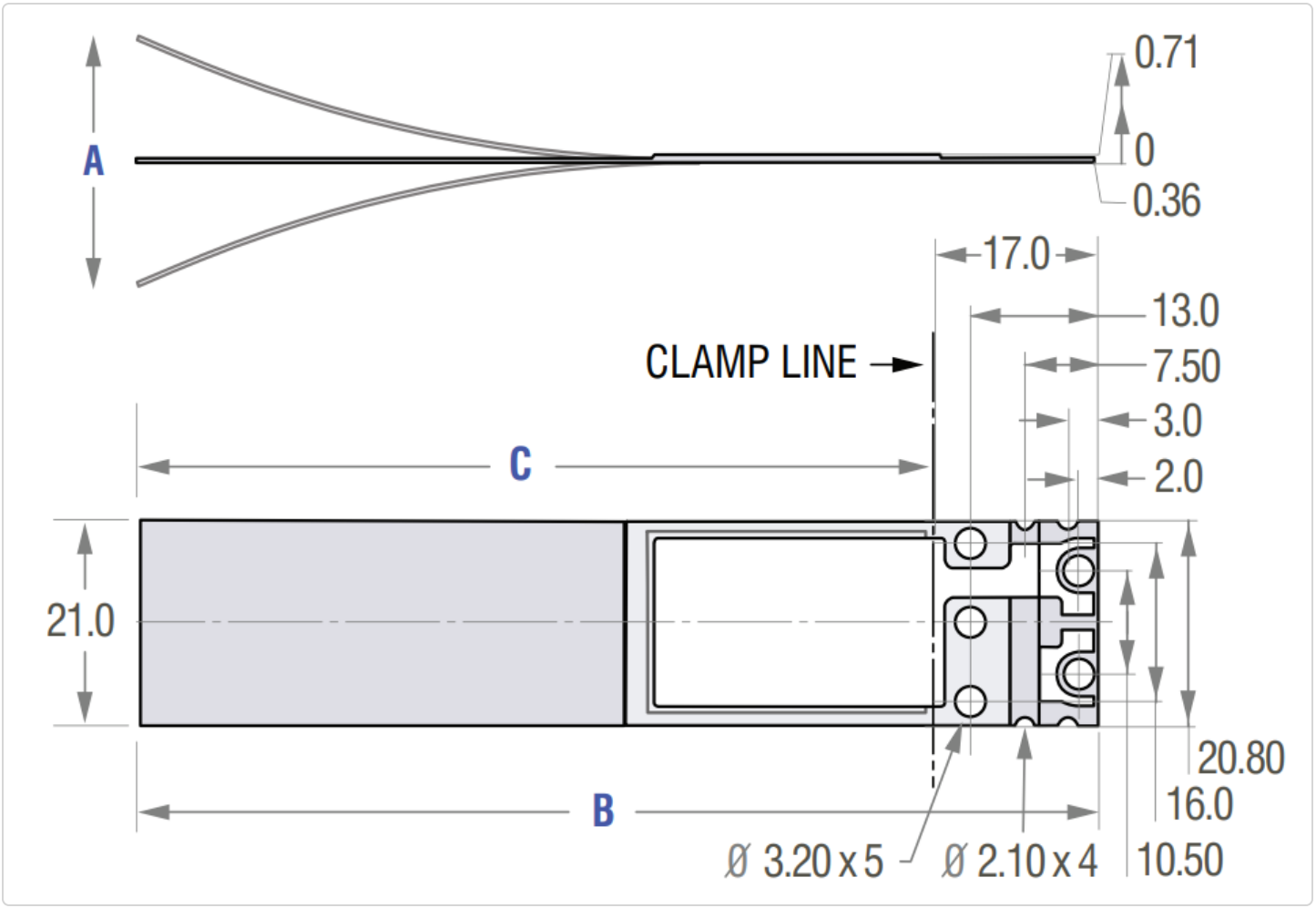
Operating Environment

The PIEZO.com fans, like the rest of our sealed piezos, have been designed specifically for applications that value reliability above all else. We have undergone very stringent reliability testing for our piezo fan development, here is a brief presentation on some of the tests completed (https://s3.amazonaws.com/helpscout.net/docs/assets/5a60b15b0428635d7f439dde/attachments/6058bee7207e3b1188e1eaf7/20150415_Piezo_Fan_Reliablity_Public_Release.pdf) . Tests include 1000 thermal cycles and 1000 hours in various extreme conditions. Specific environmental conditions of the fans are from -40 to 120C and humidity up to 95% RH non-condensing, although custom solutions can be developed for environments outside this range.

To avoid corrosion issues over long term use, any exposed copper in the area of the electrodes be sealed with a non-conductive and high-temperature sealant appropriate for use with copper and other metals. Dow Corning 748 Non-Corrosive Sealant is recommended. The clamp components provided in the kit products have a feature to allow for the sealant to be added after the clamping process is complete.

Mounting & Dimensions

The PIEZO.com fans need to be clamped at their root in order to create a cantilevered beam. The boundary conditions created by the clamp and the means of securing the clamp are critical to achieving high tip displacement and reliable long term operation. It is recommended that the clamp location on the PIEZO.com fans not be covering any part of the embedded piezoelectric element. the drawing below designates the “CLAMP LINE” for the fans. This clamp location allows for a gap of ~0.5 mm between the clamp line and the edge of the piezoelectric element. Dowel hole locations have been designed into the fan assemblies to allow for accurately locating the clamp line relative to the piezoelectric element. The clamp location is critical to achieving the desired frequency for the fans.



Dimension Variable	50 Hz 240 Vrms*	60 Hz 120 Vrms*
A (mm)	40.0	28.0
B (mm)	103.5	96.5

Dimension Variable	50 Hz 240 Vrms*	60 Hz 120 Vrms*
C (mm)	86.5	79.5

*Requires the use of the current limiting and bias voltage circuits explained below

The clamp force and the clamp material impact the natural frequency and the damping of the piezo fan, they also impact the reliability. Various clamp materials can be used based on the application. A plastic clamp material with hardness equal to or slightly less than that of FR4 (the material in contact with the clamp) is recommended for long term life. FR4 has a hardness of 110 (Rockwell M Scale). The clamp material should have a high enough operating temperature to survive the user's application requirement. For long term survivability, the material should have low saturated water absorption (less than 1%).

Depending on the application the clamp can be a standalone device or embedded into the final system. The PIEZO.com fans could also be molded into a final system. A standalone clamp design for our standard products is provided to ensure adequate clamping. There is clamping hole feature that is designed to allow a 3mm bolt to pass through to provide the clamping force. The bolt needs to be torqued appropriately to provide the proper clamp force. It is recommended a grade 12.9 bolt be used which for a 3mm bolt has a recommended torque value of 2.2 N-m.

For long term installations, a positive locking feature for the clamping bolt needs to be used. This will ensure that the bolt will not loosen over time. To guarantee that the bolt will not loosen, the use of Loctite® Threadlocker RED 271 between the threads of the M3 bolt and the mating threads is required.

Drive Electronics

The drive signal has a significant influence on the performance of the fans. Our kits include a drive circuit which conditions wall power to provide the ideal conditions for the fan. If you purchase the fans without the electronics we expect you to reproduce these circuits and conditions in your design and testing.

> Warning:

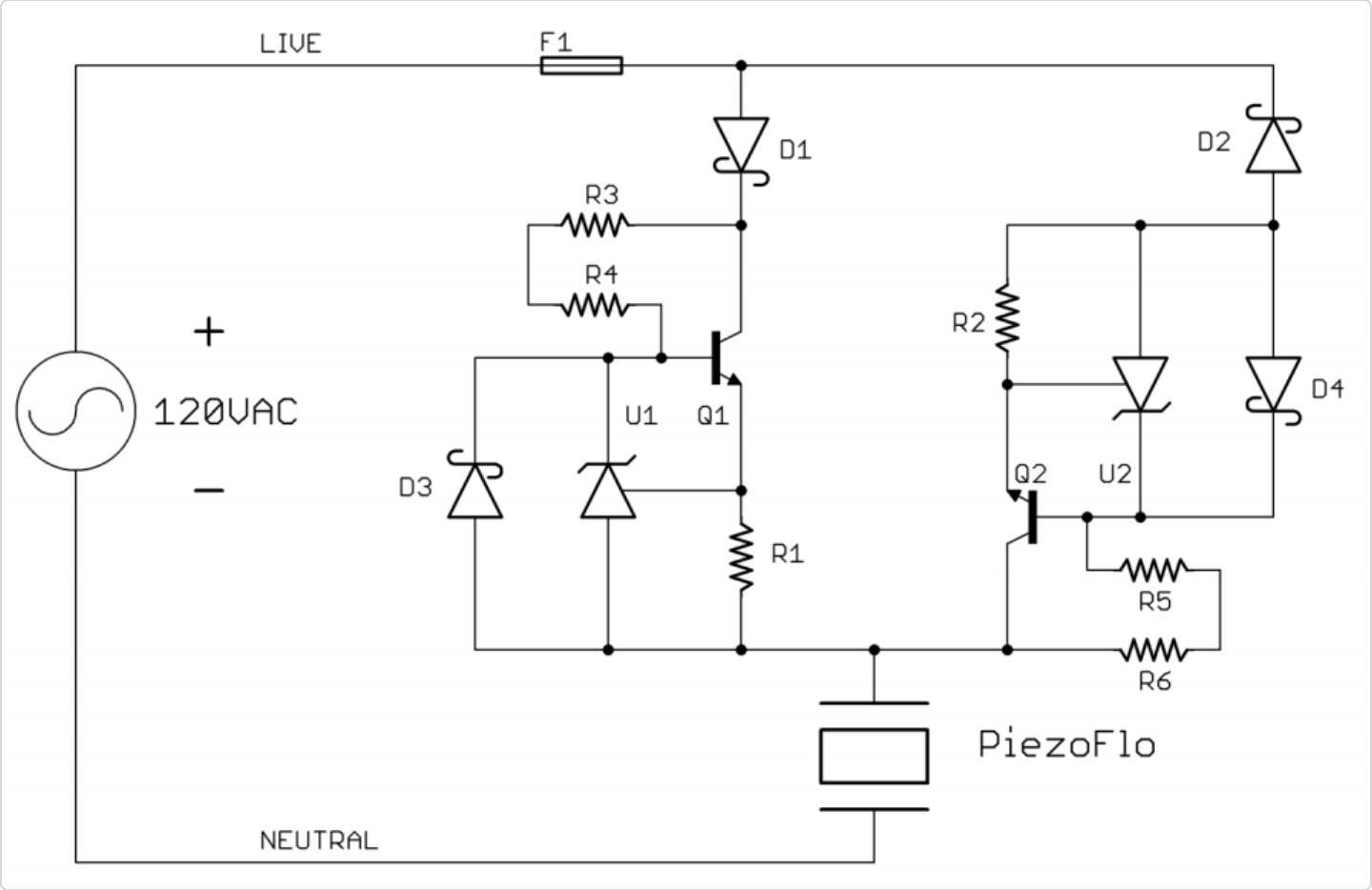
> Failure to provide the piezo fans with the following drive electronics can significantly reduce the service life of the fan.

There are multiple options for electrically driving PIEZO.com fans depending on the requirement of the application. If line power is available, that is often the most cost-effective way to power a fan or fans as it requires a limited number of supporting electrical components (see below). However, this is only appropriate if the fans' natural frequency matches that of available line power which is either 60 Hz (North America) or 50 Hz (Much of Europe). However, if an application needed a higher natural frequency or higher amplitude for improved air flow or pressure performance a custom fan device could be provided. This would require different drive electronics which could provide the fan's natural frequency at higher voltage levels. Commercially available piezoelectric drivers such as the DRV2700 produced by Texas Instruments would be one option for this approach.

> ### Warning:
> Be extremely careful when applying electrical energy to PIEZO.com fans. Shocks or serious injuries can occur if precautions are not taken. Use industry-standard safety practices when working with line power.

Line Power with Current Limit

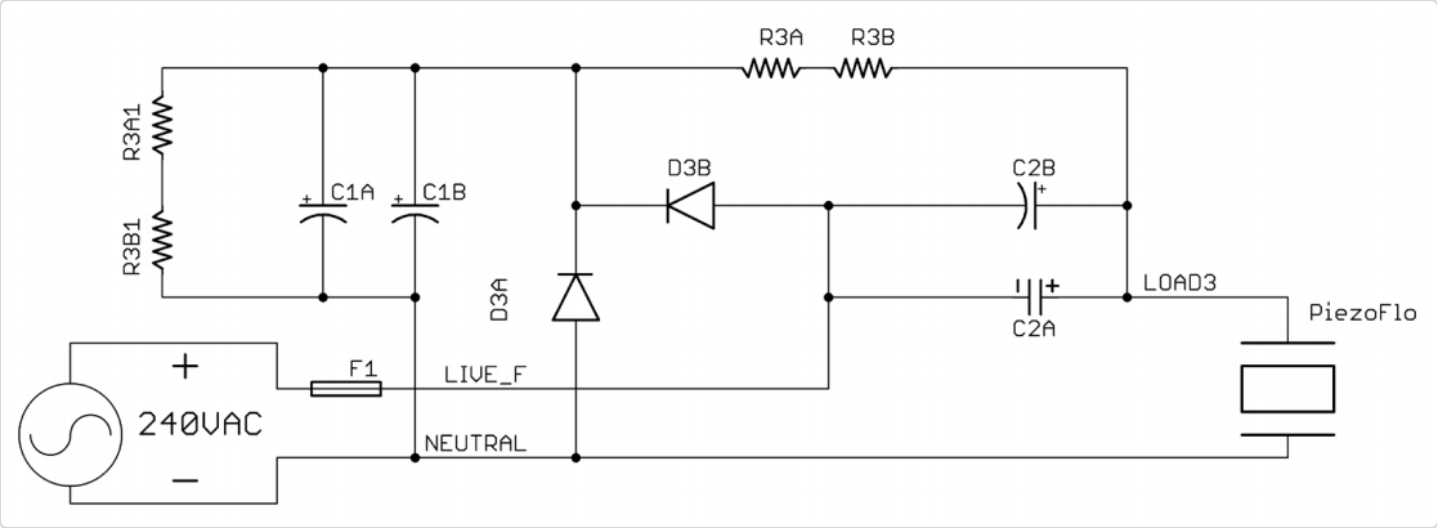
PIEZO.com fans can be connected to line power with a voltage of 120 VAC with current limit protection. Some form of surge protection is required on the line power to ensure the fan does not experience higher voltages than it is rated for. If there is no surge protection, an inline fuse in the circuit below can be used.



QTY	Parts	Description	Manufacturer Part Number
4	R3, R4, R5, R6	49.9KΩ resistor	RMCF1206FT49K9
2	R1, R2	124Ω resistor	ERJ-8ENF1240V
2	D1, D2	600V 1A Diode	CMMR1U-06 TR
1	F1	100mA,250V Fuse	5SF 100-R
2	D3, D4	5.6V Zener Diode	MMSZ5232B-7-F
2	U1, U2	Vref shunt	ZTLV431AFTA
2	Q1, Q2	MOSFET N-CH 450V 140mA	ZVN0545GTA

Line Power with Bias

PIEZO.com fans can be connected to 240V line power with the DC Bias conditioning circuit. This circuit increases the voltage tolerance of the piezo by generating and applying a DC offset to the fan, allowing it to run at a higher voltage. The schematic for the circuit is shown below.



QTY	Parts	Description	Manufacturer Part Number
1	C2A	1uF, 450V, SMT Capacitor	C5750X7T2W105M250KE
1	C2B	DNI (1uF, 450V, Radial Capacitor)	UPW2W010MPD
1	C1A	10uF, 450V, Radial Capacitor	EEU-EE2W100U
4	R3A, R3B, R3A1, R3B1	499 Kohms, SMT Resistor	RC1206FR-07499KL
1	C1B	DNI	
2	-	Fuseholder	FC 211
1	F1	80mA, 250V, 5x20mm Fuse	5ST 80-R
2	D3A, D3B	1kV, 1A diode	S1M-13-F

Specialized Piezo Driver SoC’s

There are commercially available system-on-chip drivers for piezoelectric actuators, for cases where line power is not an option. For example, the Texas Instruments DRV8662 (http://www.ti.com/product/drv8662) can produce up to 200 Vpeak-to-peak (70VAC, RMS) from a 5VDC input. Texas Instruments also has an upcoming product, the DRV2700 (http://www.ti.com/product/DRV2700), which will be capable of driving up to 1kV in Flyback configuration. For more information visit our blog on how to drive piezoelectric actuators (https://blog.piezo.com/how-to-drive-piezoelectric-actuators).

Troubleshooting

The fan is not moving at all?

Carefully check all electrical connections starting with the wall outlet to ensure that electrical energy is being applied to the device. If you have access to a voltage meter you can measure the voltage across the fan to determine if it is receiving electrical energy. If it is and there is no motion from the device ensure the fan is properly clamped. If it is properly clamped ensure that the drive frequency (50Hz, 60 Hz etc) matches the device's natural frequency (see specifications table for your product).

The fan is moving a little bit but not much?

Ensure you are driving the device at its proper natural frequency and it is properly clamped.

Last updated on March 22, 2021
