MIGA
Motor Company

# *Application Notes*

## *MigaOne™ On Board Actuators*

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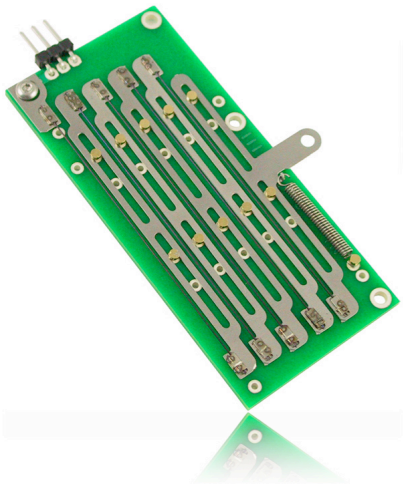
# MigaOne™

## Shape Memory Alloy Actuator Application Notes



The MigaOne™ is a very thin electric actuator powered by Shape Memory Alloy (SMA) wires. The MigaOne linear actuator can be used to replace motors and solenoids in many applications, providing a constant-force stroke of 0.375". The MigaOne has an end-of-stroke limit switch that prevents overheating of the SMA wires, and use of the Miga Motor Company MOSFET Analog Switching Circuit allows simple connection to your application.

The MigaOne™ is ideally suited for use as a latch release mechanism, but can also be used for many other modern motion applications.

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### MigaOne Specifications

- **Stroke**: 0.375 inches (9.5mm)
- **Output Force**: constant 2.5 lb-f (11 N), peak 5.0 lb-f (22 N)
- **Actuation Time**: 50 ms to position hold (depends on input voltage or PWM)
- **Actuation Speed**: up to 200 mm/s
- **Weight** (as shown): 0.45 ounces (12.8 grams)
- **Dimensions**: 2.8" x 1.3" x 0.098" (71 x 33 x 2.5mm)
- **Mounting Holes**: 1.125" x 2.675" thru pattern for #2 SHCS
- **Vertical Height** from 0.063" FR-4 PCB Surface: 0.059" (1.5mm)
- **Operating Temperature Range**: -20˚F to 140˚F (-29˚C to 60˚C)

### Operating Basics

The operating principles of the MigaOne-Series actuators are relatively simple: SMA wire segments form a series-resistive electrical circuit within the MigaOne™ actuator. Input current ohmically heats the SMA wire elements, which begin to contract when they reach a temperature of roughly 75˚C (167˚F). The wires are fully contracted at ~ 110˚C (230˚F) and should not be heated above 150˚C (302˚F)

When power is removed, the SMA wire must cool below ~60˚C (140˚F) to return fully to the un-powered position. The actuator does not need to fully return to the un-powered position to actuate again, however. In fact, using control methods described below, the actuators could maintain any position along the design stroke (though we do not recommend this type of operation except by experienced users).

The MigaOne™ provides force only in the powered direction, returning to the un-powered position if un-constrained. The MigaOne™ must be allowed to return to the un-powered position under it's built-in restoring force (bias-spring) after actuation, or

the SMA wires will 'bulge' outward, and may become caught on other structural elements of the actuator.

**Mounting Considerations**
The MigaOne™ Motor Body is designed for mounting on a flat plane, and is not designed to support the weight of other objects, or to be compressed or torqued other than at the mounting holes. Use only the four corner mounting holes for attachment.

**Side-loading**
MigaOne™ devices have not been tested extensively for side loading. However, they are very robust devices, and qualitative testing indicates that they perform well under all conditions at the rated loads. Do not manually force the output shaft to move, as this may damage the SMA wires and attachments.

**Force Rating and High Load Conditions**
The MigaOne™ has a 2.5 lb.-f (11 N) force rating. Under higher load conditions (beyond the design rating), the actuator may not reach the end of stroke. Note that the actuation time is slightly *longer* for an actuator under load, than for an un-loaded actuator.

**Operating Temperature Range**
The maximum ambient operating temperature for the MigaOne actuator is 60˚C (140˚F); while the minimum tested operating temperature is -30˚C (-22˚F). Long-term exposure to ambient temperatures above 75˚C will result in passive (un-powered) actuation of the actuator. To avoid damaging the SMA wire, the wire temperature should never exceed 150˚C (302˚F).

**Always Use Black Wire as Electrical GROUND**
The stainless steel output shaft of the MigaOne is connected electrically to the "GND" terminal, intended for use as power supply 'ground'. To avoid electrical shock or shorts, do not connect the "GND" to live power. Future models of our actuators will have electrically insulated output shafts.

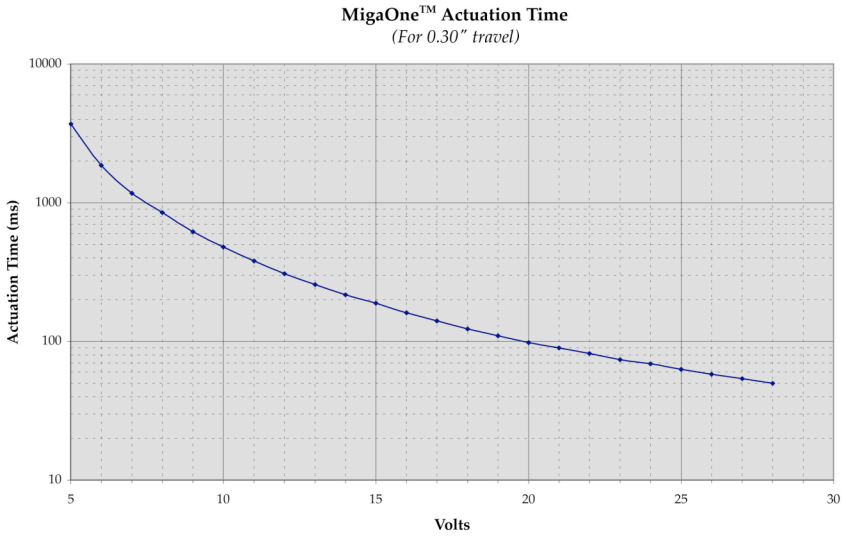
**Caution: The steel output shaft of the MigaOne actuator is at the same electrical potential as the black "GND" lead-wire. The red "+V" lead-wire should be used for positive applied voltage.**

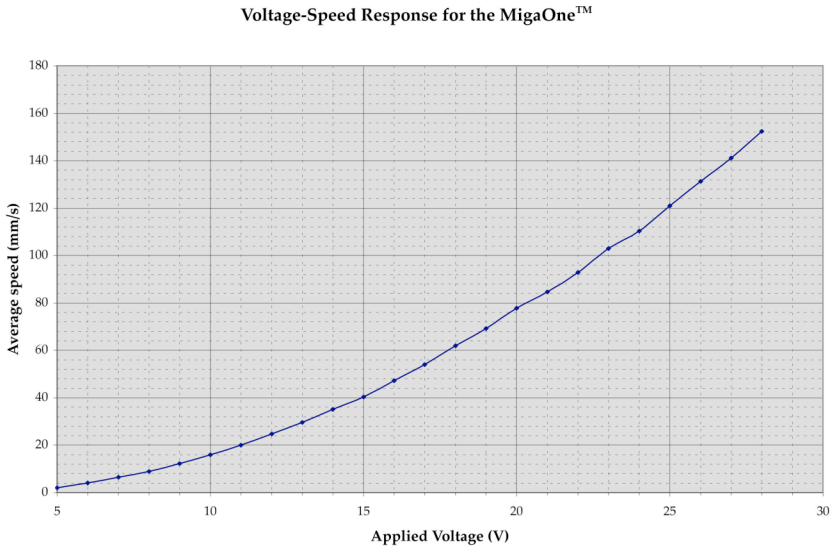
**Actuation Time**
The actuation time of the MigaOne™ depends on the input power, from ~50 ms to 'position-hold'. The actuation time also changes slightly with load and/or ambient temperature. For a given input power, actuation time *increases* for higher loads. Actuation time also *increases* for lower ambient temperatures, since additional power is required simply to raise the wire to room temperature.

If actuated rapidly, the SMA wire passes through the transition temperature range very quickly, and can become overheated if power is not removed quickly when the actuator reaches the end of stroke (and the output shaft shorts to the "SW" pin (center pin of 3-

pin connector). Use of the Miga MOSFET Analog Driver prevents overheating by removing power the moment the end-switch is reached.

The repetition rate of the MigaOne™ is governed by the time required to cool and return to the un-powered position. Unconstrained, the MigaOne™ returns fully to the un-powered position in ~5 seconds, depending on ambient conditions and the SMA wire diameter. Forced cooling can increase the repetition rate by up to 100x if high rate operation is a requirement. Actuation times (shown below for DC volts) may be different with use of AC or Pulse Width Modulated power.




**Initial Powering of the MigaOne-Series Actuators**

To safely explore the optimal input power for the MigaOne™ actuator and your application, connect a battery or power supply capable of supplying several amps

between the actuator ground ("GND" or black wire) and power ("+V" or red wire). Initial testing should be done with no external load on the actuator. A momentary switch in the power line will provide safe operator control of applied voltage. Begin with low voltages, and increase the voltage to a level appropriate for the desired actuation speed. To avoid over-heating the SMA wire, always be sure to remove power immediately upon reaching the end of stroke (or use the Miga MOSFET Analog Driver).

Voltages above +7V are capable of damaging (overheating) the wire, so pulse timing or other power control circuitry must be used. For safest operation, note the one-second rule below. Once initial power levels are determined, increase the load on the actuator, further incrementing the input power to accommodate the higher loads and your desired actuation time.

If too little power is applied to an actuator (or if it is applied too slowly), the wire loses heat to the environment more quickly than it is provided by the power source. The actuator will not function if too little power is applied, and may not achieve full stroke (full phase transition). Conversely, faster actuation loses less energy to the environment, so is more efficient. Care should be taken not to overheat the wires in this mode.

**One-Second Rule**
The so-called "one-second" rule applies for all MigaOne™ actuators, and safely assumes that, for an un-constrained actuator, the voltage and current settings that result in actuation time of one-second will not damage (overheat) the SMA wire elements, even if power is left on continuously. That is, at this power level, you cannot overheat the wire by leaving the power ON for too long (although we do not recommend this mode of operation). The safest way to determine these settings is to begin with very low voltage, and increase it slowly until full actuation occurs in one second. The following approximate values apply for the MigaOne actuators:

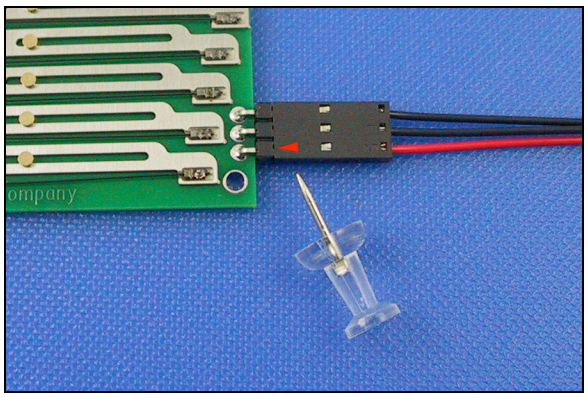
| Additional MigaOne™ Specifications | |
|---|---|
| **Wire diameter:** | 0.012" (0.3 mm) |
| **SMA wire:** | 5 segments, 10.75" Active Length |
| **Resistance:** | 3.8 ohms * |
| **10V actuation:** | ~2.7 amps, 0.5s * |
| **Mounting Holes:** | 4x 2-56 screws on 1.125" x 2.675" pattern |
| **Note: Values are approximate* | |

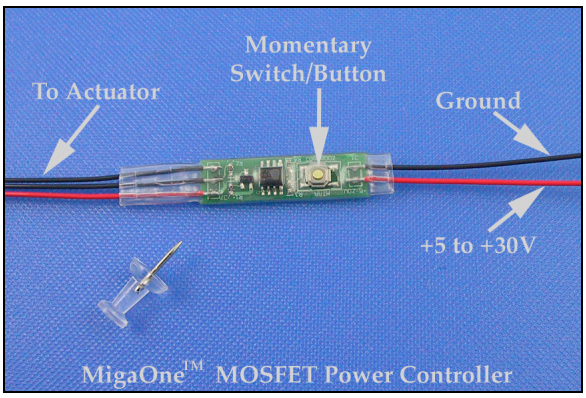
**Pulse Width Modulation (PWM) and Control Loops**
Pulse Width Modulated power can be used to optimize actuator power consumption for battery operation, or to control the position along the design stroke. After actuating, an SMA wire requires time to cool before returning to the un-powered position. If power is removed at mid-stroke, for instance, and re-applied when the wire first begins to cool, a PWM control loop can safely maintain a load at any position along the stroke.

**Powering with the Miga Analog Driver**
An analog MOSFET driver is available from Miga Motor Company to safely power the

MigaOne™ with push-button control. Future versions of the controller will enable logic pulse control. The momentary button/switch on the controller provides power while the button is pressed. The MOSFET circuit quickly removes power the moment the end-switch is reached by the output shaft, thus preventing over-heating of the SMA wires.

Connect the 3-pin connector to the MigaOne™ as shown below (left), noting the location of the arrow highlighted in red. Connect the other, loose red wire to the positive terminal of your power supply (between +5V and +30V), and the black ground wire to your power supply ground.






**Intended Operation and Limitations**

As with any motor, solenoid, or actuator, MigaOne™ SMA actuators do have their limitations, and it is important to understand these limitations in order to utilize them to their fullest potential.

1) The optimal uses for the MigaOne™ actuators are those involving powered motion in one direction only: powering OFF the actuator the moment the end of stroke is reached. The ideal example is a latch-release mechanism, whereby a spring-loaded cabinet door is released using a MigaOne™ actuator.

2) While it is possible to do high precision operations with MigaOne™ actuators (using various position encoders, for instance), SMA wires stretch or "creep" slightly with age. This may mean that periodic adjustment would be required for high accuracy positioning tasks.

3) MigaOne™ actuators have not been designed for "continuous" operation, holding a load in place for extended periods. This type of operation is possible, but not without paying careful attention to the ambient temperature environment. The maximum "duty cycle" depends upon ambient temperature conditions and load.

4) MigaOne™ actuators have a built in spring to return an un-powered actuator to the rest position if unconstrained. If constrained by a load or other friction or drag, however, the wires will elongate when cool, and 'bulging' outwards, may become trapped by other elements of the actuator. For optimal use, the actuator should be allowed to return unrestrained when power is removed.

MigaOne™ linear actuators are a well-proven and reliable technology, but we can't predict the numerous applications in which they will be used. Please contact us for assistance in safely using the MigaOne™ in your application.

When used properly, MigaOne™ actuators will provide hundreds of thousands of trouble-free operating cycles. We hope you find that Miga Motor Company devices are the solution to your motion problems.



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