

# Fast Tool Servo for Non-Circular Turning

## Solid State Piezo Drives Achieve Higher Speed, Precision

### Keywords:

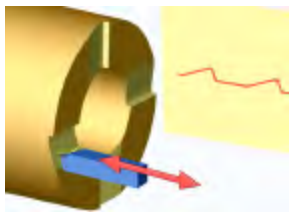
Single Point Turning, Diamond Turning, Out-of-round Turning & Drilling, Eccentric Machining, Grinding, Precision Workpiece Adjustment, Vibration Cancellation, Piezo Motor.

### Why Piezo Technology (PZT)?

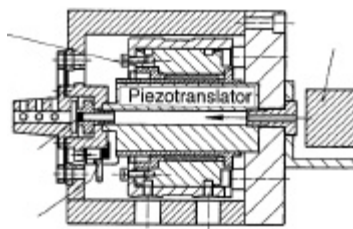
Piezo actuators are solid state motion drivers offering ideal properties for high-speed precision motion.

### Piezo Advantages:

- < 1 nm RMS Resolution
- All-Electronic Control, no Hydraulic or Pneumatic Lines
- Zero Maintenance, Wear & Tear (Dynamic Reliability >10<sup>9</sup> Cycles)
- Very High Stiffness (to 4000 N/  $\mu\text{m}$ , 20,000 lb/mil)
- Zero Friction and Stiction
- Sub-Millisecond Responsiveness
- Holds Position with zero Power



Principle of a PZT driven contouring tool servo

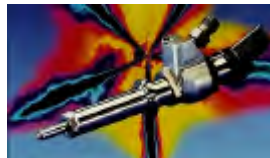


Design of a Fast Tool-Servo for diamond turning of optics. (IPT, piezo actuator: PI)

### Reliability, Experience

Piezo actuators have been used in precision motion control applications for more than 30 years. Because of their straight-forward control, ruggedness and ultra-fast response, automotive suppliers employ PZT actuators in their latest generation common rail diesel fuel injection systems where they replace solenoids.

Automotive suppliers employ piezo actuators in their latest generation common rail diesel fuel injection valves where they replace solenoids. PZTs are rugged and ultra-responsive (sub-msec).  
Photo: Siemens



### Why PI?

PI is the leading manufacturer of PZT-based precision positioning systems and PZT ceramics with more than 30 years experience. We design standard and custom engineered solutions for high MTBF applications from semiconductor manufacturing to the industrial robustness requirements of precision machining. We provide complete sub-systems or components (PZT ceramics, control electronics, sensors). Our high-speed systems are controlled via digital or analog interfaces.



Fast Tool-Servos with Solid State Piezo Drives (excentric machining of pistons)



Fast Tool-Servos with Solid State Piezo Drives (excentric turning of bearings)

### Other Piezo Actuator Applications:

- **Workpiece Adjustment:**  
PZT driven nanopositioning systems are also ideal for nanometer level workpiece adjustments during machining of critical parts. Up to 6 degrees of freedom can be adjusted with nanometer precision.
- **Precision Grinding:**  
XY or XYZ nano-dithering stages improve finish by reducing surface roughness.
- **Vibration Cancellation:**  
PZT actuators can be used to cancel vibrations in machines or damp chatter in rolling applications improving throughput & quality.
- **Smart Structures:**  
If used as active members, PZT actuators allow new machine designs, lighter, yet stiffer than conventional constructions.
- **Thermal Drift Compensation:**  
PZT actuators actively compensate for thermal drift in machine components.
- **Profiling of CBN Grinding Wheels:**  
PZT actuators replace cam following mechanisms and allow instant execution of random computer generated profiles.

# PZT Actuator Solutions for Precision Machining

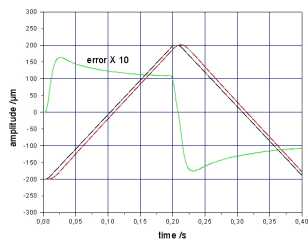
## A) Complete Sub-System Solution: Tool Servo, Amplifier, Controller



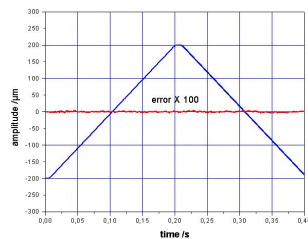
Several PZT driven tool servos (match box cars and connecting rod for size comparison)

This approach provides the highest performance. All components (actuator, guiding system, the sensor, amplifier and controller) are optimized and tuned to achieve the maximum bandwidth, linearity and resolution in the machining application. The position sensor is integrated in the tool servo and measures the tool position directly, at the tip. Our designs incorporate FEA optimized, wire EDM cut flexures for zero friction, stiction and maintenance and exceptional guiding precision and stiffness.

PI has been working with leading precision engineering companies on custom fast tool servo designs from precision optics diamond turning, to out-of-round turning of pistons and bearings and fiber-optic connectors. Sophisticated digital control algorithms (Adaptive Signal PreShaping™ and Digital Dynamic Linearization) were developed to increase bandwidth and dynamic precision by several orders over conventional solid-state driven tool servos.



Control of a conventional closed-loop PZT positioning system, triangular waveform, 400 µm Peak-Peak. Dynamic error max. 15 µm. Blue: target position. Red: actual position. Green: dynamic positioning error X 10



Same signal, Adaptive Digital Linearization: Red: dynamic error X100, max. 0.1 µm (4 micro inch)



2000 watt, energy-recovery, rackmount PZT power amplifier with fast tool-servo and match box car for size comparison

## B) Component Solution: PZT Actuators, PZT Ceramics, Power Amplifiers and Drivers, Controllers, Position Sensors

PI offers the largest selection of industrial-reliability piezo actuators and translators worldwide. We manufacture our own ceramics, tailored specifically for high-precision actuation purposes. In addition to piezoceramic actuators we also manufacture non-contact position sensors providing nanometer level accuracy and control electronics for both sensors and actuators.



Variety of custom and standard industrial PZT actuators



Custom actuator for explosive environments



Custom high-load PZT actuator for preload adjustment



Actuator embedded in carbon fiber rod (smart structure, active vibration cancellation)



XY-tool servo for fiber optic connector machining



Custom tool servo actuator for out-of-round drilling