Multilayer Piezoelectric Actuators

Sensors and actuators form the backbone of modern instrumentation systems in the process and manufacturing industries. While sensors are input devices that serve as the eyes and ears of machines, actuators are output devices that make things move. An actuator is essentially a mechanical or electro-mechanical device that produces motion in response to a control stimulus.

In a typical control system, sensors provide information to a microcontroller, and based on this information microcontroller activates the actuators. This sequence of operations is the foundation of all industrial control, instrumentation, and automation systems. This mechanism can be better understood through the following diagram:

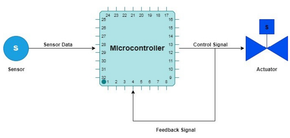

Figure 1: A simple control system

A typical actuator requires two types of signals: 1) a control signal 2) a power signal. The control signal tells the actuator when and to what extent produce the motion whereas the power signal is used for keeping the device powered up. Depending on the type of power source, actuators can be divided into three categories:

1. Hydraulic
2. Pneumatic
3. Electromechanical

Hydraulic and pneumatic actuators are mechanical type devices whereas electromechanical actuators use electrical energy. There are many different types of electromechanical actuators however in this article we will be focusing on multilayer piezoelectric actuators from KEMET.

What Are Piezoelectric Actuators?

Before discussing piezoelectric actuators, it is important to understand the concept of piezoelectricity. The ability of certain materials to develop a voltage in response to mechanical stress is known as piezoelectricity. Applying mechanical stress to a piezoelectric material will develop a voltage at the output of the material. On the contrary, applying an input voltage to the piezoelectric material will cause mechanical motion at the output such as sound, vibration, or displacement. The phenomenon of piezoelectricity is explained in the following diagram:

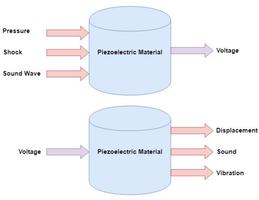

Figure 2: Piezoelectric Phenomenon

Using the principles of piezoelectricity, various types of electrical and electronic devices can be constructed including sensors and actuators. Based on their construction, piezoelectric actuators are of two types: 1) Single-layer actuators 2) Multi-layer actuators.

Comparison of Single-Layer & Multi-Layer Piezoelectric Actuators

As the name suggests, single-layer piezoelectric actuators are made from a single piezoelectric element whereas the multi-layer piezoelectric actuator consists of multiple layers of piezoelectric material stacked on top of each other. Following is the diagram showing both types of actuators:

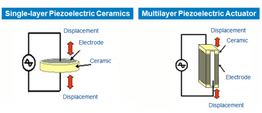

Figure 3: Single-layer vs. Multi-layer Piezoelectric Actuators

Multi-level piezoelectric actuators deliver a much wider range of forces and displacements for the same amount of applied voltage. This is because the stacking-up of piezoelectric elements results in a multiplicative effect. A single-layer piezoelectric actuator produces 1µm displacement at 1KV. In comparison, the multi-layer piezoelectric actuator produces 100µm displacement at 100V. Therefore, a multi-level piezoelectric actuator produces 100 times more force at 10 times less voltage. These numbers prove that the performance difference of these two types of actuators is massive. Low operating voltages with high magnitudes extend the capabilities of piezoelectric actuators and make them suitable for a wider range of control applications. The ceramic material used in KEMET's multi-level piezoelectric actuators is the PZT (Lead Zirconate Titanate).

How Piezoelectric Actuators compare to Electromagnetic Actuators?

There are two major technologies used for the construction of electromechanical actuators: 1) electromagnetism 2) piezoelectricity. Piezoelectric actuators are better than electromagnetic actuators in terms of force output, accuracy, response time, efficiency, control, and size. A comparison of these two actuator technologies is presented in the figure below:

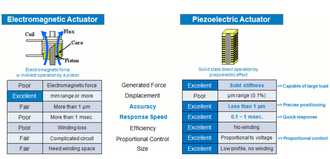

Figure 4: Comparison of electromagnetic and piezoelectric actuators

It is clear from the comparison, that piezoelectric actuators deliver excellent performance in terms of force, accuracy, response time, control and size. The only area where these actuators lag behind electromagnetic actuators is displacement. The displacement produced by electromagnetic actuators falls within the range of several millimeters whereas piezoelectric actuators produce displacement of the order of a few micrometers. However, with the advancements in multilevel piezoelectric actuator technology, the displacement response is expected to get better with time.

How Are KEMET Piezoelectric Actuators Better?

A closer look at KEMET piezoelectric actuators reveals some key structural changes as compared to the conventional piezoelectric actuators. The primary difference lies in the placement and structure of electrodes. Conventional piezoelectric actuators feature partial internal electrodes whereas the KEMET piezoelectric actuators have full internal electrodes. The ability to withstand mechanical stress is lower in partial internal electrodes due to which they easily get cracked or fractured. On the contrary, full internal electrodes exhibit high reliability, durability, and efficient performance. The difference in the electrode structure of conventional and KEMET piezoelectric actuators is depicted in the figure below:

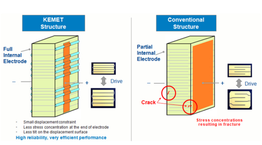

Figure 5: KEMET vs. Conventional Piezoelectric Actuators

KEMET Piezoelectric Actuator Offerings

KEMET offers a wide range of multilevel piezoelectric actuators which cover a broad spectrum of industrial and commercial applications. Multilevel piezoelectric actuators from KEMET fall under two main major categories:

1. Resin-coated type actuators
2. Metal-cased type actuators

Resin-coated actuators are standard-type actuators with a thin white coating. There are two product series in this category i.e AE and AER. AE series consists of standard-type actuators in a rectangular form factor whereas the AER series consists of ring-type resin-coated actuators.

Metal-cased type category consists of three product series i.e ASB, ASL, and AHB. These are high-performance actuators with increased thermal ratings. ASL series offers thermal ratings up to 150°C. AHB series offers a thermal rating of 85°C with higher displacement.

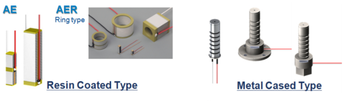

Figure 6: KEMET Actuator Offerings

Inside Structure of Metal Cased Type

Figure 7: Construction of Metal Type Piezoelectric Actuator

Applications of Multilevel Piezoelectric Actuators

Multilevel piezoelectric actuators can be used in a wide range of applications. Some of the major applications of these high-performance actuators include:

1. Precision machining and position control systems (XY stages, part feeders, knitting machines)
2. Semiconductor assembling and manufacturing (mass flow controllers, stepper motors, and nano-printing machines)
3. Optical instrumentation (lens positioning, autofocus microscopes)
4. Instrumentation (vibration control, control valves, test instruments)

Conclusion

Mechanical and electromechanical actuators are an essential part of all types of instrumentation and control systems. Piezoelectric actuators are electromechanical actuators that convert electrical energy into mechanical motion. KEMET multilevel piezoelectric actuators offer many advantages over single-layered and conventional piezoelectric actuators. They exhibit superior accuracy, response time, efficiency, and control characteristics. Due to this reason, they are well-suited for applications requiring a high degree of precision, accuracy, and efficiency. So wait no more. Boost the efficiency and performance of your engineering systems with our AE, AER, ASB, ASL, and AHB series multi-level piezoelectric actuators.