Technical Note – Piezo Controller Thermal Stability Comparison

Piezo controller design can have a significant effect on thermal stability causing excessive error in precision motion applications. In this technical note, we briefly describe some techniques used for controlling thermal effects and compare the thermal stability of our piezo control electronics with a competitive design.

Thermal stability is paramount in any precision process. Thermal drift of mechanical and electrical components can cause errors that far exceed any tolerance stackup of components or positioning errors of motion equipment used in that process. There are three common ways that designers can manage thermal effects in precision machinery and instrumentation.

1. Control the environment where the instrument or machine resides. Typically the best approach as it addresses the root of the problem, this technique can be very costly as environmental control requires air handling, conditioning equipment, and a temperature control system.

2. Measure thermal variations and compensate with control systems. This technique can be effective, but typically requires a sensor network and an accurate system model. The system model is usually a unique model that describes the instrument, machine, and surroundings to a reasonable level of accuracy

3. Design the instrument or machine to be insensitive to thermal changes. This technique is usually the most difficult to employ, but when implemented correctly, can be very robust and cost-effective.

Piezoelectric nanopositioning stages with capacitance sensor feedback are commonly used in precision processes due to their high levels of accuracy, repeatability, and resolution coupled with millisecond response times. To achieve long-term stability with capacitance sensor feedback piezo stages, it is well-known that a robust mechanical design is necessary. However, most users don't realize that the piezo controller design can have a large effect on the thermal stability of the instrument or machine. To make matters worse, the piezo stage electronics are typically placed in electrical cabinets or in areas that are not temperature controlled, causing apparent thermal drift of the process.

Aerotech has designed our A3200 and Ensemble QLAB, QDe, and QLe controllers with an advanced thermal stability feature that makes the capacitance sensor feedback circuit largely insensitive to environmental changes. To illustrate the effect of this feature, a test was performed on both an Aerotech A3200 QLe controller and a leading competitive controller. To eliminate the differences in the stage designs, an ultra-stable, low-CTE (Coefficient of Thermal Expansion) capacitor (1.3 nm/°C effective thermal sensitivity) was connected to the feedback input of both controllers. This capacitor mimics a piezo stage with capacitance sensor feedback sitting at a constant position. The controllers and feedback capacitors were placed into a small thermal enclosure where the air temperature was varied by approximately 7°C with a heating cycle of 1 hour and a cooling cycle of 1 hour. The position feedback and air temperature were monitored over a period of 70 hours. The results of this test are shown in Figure 1.

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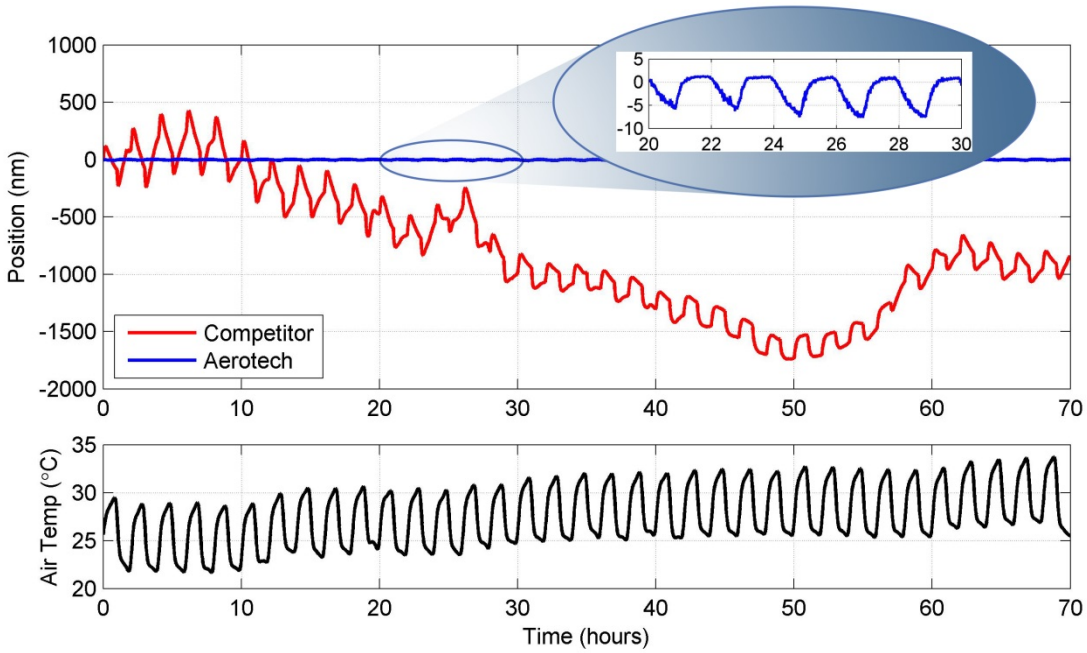

Figure 1. Thermal stability comparison between an Aerotech A3200 QLe controller and a leading competitive controller.

At a 2 hour heat-cool frequency, the test results show the QLe thermal sensitivity to be approximately 1.4 nm/°C while the competitive controller exhibited a thermal sensitivity of approximately 59 nm/°C.

Summary

Thermal management is critical in precision processes. In addition to the stage mechanical design, the electronics used in piezo stage capacitance feedback play a vital role in maintaining process thermal stability. Aerotech's high-performance piezo controllers show 40 times higher thermal stability than the leading competitive controller.

Contact Aerotech today to discuss your application and discover how Aerotech's Q-Series™ piezo controllers and nanopositioning stages can improve your process.

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