PIRest Technology – New Experimental Findings

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Abstract

The first paper on PIRest technology was published at the "euspen international conference and exhibition" in Venice, Italy in 2018. The technology is used in semi-active and long-term stable micro- and nanopositioning applications and it is based on ferroelectric domain switching processes in soft, low voltage PZT ceramics (LVPZT). By applying special electrical signals, which are calculated by a phenomenological model, the remanent strain of LVPZT actuators can be changed with nanometer resolution. This allows displacements in the micrometer range without supplying any offset voltage. The technology simplifies and significantly accelerates adjustments and error corrections in hard-to-access areas, prevalent, for example, in vacuum, synchrotron and astronomy applications.

Meanwhile, the technology has been extended by several new experiments that will be part of this work. The technology works with soft, high voltage piezo ceramics (HVPZT), too. This has been proven by using three HVPZT actuators in a tripod setup. As a result, the technology can also be used for nanometer-precise alignments of high loads with up to several tons. By using the new drive signal shaping, the dynamic impact during the positioning process can be minimized, which is essential in high load applications.

The behavior of the PIRest technology at cryogenic temperatures is very interesting. By adjusting the drive signals at very low temperatures, experiments show that the PIRest stroke can even be increased by a factor of four compared to the adjustment range at room temperature. This offers a wide range of new applications.

The continued lifetime and long-term stability tests demonstrate that the PIRest operation mode has no influence on the lifetime of the piezo actuators and that the long-term stability is mainly influenced by temperature changes over several months.

The present phenomenological model only works in open loop by commanding relative target positions. Nevertheless, it achieves a positioning accuracy of ±3.5% of the actuator's adjustment range. Meanwhile, a new PIRest control algorithm for a closed-loop PIRest operation was developed and verified too. Consequently, the positioning accuracy can be improved even more. The PIRest closed-loop concept can't be compared to the concepts that are widely known for conventionally driven piezo systems. Two conditional control loops are used to achieve the target position by minimizing the position error.