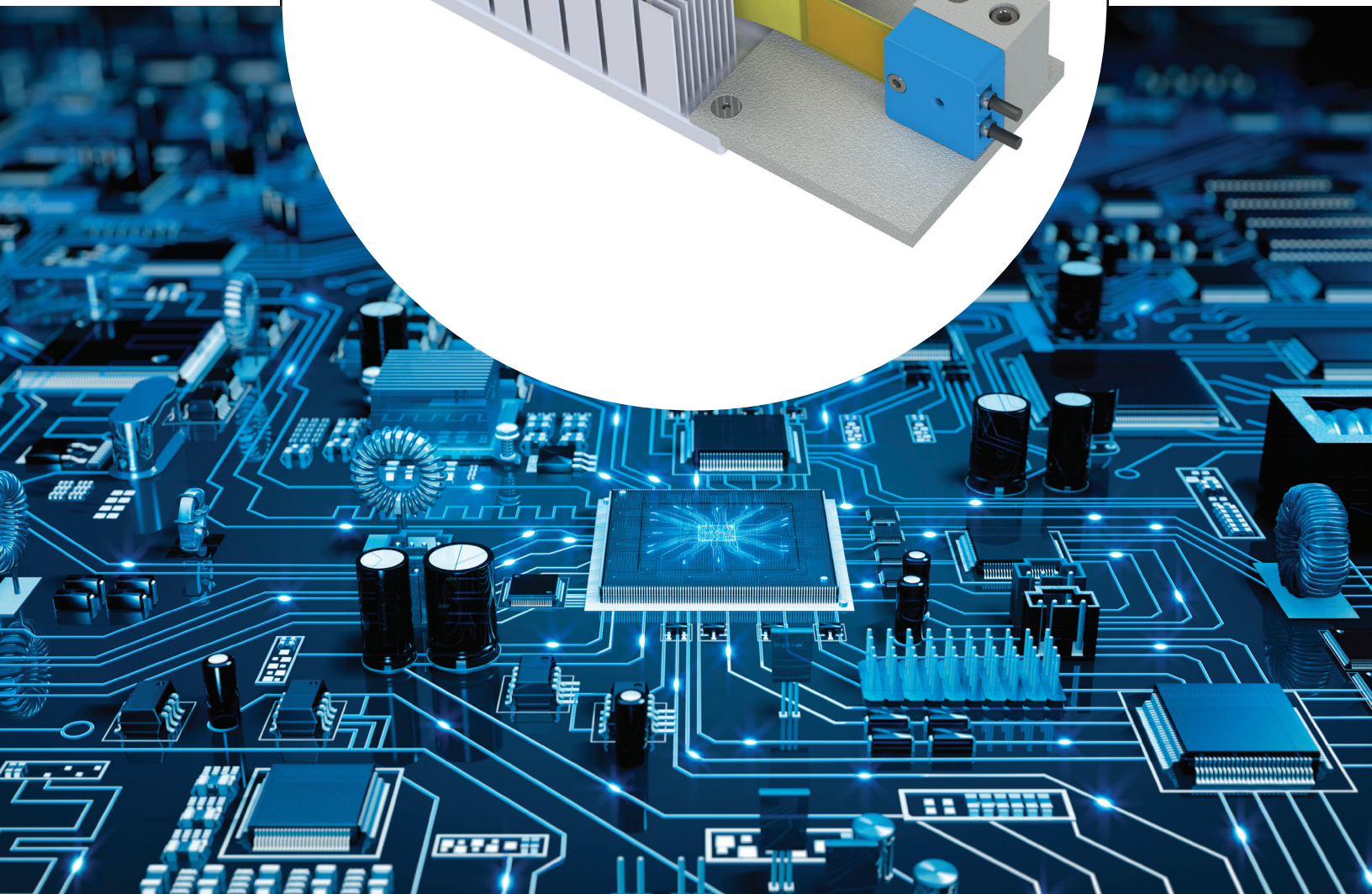
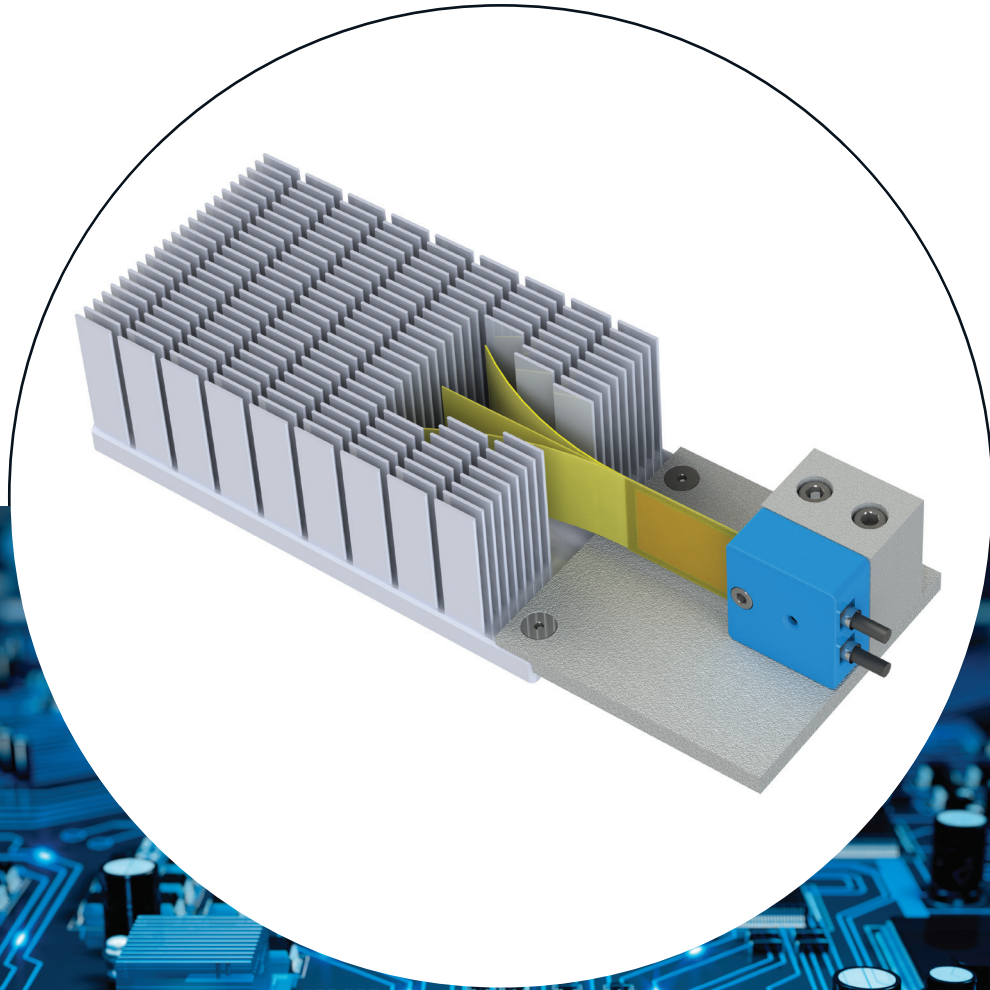




**PIEZOFLO™**  
LONG-LIFE ACTIVE COOLING TECHNOLOGY

## User Manual



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# General Information

## Copyright

This manual, software and the design data which it describes are copyright with all rights reserved. None of the data may be copied without the express written consent of Midé Technology Corporation. Refer to Midé Technology Corporation's full Copyright Policy at [http://www.mide.com/legal/legal\\_copyright.php](http://www.mide.com/legal/legal_copyright.php) for the full legal terms in regard to this copyright.

## Warranty

Midé Technology Corporation warrants that the PiezoFlo will be free from defects in workmanship and materials in normal use and operation within one year from date of shipment. This warranty only applies when the PiezoFlo is installed, maintained, and repaired in accordance with all of the directions, instructions, diagrams, safety warnings, cautions, and other notices set forth in this manual, and if not damaged by persons, actions, or inactions unrelated to Midé. In the event of any such defect of which Midé is informed in writing within such one year period, Midé's sole responsibility is, at Midé's option, to provide a replacement PiezoFlo at no cost to the Buyer upon the return of the defective product. Requests for compliance with this express, limited warranty shall be honored only when made by the Buyer. Refer to the Terms and Conditions at [http://www.mide.com/legal/legal\\_terms.php#4](http://www.mide.com/legal/legal_terms.php#4) for the full legal terms in regard to this warranty.

## Safety Precautions

A number of warnings and cautions appear in the text of this technical manual. They are intended to safeguard personnel and equipment from potential hazards or damage during equipment installation, operation, and maintenance. These warnings and cautions will be presented in the following manner.

**WARNING:** This represents an operating procedure, practice condition, statement, etc., which if not strictly observed, could result in injury to personnel or long term health hazards.

**CAUTION:** This represents an operating procedure, practice condition, statement, etc., which if not strictly observed, could result in damage to, or destruction of, equipment or a reduction in performance.

In addition to the specific warnings and cautions included in this manual, Midé recommends that all customers install, operate, and maintain the PiezoFlo in accordance with general safety guidelines included in standards published by OSHA.

## Introduction

PiezoFlo products offer highly reliable active cooling solutions. Many applications cannot use standard axial fan due to the reliability issues with the rotating bearings. PiezoFlo products 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, PiezoFlo products 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, PiezoFlo products can operate in temperature between -55C to 125C.

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

Reliability is the key advantage to PiezoFlo products. The reliability of PiezoFlo 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 in tension 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 which don't have this packaging process will not be able to offer the reliable performance that PiezoFlo products can offer. The PiezoFlo 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 have been operating in the field for over 20 years. For more information please go to [www.mide.com](http://www.mide.com). Any questions about Midé's products can be asked by emailing [service@mide.com](mailto:service@mide.com) or calling +1 781-306-0609.

## Overview of Features

PiezoFlo products are highly reliable solid state active cooling solutions. Developed to integrate into heat sinks, and add air flow 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.

Unlike other active cooling products, such as standard rotary fans, whose bearings and moving parts can wear and fail, PiezoFlo products have no moving parts. They are solid state, and offer a highly reliable solution utilizing the unique properties of piezoelectric materials.

PiezoFlo's piezoelectric materials have patented protective packaging (known as the [Piezo Protection Advantage](#)). The protected piezos enable PiezoFlo products to be easily integrated into electronic systems, survive harsh environments and provide superior reliability performance compared to other non-packaged piezoelectric products.

PiezoFlo products can be used in both indoor and outdoor applications and can operate effectively in the harshest environments; including military applications requiring -55C to 125C operating temperature ranges. PiezoFlo products have undergone substantial accelerated life testing and are based on a technology platform that has been fielded for over twenty years. Testing has shown that a single PiezoFlo PFN-1011 product can dissipate up to 70W of power from a standard heat sink.

## Specifications

For a more detailed overview of the product's specifications, please refer to the PiezoFlo datasheet available at <http://www.mide.com/pdfs/quickpack-piezo-fan-datasheet.pdf>.

**Table 1: General PiezoFlo Specifications**

Environmental	Specification	Note
Operating Temperature	-55C to 125C	
Humidity	0 to 95 %RH	Non-condensing

Physical	Specification	Note
Mounting Torque	2.2 N-m	Grade 12.9 M3x.5 bolt
Material	PZT, FR4, Copper, Adhesive	
L10 Lifetime	>15 Years	Testing still being performed
MTBF	>180 kHrs	Testing still being performed

**Table 2: Product specific specifications**

Specification	PFN-1011	PFN-1012
Static Pressure @ Max. Voltage	25 Pa	32 Pa
Max Flow rate @ Max. Voltage	10.2 CFM	10.6 CFM
Capacitance	27 nF	41 nF
Resonant Frequency ( $f_n$ ) @20 C	51 +/-1 Hz	61 +/- Hz
Resonant Frequency ( $f_n$ ) @85 C	50 +/-1 Hz	60 +/- 1Hz
Max Voltage	240 VAC RMS	120 VAC RMS*
Current at $f_n$ at Max Voltage	3.2 mA	7.7 mA
Current at $f_n$ at 120 VAC RMS	1.3 mA	7.7 mA
Power at $f_n$ at Max Voltage	0.77 W	0.99 W
Displacement at Max Voltage	42 mm	26 mm
Displacement at 120 VAC RMS	28 mm	26 mm
Max Current	10 mA	10 mA
Mass	2.9 g	2.7 g

\*PFN-1012 requires current limiting electronics when being driven at 120 VAC RMS

## Evaluation Kit Contents

There are four (4) PiezoFlo products. Two of the products are individual fan elements: PFN-1011 (50Hz, 240V) and PFN-1012 (60Hz, 120V). The contents of the kits can be found below:

**Table 3: Midé's PiezoFlo Kit PFN-9001**

DESCRIPTION	PART NO.	QTY	SUPPLIER
PiezoFlo Unit, 50 Hz	PFN-1011	1	Midé
Clamp	PFN-5001	2	Midé
Clamp Bolt	95263A146	2	McMaster
Drive Electronics, 240V	PFN-0001	1	Midé
Modified Heat Sink	PFN-5003	1	Midé
Heat Sink Attachment	PFN-5004	1	Midé
Heat Sink Attachment Bolts	90585A210	2	McMaster
Clamp Attachment	PFN-5005	1	Midé
Clamp Attachment Bolts	90128A219	2	McMaster

**Table 4: Midé's PiezoFlo Kit PFN-9002**

DESCRIPTION	PART NO.	QTY	SUPPLIER
PiezoFlo Unit, 60 Hz	PFN-1012	1	Midé
Clamp	PFN-5001	2	Midé
Clamp Bolt	95263A146	2	McMaster
Drive Electronics, 120V	PFN-0002	1	Midé
Modified Heat Sink	PFN-5003	1	Midé
Heat Sink Attachment	PFN-5004	1	Midé
Heat Sink Attachment Bolts	90585A210	2	McMaster
Clamp Attachment	PFN-5005	1	Midé
Clamp Attachment Bolts	90128A219	2	McMaster

# Transportation & Storage Requirements

The PiezoFlo products (PFN-1011 and PFN-1012) are robust and will survive commercial shipping and storage situations. Do not exceed the maximum or minimum operating temperature during shipping or storage. However, as a cantilevered beam the device can be damaged if enough load is applied to the tip of the beam causing it to deflect past a yield point.

**CAUTION:** If shipped or stored in a cantilevered condition be sure to protect the PiezoFlo fan products such that the product is not over strained causing failure.

The PiezoFlo kit products (PFN-9001 and PFN-9002) have electronics which operate off line power. These electronics should be stored and shipped at or near room temperature. They should be protected during shipment using normal shipping packaging practices.

**WARNING:** Be extremely careful when operating the PiezoFlo electronics. Do not operate near any water source. If the electronics are overheating, sparking or showing any signs of abnormality remove the power source immediately. Do not leave the electronics plugged in unattended. It is recommended you use a power surge protection device with the electronics to avoid electronics failure in the event of a power surge from your wall socket.



# Operation

## Operation Environment

PiezoFlo products (PFN-1011 and PFN-1012) have been designed and tested to operate reliably from temperatures ranging from -55C to 125C, up to humidity levels of 95% RH (non-condensing). PiezoFlo products are qualified both for indoor and outdoor (not directly exposed to the elements) environments.

The drive electronics can operate at commercial operating conditions for electronics. This is typically in a sealed enclosure with no dust and a small amount of humidity. The operating temperature range for the electronics is 0C to 85C. The electronics (PFN-1011 and PFN-1012) were designed as demonstration electronics and could be designed to be more robust if required.

**WARNING:** Be extremely careful when operating the PiezoFlo electronics. Do not operate near any water source. If the electronics are overheating, sparking or showing any signs of abnormality remove power to the wall power source immediately. Do not leave the electronics plugged in unattended.

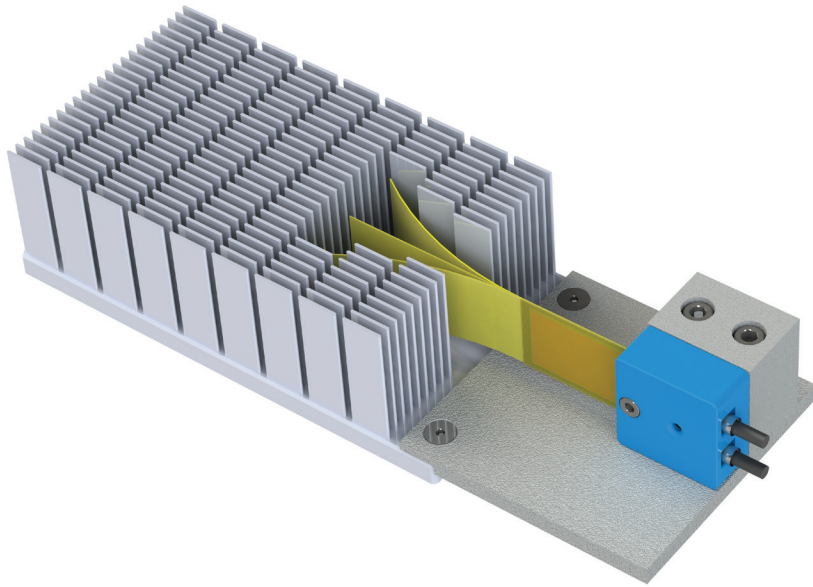
**CAUTION:** It is recommended you use a power surge protection device with the electronics to avoid electronics failure in the event of a power surge from your wall socket.

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.

**CAUTION:** Any exposed metal, specifically copper, will corrode over long periods of time in outdoor or other corrosive environments. Seal any exposed copper in the area of the PiezoFlo product to avoid corrosion issues.

## Mounting and Clamping Instructions

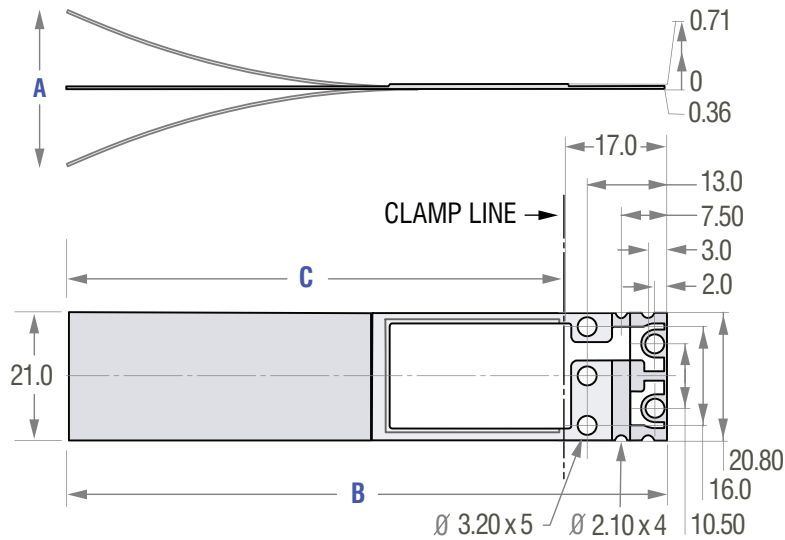
The PiezoFlo products need to be clamped at their root in order to create a cantilevered beam. The boundary conditions created by the clamp, and the means of securing the clamp are critical to achieving high tip displacement and reliable long term operation.



**Figure 1:** PiezoFlo product shown properly clamped in the evaluation kit product (PFN-9001 or PFN-9002).

**CAUTION:** If the clamping instructions are not followed carefully the PiezoFlo product will not operate as expected and may experience pre-mature failure.

It is recommended that the clamp location on the PiezoFlo product not be covering any part of the embedded piezoelectric element. Figure 2 designates the “CLAMP LINE” for the PiezoFlo products. This clamp location allows for a gap of  $\sim 0.5$  mm between the clamp line and the edge of the piezoelectric element. Dowel hole locations have been designed into the PiezoFlo products to allow for accurately locating the clamp line relative to the piezoelectric element. The clamp location is critical to achieve the desired frequency for the PiezoFlo products.



	PFN-1011	PFN-1012
<b>A</b> (mm)	40	28
<b>B</b> (mm)	103.5	96.5
<b>C</b> (mm)	86.5	79.5

**Figure 2:** Dimensions of the electrical connection and clamp area for all of the PiezoFlo products. All dimensions are in millimeters (mm).

The clamp force and the clamp material impact the natural frequency and the damping of the PiezoFlo product, they also impact the reliability of the PiezoFlo product. 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 PiezoFlo 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 users application requirement. For long term survivability the material should have low saturated water absorption (less than 1%). Midé recommends the following hard plastics as possible clamp materials:

**Table 5: Recommended Clamp Materials**

Material	Typical Hardness (Rockwell M)	Typical Max Operating Temperature (°C)	Manufacturing Capability
Glass Filled Nylons	71 to 102	65 to 240	Injection Mold, Machine
ABS	70 to 90	77 to 109	Injection Mold, Machine
Thermoplastics-Delrin®	94	85	Injection Mold, Machine
Polycarbonates	75 to 91	116 to 200	Injection Mold, Machine
Phenolics - FR4	110	140	Machine
Thermoplastics - PEEK	99	249	Injection Mold, Machine
Thermoplastics - Torlon®	120	260	Injection Mold, Machine

Depending on the application the clamp can be a standalone device or embedded into the final system. The PiezoFlo products could also be molded into a final system. A standalone clamp design for a single PiezoFlo fan is provided with the development kits (PFN-9001 and PFN-9002). This standalone clamp design can be downloaded for free on the product webpage:

There is clamping hole feature in the PiezoFlo products which is designed to allow a 3mm bolt to pass through to provide the clamp force. The bolt needs to be torqued appropriately to provide the proper clamp force on the PiezoFlo product. 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.

**CAUTION:** Be sure to choose the bolt material appropriately for your application. To avoid corrosion issues it is recommended to use stainless steel or similar materials for the bolt and mating threaded material.

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.

**CAUTION:** Do not remove the bolt after applying Threadlocker. Threadlocker should only be added during the final installation in the system.

**CAUTION:** Ensure the surfaces where the Threadlocker red 271 will be applied are clean and dry. Shake the Threadlocker red 271 thoroughly before use. Follow all instructions provided by the manufacturer of Threadlocker red 271 to ensure a proper installation.

**WARNING:** Follow all instructions and heed all warnings and cautions, such as the material safety data sheet (msds) for use any chemical agent such as Threadlocker red 271.

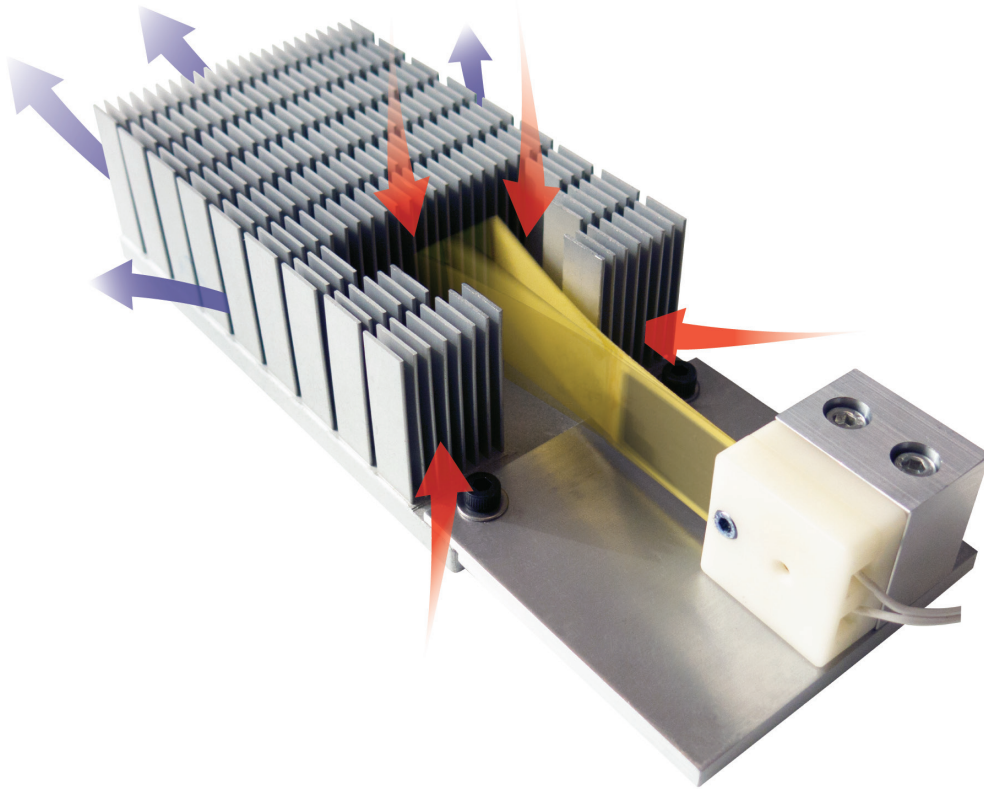
All bolts used in the development kits (PFN-9001 and PFN-9002) have had Loctite® Threadlocker Red 271 applied prior to shipment. Do not remove these bolts. If the bolts are removed they will need to be cleaned and have the Loctite® Threadlocker Red 271 re-applied to guarantee long term performance.

## Airflow, Static Pressure and Cooling Performance

PiezoFlo products do not operate the same way as standard axial fan products (simple inlet and outlet). The flow generated by PiezoFlo products is more complex. The structure around the PiezoFlo product (inlet and outlet) will have a large impact on the air flow. There has been work done in industry and academia around optimizing airflow for piezoelectric fan devices. Please visit our webpage which provides links to published papers in this area at [service@mide.com](mailto:service@mide.com).

**Table 6: Static Pressure and Maximum Flow Rate Values**

	PFN-1011	PFN-1012
Static Pressure @ Max. Voltage	25 Pa	32 Pa
Max Flow rate @ Max. Voltage	10.2 CFM	10.6 CFM



**Figure 3:** General airflow of the PFN-9001 AND PFN-9002 evaluation kit products. The structure around the PiezoFlo device will greatly impact the flow direction and velocity.

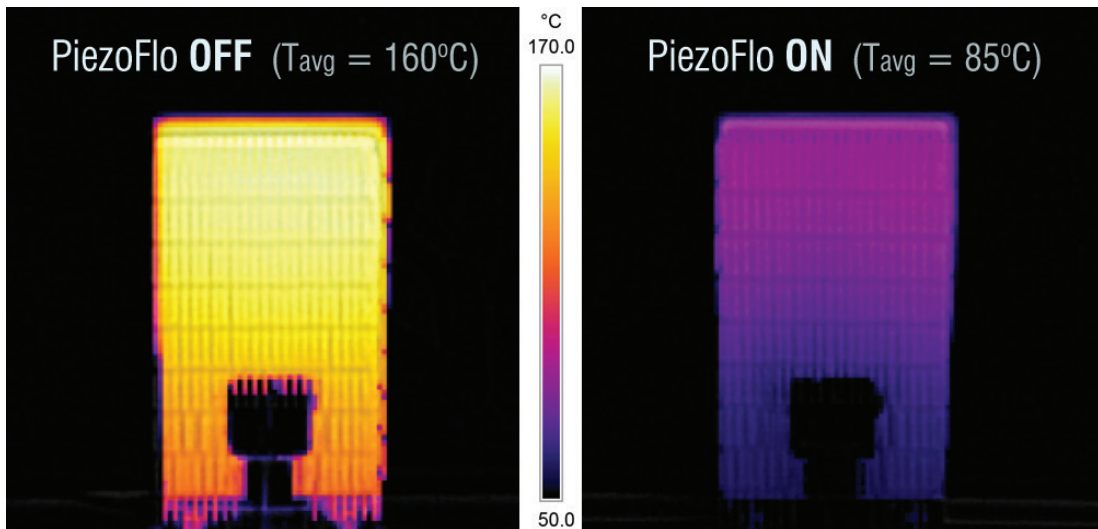
There are some general rules of thumb to ensure high airflow and cooling performance:

- 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
- Where possible mount heat sinks vertically to assist natural convection better

- Horizontal mount will still be benefited by PiezoFlo
- Do not block the intake area of the PiezoFlo device.
  - See Figure 3 for intake area

The structure surrounding the PiezoFlo device will have a drastic influence on the air flow and static pressure performance. The evaluation kit structure is representative of a best practice situation but is not optimized for flow performance. The primary important structural design features are to leave one side of the PiezoFlo device completely open (intake, see Figure 4) 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 PiezoFlo device 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 PiezoFlo products is more complex than standard fans. Many factors will influence the power dissipation potential of a PiezoFlo device, including the surrounding structure and heat sink design. Using the PFN-9001 development kit, a single PFN-1011 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.



**Figure 4:** Infrared image of a heat sink before and after a PiezoFlo device was turned on.

## Electrically Operating PiezoFlo

For the PiezoFlo products to work they require AC voltage to be applied to their electrodes. Do not exceed the maximum allowable voltage for the PiezoFlo Products. See table 2 for the product voltage specifications.

**CAUTION:** Exceeding the allowable voltage threshold could lead to product failure.

**WARNING:** Always remove power to the PiezoFlo device before handling, moving or working on the device.

If a kit product is purchased (PFN-9001 or PFN-9002) the electronics are included and simply need to be plugged into a wall outlet. Ensure the PiezoFlo product is properly clamped and mounted prior to plugging in the electronics.

**CAUTION:** Do not plug in the electronics in a PFN-9001 into a wall outlet that can provide a voltage greater than 240V AC, this may cause failure of the electronics and/or product. Do not plug the electronics in a PFN-9002 into a wall outlet that can provide a voltage greater than 120V AC, this may cause failure of the electronics and/or product.

If only a PiezoFlo product was purchased, PFN-1011 or PFN-1012, the proper AC electricity will need to be applied to the electrodes. Wires can be soldered to the electrodes.

**CAUTION:** Do not leave the soldering iron on the electrodes for too long, damage to the thin copper electrode may occur. Ensure a proper solder joint is made.

**WARNING:** Take all precautions necessary to safely work with solder and soldering irons.

# Drive Electronics

There are multiple options for electrically driving PiezoFlo devices depending on the requirement of the application. If line power is available, that is often the most cost effective way to power a PiezoFlo device or devices as it requires a limited number of supporting electrical components (see below). However, this is only appropriate if the PiezoFlo devices natural frequency matches that of available line power which is either 60 Hz (North America) or 50 Hz (Much of Europe). The PFN-1011 and PFN-1012 have natural frequencies of 50Hz and 60 Hz respectively. However, if an application needed a higher natural frequency or higher amplitude for improved air flow or pressure performance a custom PiezoFlo device could be provided. This would require different drive electronics which could provide the PiezoFlo'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 PiezoFlo devices. Shocks or serious injuries can occur if precautions are not taken. Use industry standard safety practices when working with line power.

## Line Power

It is possible to drive certain piezoelectric materials directly from line power with no additional circuitry. However, for better cooling performance it is advantageous to use higher performing piezoelectric materials which require some additional electronics. Midé's PFN-1011 product can be driven from 240V AC line power at 50 Hz but requires a bias circuit. Midé's PFN-1012 product can be driven from 120V AC line power at 60 Hz but requires a current limiting circuit.

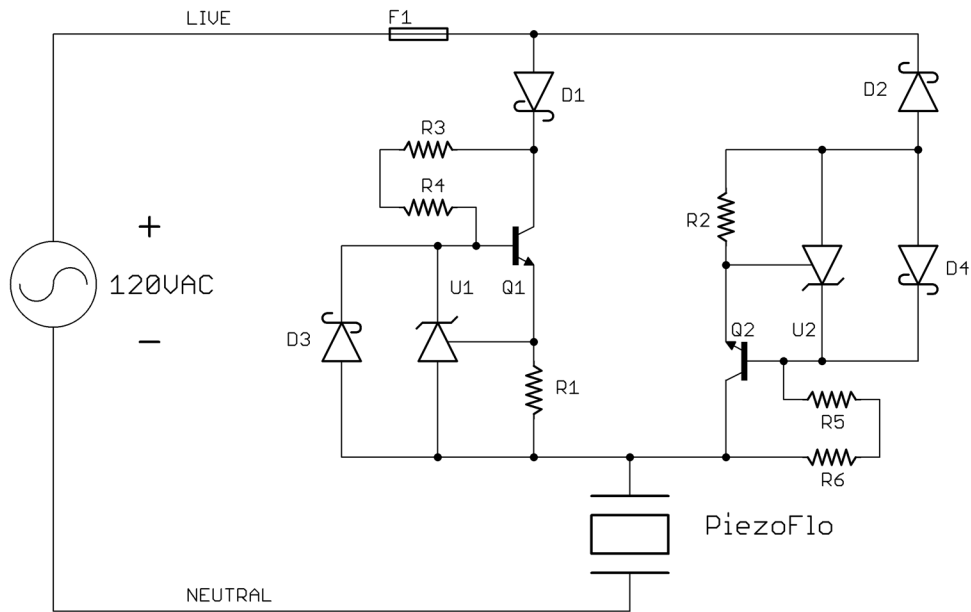
## Direct from Line Power

Midé does not offer a standard product that is driven direct from line power but it is possible to provide one if needed.

## Line Power with Current Limit

PiezoFlo product PFN-1012 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 PiezoFlo device does not experience higher voltages than it is rated for. If there is not surge protection, an in line fuse in the circuit below can be used.





**Figure 6:** Electrical diagram showing drive circuitry using line power with the addition of a current limiting circuit. This approach needs to be used with the PFN-1012 due to the type of piezoelectric material in that product.

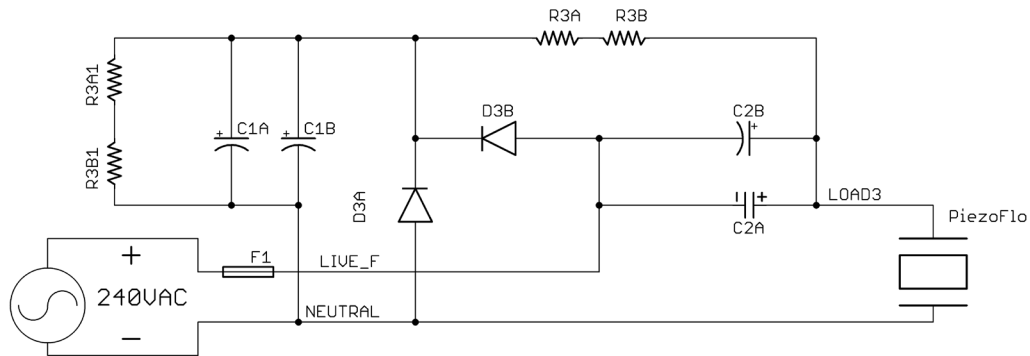
**Table 7: BOM for Current Limiter rev 1.4**

QTY	Parts (Ref Des.)	Value	Manufacturer Part Number
4	R3, R4, R5, R6	49.9K $\Omega$ resistor	RMCF1206FT49K9
2	R1, R2	124 $\Omega$ 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

PiezoFlo product PFN-1011 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 PiezoFlo device, allowing it to run at a higher voltage. The schematic for the circuit is shown in below.

# PiezoFlo DC Bias Circuit



**Figure 7:** Electrical diagram showing drive circuitry using line power with the addition of a DC bias circuit.

**Table 7: BOM for DC Bias rev 1.4**

QTY	Parts (Ref Des.)	Value	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 can produce up to 200 V<sub>peak-to-peak</sub> (70VAC, RMS) from a 5VDC input. More information is available at: <http://www.ti.com/product/drv8662>. Texas Instruments also has an upcoming product, the DRV2700, which will be capable of driving up to 1kV in Flyback configuration. More information is available at <http://www.ti.com/product/DRV2700>.

# Troubleshooting

My PiezoFlo device 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 PiezoFlo device to determine if it is receiving electrical energy. If it is and there is no motion from the device ensure the PiezoFlo device is properly clamped. If it is properly clamped ensure that the drive frequency (50Hz, 60 Hz etc) matches the devices natural frequency (see specifications table for your product).

My PiezoFlo device is moving a little bit but not much?

Ensure you are driving the device at its proper natural frequency (see specifications table).

## Product Support

For technical support, repair, and returns please contact Midé's PiezoFlo sales department at 781-306-0609 extension 239. We can also be reached by email at [service@mide.com](mailto:service@mide.com).

Please note that product specifications are subject to change without notice. This often occurs due to Midé's continued effort to improve the features and functionality of this product. For software updates, up-to-date user guide, datasheet and other product information please visit our website at [www.mide.com](http://www.mide.com). Midé's sales and technical staff would also be happy to help with any inquiries of updated product information.

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*Midé Technology is an ISO 9001:2008 Certified Company.*