



Aerotech Capabilities in Big Science

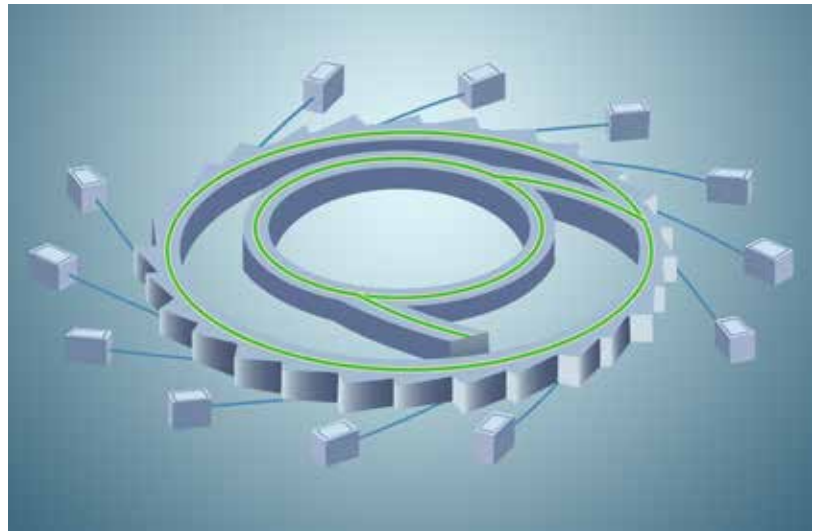
The Most Advanced Motion Controls

Pushing the boundaries of understanding in fields like biology, chemistry, materials science, engineering, and physics increasingly requires more precise control of the highest precision experimental equipment. To enable imaging of atomic-scale structures and processes in real time, scientists need the best tools available. Aerotech offers the highest precision end-station positioning solutions for:

- Diffraction
- Crystallography
- Tomography
- Laminography
- Monochromator Positioning
- X-Ray Mirror Inspection

Aerotech controls and positioning systems are designed to be the most powerful, flexible, and easy-to-use motion controllers on the market. We can help you increase the accuracy and reliability of experimental data, allow both operators and administrators faster access to diagnostic tools and advanced features, and decrease installation or changeover time.

- Fast and easy setup
- User-friendly, modern Windows® interface
- One-click performance tuning
- Flexible electronics: drive DC brush, brushless, stepper, and piezo-driven mechanical systems with one user interface
- PWM and linear amplifier options for cost-effective or high-performance applications
- **EPICS and TANGO drivers via ASCII or Ethernet**
- Local support and expertise via native speakers in the US, Canada, UK, France, Germany, Italy, India, China, Taiwan, Japan, and Thailand



Aerotech Motion Controller Solutions Deliver High Performance with Quick and Easy Setup

Increased Performance	Ease of Use	Reduced Setup Time
Decrease move and settle time	One software environment	Setup wizards
Increase contour speeds and accuracy	Extensive diagnostics	Configurable autotuning tools
Easily remove machine resonance	Multiple languages	Software oscilloscope

Single-Source Provider

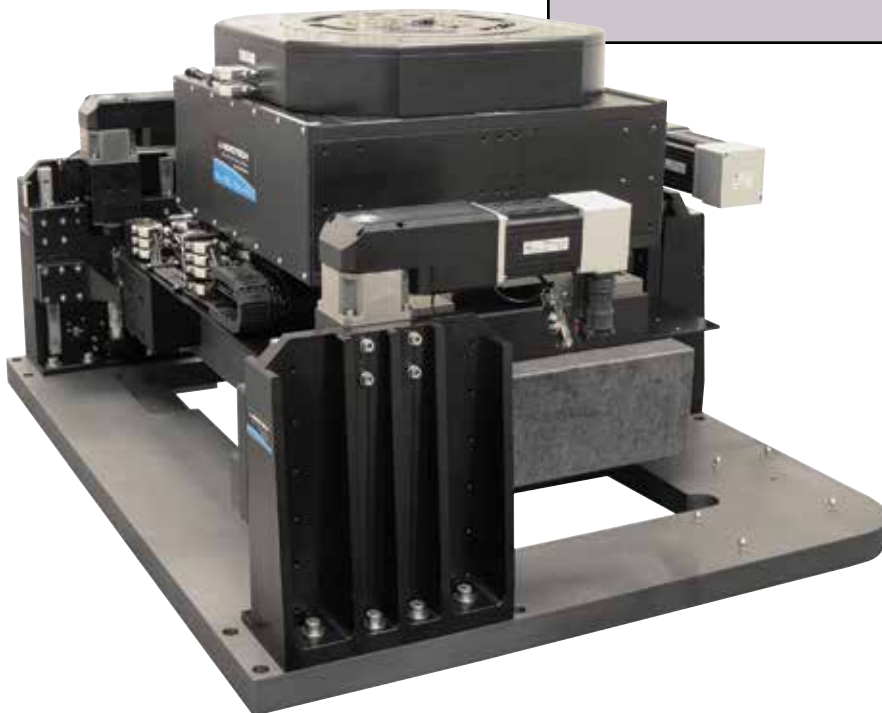
- Motion Controls
- Software
- Amplifiers/Drives
- Motors
- Positioning Stages
- Systems

The Most Advanced Motion Systems

Minimizing spatial errors including accuracy, repeatability, and sphere of confusion to the nanometer-level allows for more accurate imaging and higher quality data. Stepper, servo, and piezo actuator technology can be mixed and matched to optimize each piece of the instrument. This provides a high degree of flexibility for future experiments and upgrades with minimal difficulties.



Linear air-bearing flatness	<1 μm
Linear air-bearing pitch/roll/yaw	± 1 arc-sec
Fine positioning piezo stages	Sophisticated slip-ring arrangement allows 360 degree continuous travel in theta
Lift/tip/tilt	3-point mount Z axes with kinematic mount offer precision lift, tip, and tilt motion for entire assembly



Crystallography Sample Positioning



Design Features

- Minimizing spatial errors including accuracy, repeatability, and sphere of confusion to the nanometer-level allows for more accurate imaging and higher quality data
- Optional cable management simplifies experimental setup and reduces operating complexity

Grazing Incidence Mirror Inspection

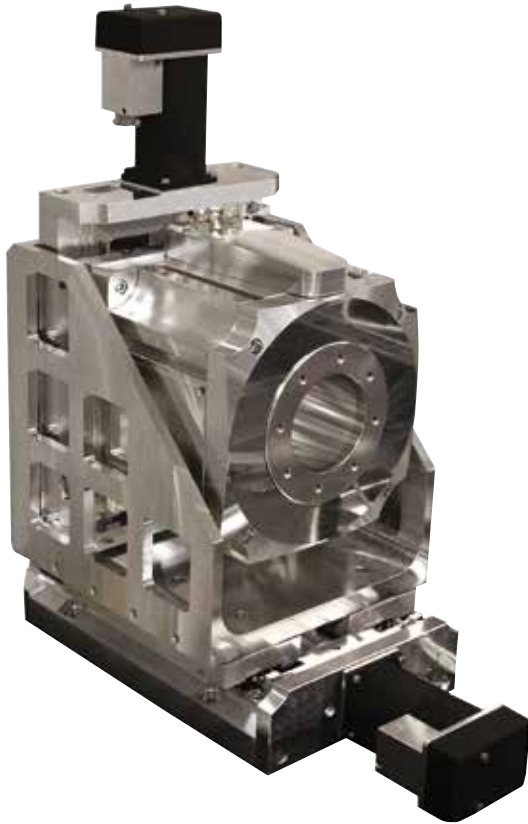
Light sources use long (~1 m) mirrors known as grazing incidence mirrors coated with various substances to direct and focus X-rays. X-rays are difficult to focus with lenses, so mirrors are the solution for many of these applications.

The system shown here was designed to inspect the flatness and surface quality of these mirrors. The key performance requirement was outstanding angular motion performance. Pitch, roll, and yaw were less than 7 arc-sec over 1 m of travel.

The performance of grazing incidence X-ray mirrors depends heavily on the slope of the mirror surface. It is critical to measure that slope error to the highest degree possible. Aerotech's air-bearing stages offer the ultimate angular stability for optical measurement equipment used to characterize these mirrors.

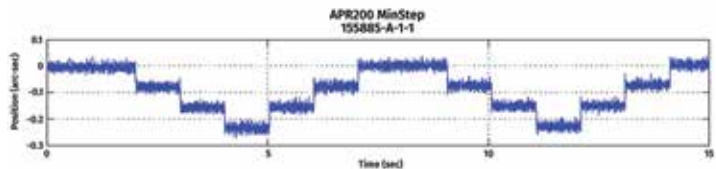


Monochromator Crystal Positioning



This system is used for positioning of diffraction crystals for X-ray beam conditioning in a high-vacuum environment. Very fine step-size and repeatability on the rotary axis were the key requirements in order to position crystals used in the beamline. Aerotech's APR200 rotary stage achieved the specifications easily, and there are no competitive solutions for a mechanical-bearing rotary stage with the required accuracy/repeatability and step size.

Motion	X, Z, Theta: ATS2000 and APR200
Critical Specification	Rotary step size: 0.1 arc sec or better
Environment	High Vacuum



Custom Systems



Vacuum Systems

- Our wide range of standard products are easily configured for vacuum applications
- Three vacuum level options:
 - Low Vacuum Option (10^{-3} torr)
 - Standard Vacuum Option (10^{-6} torr)
 - High Vacuum Option (10^{-8} torr)
- This machine is an example of how we combine standard and custom products into very specialized vacuum-rated automation solutions

HexGen[®] Hexapods

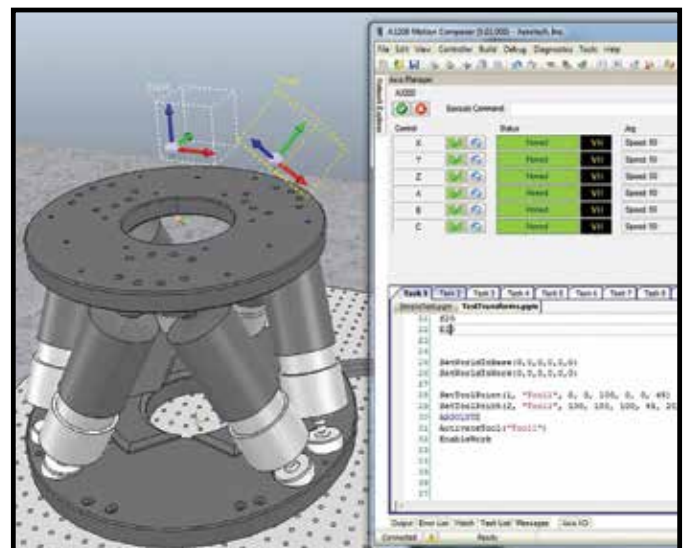
The next-generation in 6 degree-of-freedom positioning



HEX500-350HL

HexGen[®] hexapods coupled with our control and visualization software make accurate six degree-of-freedom positioning incredibly easy.

- Six degree-of-freedom positioning with linear travels to 110 mm and angular travels to 40°
- Precision design with guaranteed positioning accuracy specifications
- Minimum incremental motion to 20 nm in XYZ and 0.2 μ rad in $\theta_x\theta_y\theta_z$
- Flexible configurations and customization
- Vacuum preparation available upon request
- Powerful controls and software with visualization of work and tool coordinate systems
- Absolute encoders optional



HexGen Visualization Software

HEX RC Multi-Axis Robotic Controller



QNP2 Series Piezo Nanopositioners

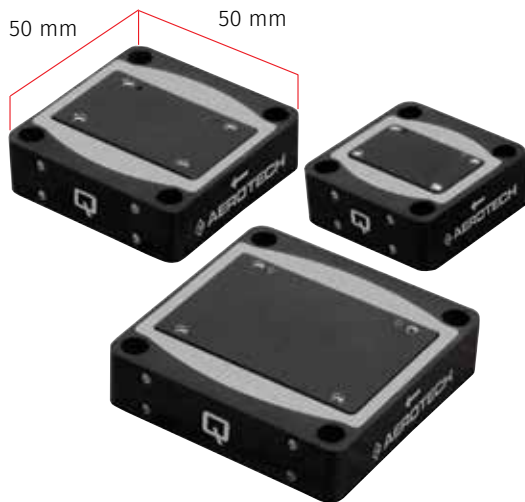


QNP2 Series

- Travels to 120 μm x 120 μm
- 50 x 50 mm square clear aperture
- Superior multi-axis accuracy via parallel-kinematic design
- High-stiffness and dynamics resulting in high process throughput
- High-precision, frictionless flexure guidance
- Patent-pending design provides unmatched geometric performance
- Long device lifetime
- Superior positioning resolution and linearity with direct-metrology capacitive sensor option
- Open-loop and vacuum versions

QNP2 Series	
Features	QNP2-100-100XYA
Closed-Loop Travel (X x Y)	100 μm x 100 μm
Open-Loop Travel, -30 to +150 V	120 μm x 120 μm
Linearity	0.01%

QNP-L Series Piezo Nanopositioners



QNP-L Series

- High-precision, frictionless flexure guidance system
- Proprietary piezo multi-layer stack actuator
- Closed-loop travel options of 100, 250, and 500 μm
- High-positioning resolution and linearity with direct-metrology capacitive sensor options
- Mounting compatibility with other QNP-series piezo nanopositioners (XY and Z)
- Open-loop and vacuum versions

QNP-L Series			
Features	QNP-40-100L	QNP-50-250L	QNP-60-500L
Closed-Loop Travel	100 μm	250 μm	500 μm
Open-Loop Travel	120 μm	300 μm	600 μm
Linearity	0.01%	0.01%	0.007%

QNP-XY Series Piezo Nanopositioners



QNP-XY Series

- High-precision, frictionless flexure guidance system
- Proprietary piezo multi-layer stack actuator
- Closed-loop travel options of 100, 250, and 500 μm
- High-positioning resolution and accuracy with direct-metrology capacitive sensor options
- Mounting compatibility with other QNP-series piezo nanopositioners (L and Z)
- Open-loop and vacuum versions

QNP-XY Series			
Features	QNP-40-100XY	QNP-50-250XY	QNP-60-500XY
Closed-Loop Travel	100 μm x 100 μm	250 μm x 250 μm	500 μm x 500 μm
Open-Loop Travel	120 μm x 120 μm	300 μm x 300 μm	600 μm x 600 μm
Linearity	0.01%	0.01%	0.007%

QNP-Z Series Piezo Nanopositioners



QNP-Z Series

- High-precision, frictionless flexure guidance system
- Proprietary piezo multi-layer stack actuator
- Closed-loop travel options of 100, 250, and 500 μm
- High-positioning resolution and accuracy with direct-metrology capacitive sensor options
- Mounting compatibility with other QNP-series piezo nanopositioners (L and XY)
- Open-loop and vacuum versions

QNP-Z Series			
Features	QNP-40-100Z	QNP-50-250Z	QNP-60-500Z
Closed-Loop Travel	100 μm	250 μm	500 μm
Open-Loop Travel	140 μm	300 μm	600 μm
Linearity	0.01%	0.01%	0.007%

The Aerotech Controller Advantage



High Performance

- Improve productivity, accuracy, and reliability and deliver results!

Easy to Use

- Common interface and advanced diagnostics for all platforms shorten development and maintenance time

Flexible

- Total control to customize the system without compromise

Advanced Control Technology

- Achieve better control with existing mechanical systems

Networked

- Communicate with equipment on the factory floor, in your office, or across the globe

Design Features

- Output power range of 10 or 20 A peak

Scalable

- Use for simple or complex systems

Lowest Cost of Ownership

Ndrive[®] MPC Compact, Low Cost, 8-Axis Controllers



Design Features

- Optimized design uses 46% less space than Ndrive MP
- 10 A peak output per axis
- 80 VDC (max) DC input
- Supports brushless, DC brush, and stepper motors
- Eight primary and four auxiliary encoder inputs
- 32X inputs, 32X outputs, opto-isolated
- 4X analog inputs, 4X analog outputs
- Efficient PWM power stage

A3200 Motion Server



Design Features

- Complete motion capabilities include: point-to-point; linear, circular, helical, and spherical interpolation; velocity profiling; electronic gearing; on-the-fly trajectory modification; high-speed I/O; camming
- 1 to 32 axes of scalable, synchronized motion
- Utilizes the power of the PC to eliminate the motion control card
- Uses commercially available FireWire® determinism for communications between drives and controller
- Programmable in native RS-274 G-code, AeroBasic command set, C, C++/CLI, .NET, MATLAB®, LabVIEW®, or IEC 61131-3 (LD, FBD, ST) for flexibility
- Runs brushless servo, brush, stepper, or voice coil
- Get details on our Order-to-Ship Program that could have this product shipped to you in one week

Ensemble®



Design Features

- Up to 10 axes of coordinated motion
 - Multiple 10-axis systems can be controlled by a single PC via Ethernet or USB
 - Controller architecture capable of coordinating motion of up to five independent tasks
 - Capable of driving and controlling linear or rotary brushless, DC brush servo, and micro-stepping motors
- Complete motion capabilities include: point-to-point, linear and circular interpolation, electronic gearing, velocity profiling
 - Runs brushless servo, brush, stepper, or voice coil
 - Get details on our Order-to-Ship Program that could have this product shipped to you in one week

Soloist®



Design Features

- Positioning control for brushless, DC brush, or stepping motors
- Available in models up to 150 A peak current
- Ethernet, USB, or RS-232 connectivity
- Digital current loop
- Integral shunt resistor network or optional external shunt
- Optional encoder multiplier (up to x1000)
- CE approval
- Linear amplifier (HLe, ML) for low noise, ultra-high-performance applications
- Runs brushless servo, brush, stepper, or voice coil
- Get details on our Order-to-Ship Program that could have this product shipped to you in one week

Npaq® Drive Rack



Design Features

- 3U plug-in drives
- 19 inch rack-mount design
- Flexible design provides the ability to drive brush, brushless, or stepper motors with the same amplifier
- 5 A to 30 A peak output current
- PWM or linear amplifier
- Integral power supplies
- IEEE-1394 FireWire® interface
- Digital current, velocity, and position loops for improved motion stability
- Optional Ethernet for I/O expansion
- Integrated encoder multiplier for higher throughput and reduced wiring
- Encoder feedback
- NRTL safety certification and CE approval

Npaq[®] MR Drive Rack



Design Features

- 3U, 19-inch rack-mount design with integral drives
- Flexible design provides the ability to drive brush, brushless, or stepper motors with the same amplifier
- 5 A continuous, 10 A peak output current
- PWM or linear amplifiers
- Integral power supplies
- IEEE-1394 FireWire[®] interface
- Digital current, velocity, and position loops for improved motion stability
- Optional Ethernet for I/O expansion
- Integrated encoder multiplier for higher throughput and reduced wiring
- NRTL safety certification and CE approval

Ensemble[®] Epaq Stand-Alone Controller



Design Features

- Up to six integrated drives in one stand-alone controller
- Additional external drive axes can be added to provide up to nine axes of coordinated motion
- Controller architecture capable of coordinating motion of up to five independent tasks
- Capable of driving and controlling linear or rotary brushless, DC brush servo, and micro-stepping motors
- Complete motion capabilities include: point-to-point, linear and circular interpolation, electronic gearing, velocity profiling
- Program in AeroBasic with the IDE, Microsoft .NET including C#, VB.NET, C++/CLI, LabVIEW[®], and MATLAB[®]
- Remote ASCII interface provided for Windows[®] or non-Windows[®] programs (including Linux) to command the Epaq through standard Ethernet, RS-232 port, and optional IEEE-488

Ensemble[®] LAB Stand-Alone, Multi-Axis Motion Controller



Design Features

- Up to 4 axes of brush, stepper, or brushless servomotors
- Aerotech's FlashConfig feature automatically configures axis parameters based on the connected stage type
- Touch screen with intuitive menu-driven interface for quick and easy access to system functionality
- Joystick input for manual control of motor positions
- Ethernet and USB 2.0 communication interfaces
- ASCII-based command protocol for Windows[®] or Linux remote control
- Advanced Windows[®]-based remote diagnostics, tuning and programming interface software
- Program in AeroBasic using Aerotech's IDE or create custom remote interfaces with Microsoft .NET including C#, VB.NET, C++/CLI, LabVIEW[®], and MATLAB[®]

Ensemble® QLAB Stand-Alone, 1-4 Axes Piezo Motion Controller



Design Features

- Control 1 to 4 axes of piezo nanopositioning stages in open or closed-loop operation
- Configurable open-loop and closed-loop control in one controller platform
- High-precision 20-bit sensor resolution for capacitive sensor feedback in closed-loop operation
- Thermally-stable feedback circuit design
- Configurable, high-resolution analog input for external feedback sensor integration or command generation
- Advanced control features such as learning control, harmonic cancellation, and command shaping improve tracking error and overall process throughput
- Touch screen with intuitive menu-driven interface for quick and easy access to system functionality
- Ethernet and USB 2.0 communication interfaces

Ndrive® HPe PWM Digital Amplifier



Design Features

- Wide output power range from 10 A peak to 200 A peak at 320 VDC
- 3-phase AC line input
- CE approved and NRTL safety certification
- PWM power stages
- Digital current, velocity, and position loops for improved motion stability
- Optional integrated encoder multiplier for higher throughput and reduced wiring
- Flexible design provides ability to drive brushless and DC brush-type servomotors as well as stepping motors
- Encoder or resolver feedback

Ndrive® CP PWM Digital Amplifier



Design Features

- Output power range 10 A peak to 30 A peak at 320 VDC
- Single-phase AC line input
- CE approved and NRTL safety certification
- PWM power stages
- Digital current, velocity, and position loops for improved motion stability
- Optional integrated encoder multiplier for higher throughput and reduced wiring
- Flexible design provides ability to drive brushless and DC brush-type servomotors as well as stepping motors
- Encoder or resolver feedback

Ndrive® MP PWM Digital Amplifier



Design Features

- Output power range up to 10 A peak
- DC input
- CE approved and NRTL safety certification
- PWM power stages
- Digital current, velocity, and position loops for improved motion stability
- Optional integrated encoder multiplier for higher throughput and reduced wiring
- Flexible design provides ability to drive brushless and DC brush-type servomotors as well as stepping motors
- Encoder feedback

Ndrive[®] HLe Linear Digital Amplifier



Design Features

- Output power range of 10 A or 20 A peak
- Single-phase AC line input
- CE approval
- Linear power stages
- Digital current, velocity, and position loops for improved motion stability
- Optional integrated encoder multiplier for higher throughput and reduced wiring
- Flexible design provides ability to drive brushless and DC brush-type servomotors as well as stepping motors
- Encoder or resolver feedback

Ndrive[®] ML Linear Digital Amplifier



Design Features

- Output power of 10 A peak
- DC input
- CE approval
- Linear power stages
- Digital current, velocity, and position loops for improved motion stability
- Optional integrated encoder multiplier for higher throughput and reduced wiring
- Flexible design provides ability to drive brushless and DC brush-type servomotors as well as stepping motors
- Encoder or resolver feedback

Ensemble® QDe High-Performance Networked Desktop Piezo Drive



Design Features

- Networkable with any Ensemble drive to control up to ten axes of piezo and/or servomotor stages
- Multi-axis Position Synchronized Output (PSO) for real-time triggering of events
- High-precision 20-bit sensor resolution for capacitive sensor feedback
- Thermally-stable feedback circuit design
- Configurable 18-bit analog input for external feedback sensor integration or command generation
- Advanced control features such as learning control, harmonic cancellation, and command shaping improve tracking error and overall process throughput
- Ethernet and USB 2.0 communication interfaces
- Advanced Windows®-based remote diagnostics, tuning, and programming interface software
- Program in AeroBasic using Aerotech's IDE or create custom remote interfaces with Microsoft .NET including C#, VB.NET, C++/CLI, LabVIEW®, EPICS, MATLAB®, and TANGO
- OEM versions available

Ensemble® QL and QLe Networked Panel-Mount Piezo Drive



Design Features

- Networkable with any Ensemble drive to control up to ten axes of piezo and/or servomotor stages
- Multi-axis Position Synchronized Output (PSO) for real-time triggering of events
- High-precision 20-bit sensor resolution for capacitive sensor feedback
- Thermally-stable feedback circuit design
- Configurable 18-bit analog input for external feedback sensor integration or command generation
- Advanced control features such as learning control, harmonic cancellation, and command shaping improve tracking error and overall process throughput
- Ethernet and USB 2.0 communication interfaces
- Advanced Windows®-based remote diagnostics, tuning, and programming interface software

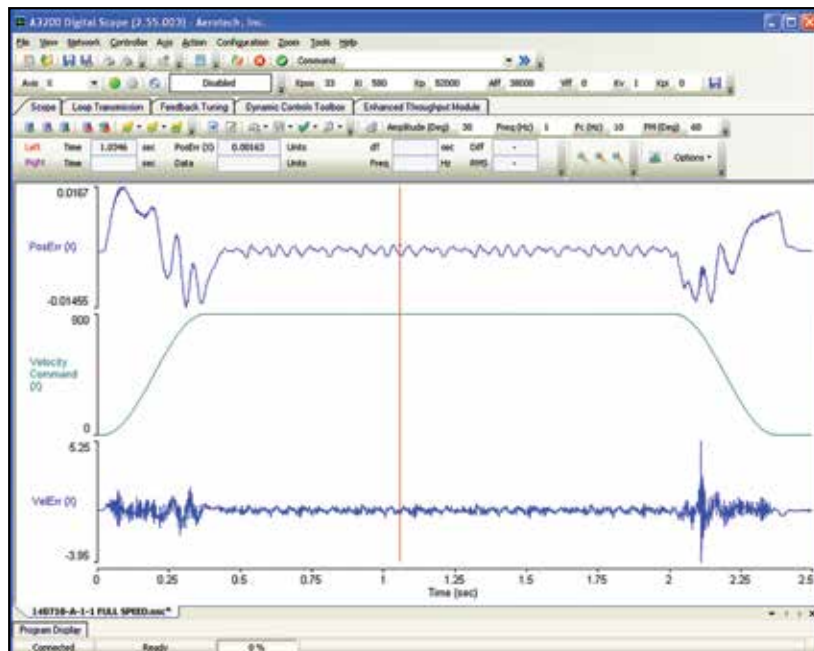
Extensive Diagnostics Shorten Debug & Startup Time

The screenshot shows the Ensemble software interface with several callout boxes pointing to specific features:

- System toolbar for system control**: Located at the top left of the interface.
- Axis toolbar for control of each axis**: Located below the system toolbar.
- Standard toolbar for program control**: Located at the top right of the interface.
- Issue immediate commands without operator interface open**: Located at the top right, pointing to a specific button.
- Control all axes at once**: Located on the left side, pointing to a button.
- Multiple tabs for organized programming**: Located on the left side, pointing to the tabbed interface.
- View task status as needed**: Located on the left side, pointing to a task status window.
- Watch any variables as the program runs**: Located on the left side, pointing to a variable watch window.
- Pop-up error reporting**: Located on the left side, pointing to an error message box.
- Compiler output screen**: Located on the left side, pointing to a text window.
- Dockable windows for custom work environment**: Located on the right side, pointing to a docked window.
- Configurable to see only the information you want**: Located on the right side, pointing to a window's configuration options.
- Real-time readout of system state variables**: Located on the right side, pointing to a data display window.
- Real-time access to system signals**: Located on the right side, pointing to a signal display window.
- Real-time reporting of all faults**: Located on the right side, pointing to a fault log window.
- Real-time system information**: Located on the right side, pointing to a system status window.

Linear Amplifier Technology

Linear amplifiers provide low noise, low power, and high velocity stability

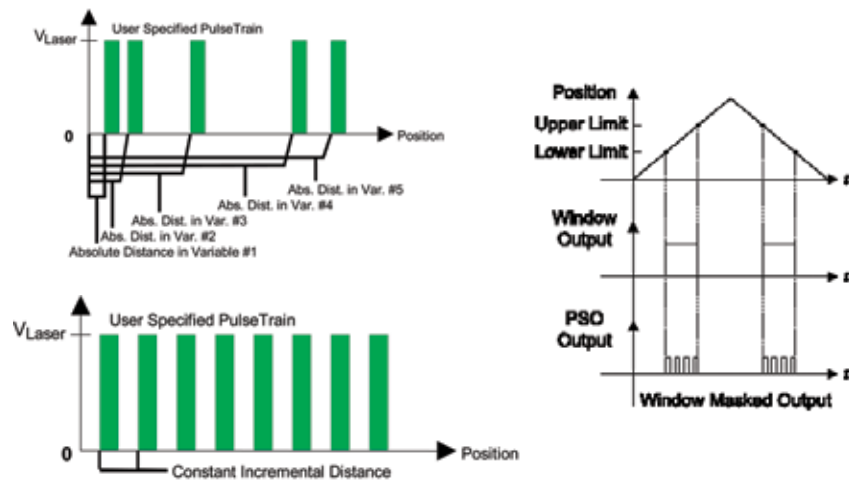


Data Collection and Triggering on the Fly

- A3200, Soloist, and Ensemble drives all contain on-board encoder tracking and synchronization pulse generating hardware, referred to as Position Synchronized Output (PSO)
- Track encoder position at varying rates and generate firing pulse when specified distance is traveled
- Key Advantages:
 - Triggers digital output based on actual position, eliminating effects of external disturbances
 - The output can also be fired based on corrected encoder calibration table (patented technology)
 - Trigger data acquisition seamlessly, on the fly

Position Synchronized Output (PSO)

- Firing methods
 - Fixed distance
 - Absolute or relative
 - Windowing
 - Array based
 - Pulse control
- Multi-axis PSO
- Tracking rates up to 20 MHz
- Firing frequency up to 12.5 MHz
- Latency as low as 50 nsec



EPICS and TANGO

- EPICS is supported on the Ensemble
- EPICs Motor Record has been created and submitted to the public library, available from Argonne National Lab
- Ethernet connection or RS-232 communication
- TANGO "universal" driver available from SourceForge to allow interfacing a user's TANGO interface to the Ensemble or A3200

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