DESIGN
CONTROL
DRIVE
CONNECT

A3200®

Expert Level Power — Accessible to All

The power of the A3200 Software-Based Motion Controller (SMC) stems from the two pillars it was built upon: powerful features and usability.

The A3200 SMC is powerful. We have gone to great lengths to design a controller that excels in delivering precision. Swimming against popular trends, we develop our controller technology from the ground up, allowing us to provide the most powerful controller in the industry. We strategically build these solutions on top of high-end, reliable, stable, industrial-grade technologies. For this reason, nobody can duplicate the multi-axis coordination and precision of the A3200.

The A3200 controller is programmed with our own programming language, AeroBasic, and set of libraries. Our A3200 software includes a development environment in which programs are developed, compiled, and loaded on the controller. By developing our own language and environment, we develop our own concepts and processes. These processes include:

- Infinite Field of View (IFOV) coordination of galvo scan-head and servo stage axes

- Position Synchronized Output (PSO) distance-based process triggering
- Non-delineated, RS-274 G-code integration into our AeroBasic language

These programming constructions fit seamlessly into a language that includes standard program flow and mathematical concepts.

Powerful Multi-Axis Trajectory Generation

At the heart of our controller is the ability to translate commands into the industry's best trajectory. Our controller includes the Aerotech motion engine — a powerful piece of technology that differentiates Aerotech control from other motion providers. This technology translates what you programmed into a multi-axis synchronized and coordinated trajectory. This trajectory is sent out over the industry's most flexible motion control bus.

Aerotech's FireWire Bus®, still available on A3200, paved the way for the new HyperWire fiber-optic bus. The nearly jitter-free nature of both FireWire and HyperWire preserves the integrity of up to 32 axes of synchronized motion control trajectory points. They both also allow servomotors, galvo scan-head, hexapods, piezos, voice coil, and stepper motor control to exist

── PRODUCT HIGHLIGHTS ──

Software-based machine and motion controller – part of the Automation 3200 Platform

PC-based controller for high-precision industrial and research systems

Delivers productivity and quality through combined motion and process control

Executes real-time application code developed in the A3200 Motion Composer Suite

Directly programmable through the .NET, C, C++, MATLAB, and LabVIEW libraries

Connects to and synchronizes the motion trajectory and I/O of up to 32 drives

Controller data is accessible to SCADA and MES control systems via libraries

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

on a common bus communicating to a common controller and trajectory generator.

More Than Just Motion

Modern machines do more than move. Vision systems, robotics, laser control, sensor integration, and much more must come together to control complex automation solutions.

The A3200 software-based machine controller (SMC) runs directly on an industrial PC, side-by-side with other automation control systems, requiring no additional hardware.

Flexible, High-Performance System Architecture

The A3200 SMC is a controller capable of managing a network of up to 32 axes of motion without sacrificing performance. With a wide offering of drive hardware, each axis of motion can be either a servomotor, stepper motor, voice coil motor, galvanometer motor, or piezoelectric actuator. The controller is high performance — producing native trajectory rates of up to 48 kHz without sacrificing other performance criteria.

Our controller enables the system's high performance because it manages a distributed control architecture. Whereas centralized control architectures close the servo and current loops on a central controller, the Automation 3200 platform closes the position, velocity, and current loops on each individual network drive (Ndrive), avoiding processing bottlenecks. The A3200 SMC uses a real-time operating system that runs with higher priority than Windows®. The PC executes programs and sends the position commands to the Ndrive via the IEEE-1394 (FireWire®) or HyperWire glass-optical-fiber high-speed serial bus.

A3200-iPC Industrial PC

The A3200 SMC is available pre-installed and optimized on the Aerotech A3200-iPC industrial PC. This PC is fully tested and optimized. The A3200-iPC is ready to work right out of the box, allowing fast integration of your value-added process. Get more information including specifications, CADs, and ordering information on our A3200-iPC web page.

Extended Architecture with Fieldbus Support

EtherCAT I/O and PROFINET I/O are each tightly integrated into the A3200 automation machine controller. With the simple addition of Hilscher PCIe card, either EtherCAT or PROFINET I/O devices can be configured and mapped with meaningful I/O tag names.

Hilscher PCIe card can be added to any PC to extend the A3200 SMC to control EtherCAT or PROFINET fieldbus.

WAGO I/O is tightly integrated into the A3200 automation machine controller and devices can be connected to a PC via a standard Ethernet port. Modular devices can be stacked together as needed and can be configured and mapped with meaningful I/O tag names. These tags are directly available for use in the AeroBasic™ programming language and throughout the Motion Composer Suite.

Set up Your Controller with the Feature-Rich Motion Composer Suite Engineering Software

Aerotech's A3200 Motion Composer Suite is a feature-rich engineering software package. This software allows each member of your design team to contribute in setting up the controller and networked drives as per your application's requirements.

Simply connect to the controller using the Motion Composer Suite. Then use several user-friendly tools to set up each control loop on the drive and the controller-specific parameters.

Programming for Performance

The A3200 Motion Composer Suite includes the Motion Composer IDE — a feature-rich programming environment for developing real-time application code. The Motion Composer IDE allows you to quickly build, debug, load, and run real-time application code on the controller.

Programming a Custom User Experience

When your goal is to deploy a custom user experience, the A3200 Software-Based Machine Controller (SMC) enables many paths for your success. Standard programming libraries for .NET, C, and C++ are included with the controller. A simple REST web interface is also included.

If you are developing a MATLAB or LabVIEW application, support for each product is available.

Custom Applications Side-By-Side With The Controller

Another unique outcome of a software-based controller is that your custom application code, developed with the use of Aerotech's APIs, can run on the same industrial PC as the controller. This allows for fast communication times of 10-20 milliseconds (estimated) when using a programming library approach. This communication rate will allow your customers to have a user experience that is free of frustration.

Power Tradeoffs in the A3200 Platform

Your final automation solution becomes a matter of matching design preferences and application requirements to Aerotech's automation solutions. Our wide variety of hardware, bus, and language support provides you the power and flexibility that you need to succeed.

Aerotech has customers who develop their applications within our Motion Composer Suite using our AeroBasic language. Some of those customers deploy user interfaces by investing in the CNC Operator Interface. Some simply command their system using the A3200 Motion Composer Suite's development environment.

We also have customers who program using one of our several libraries, remaining in the development environment in which they feel most comfortable. Often these customers are investing in a custom HMI for their end-users.

It is very common that we see a combination of approaches and this is true on the hardware side as well. Aerotech's customers use servomotor, galvo scan-head, and piezo actuator control hardware. They control servo motors, stepper motors, hexapods, piezo actuators, gimbals, gantries, spindles, delta robots, and

all types of precision stages. Our users are able to deploy these systems by choosing drive electronics offered from the A3200 platform.

System Setup with the A3200 Software-Based Machine Controller

The center of a powerful setup experience is the controller. Not only do you use the development environment to set up the controller parameters, you also connect to the network of drives through your controller. This enables the controller, fieldbus support, and all the drives in the control system to be set up simultaneously and with a single parameter file.

| DESIGN | CONTROL | DRIVE | CONNECT |
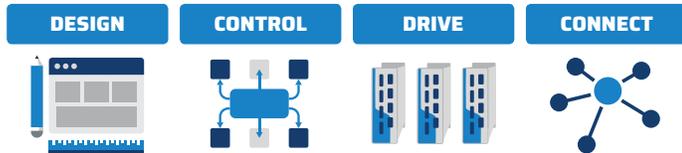
Programming Libraries

.NET, C, and C++ Libraries Plus REST Interface

Aerotech's standard controllers are flexible enough to handle almost any control application. From simple motion to coordinating and synchronizing the motion of multiple axes in your machine, Aerotech automation controllers provide the flexibility and power required for today's automation challenges, and it is all accessible through powerful programming libraries.

MATLAB® Library and LabVIEW® VIs

Users who program in MATLAB and LabVIEW can benefit from Aerotech's powerful automation tools. Integrate into your native environment with well-documented libraries.

.NET Library – Fully Functional for Developers

The A3200 .NET library is made accessible to our customers in the same structure and format that we use to develop our own applications. Therefore, developers should never worry that using our API will somehow reduce the capabilities of their own products or developments.

Some of the high-level functionality available in our APIs include:

Functionality	Description
Connect	Connect to one or several controllers
Configure	Configure settings, set/retrieve controller and drive parameters, tune motors and encoders, and load drive firmware
Execute Commands	Execute AeroBasic commands in .NET
Program Files	Compile AeroBasic programs, get build errors, load and run AeroBasic programs on the controller, and handle the controller tasks that run AeroBasic programs
Communicate	Setup and command drive and controller communication ports and protocols
Monitor Status	Get status and monitor information coming from the controller
Collect Data	Collect data on the controller in real time; exposes functionality used by the Digital Scope

Accessing Data with the A3200 Software-Based Machine Controller

Accessing data from your controller is simple. The A3200 SMC allows fast and easy access to data through both the A3200 Motion Composer Suite and through the APIs.

Through the Motion Composer Suite

More than 70 axis status items are available for each controller axis, and more than 50 task status items are available for each controller task.

Through the API

These same signals are available for collection and later analysis through industry-standard tools using the programming APIs.

Machine Performance with the A3200 Software-Based Machine Controller

Once set up and ready to go, you can start using the A3200 SMC's long list of standard controller capabilities as well as advanced powerful controller capabilities.

These features are all easy to access with the powerful Motion Composer Suite software and controller APIs.

Point-to-Point Motion	Acceleration Limiting	Coordinated Motion	Arbitrary Path Generation (PVT)
Electronic Gearing	On the Fly End-Point Modification	Cutter Compensation	Parts Rotation
Velocity Profiling	Seven Segment Acceleration	Velocity Blending	Fast Position Capture
Retrace	Intra Block Retrace	High-Speed Registration	Gantry Mode
Kinematics	Analog Power Control	Motor Control	Orthogonality Correction
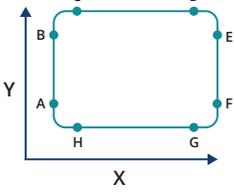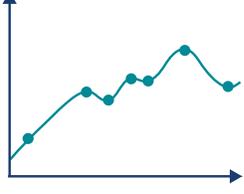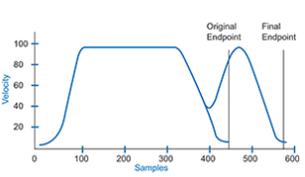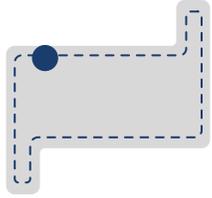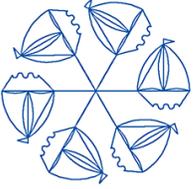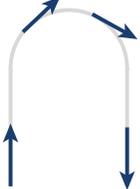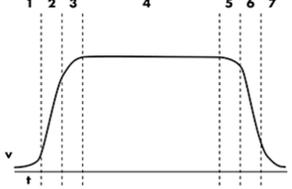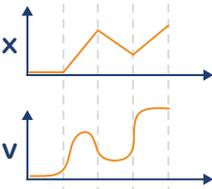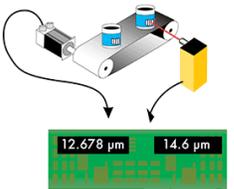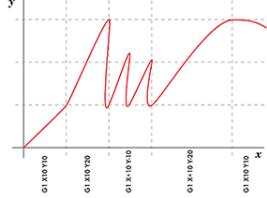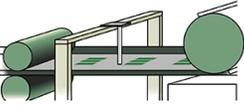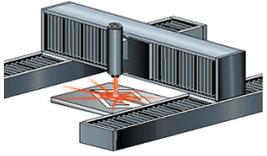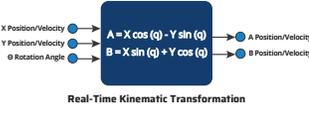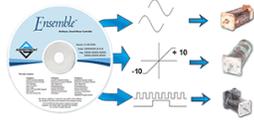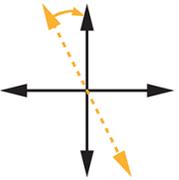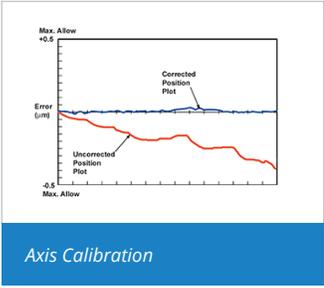
Axis Calibration
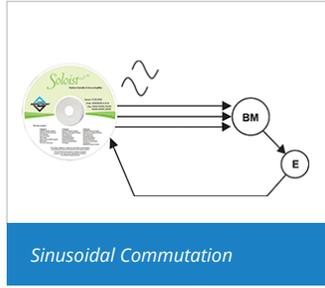
Sinusoidal Commutation
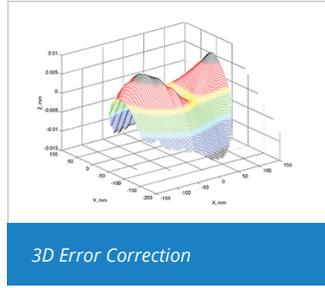
3D Error Correction
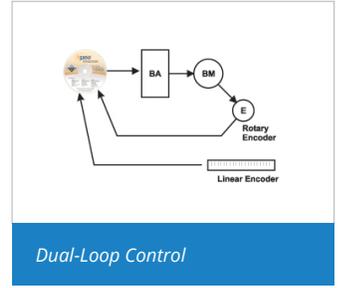

Dual-Loop Control
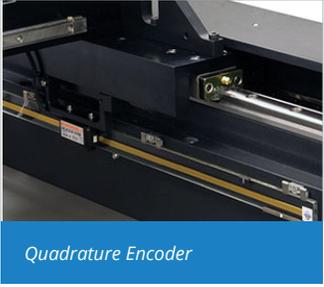

Quadrature Encoder

Analog Feedback
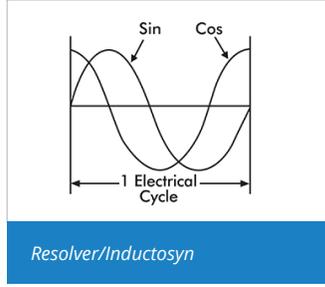
Resolver/Inductosyn


Laser Interferometer
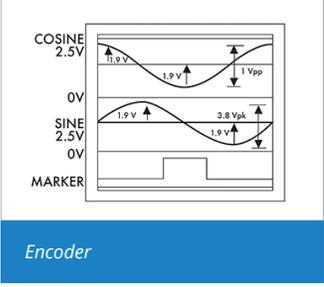

Encoder
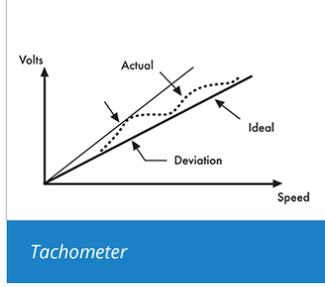
Tachometer
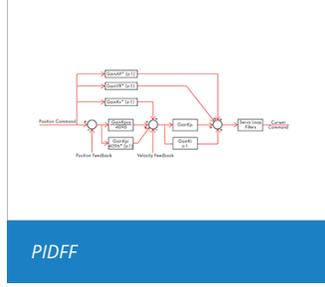


PIDFF
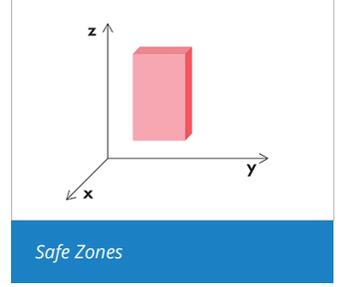
Safe Zones
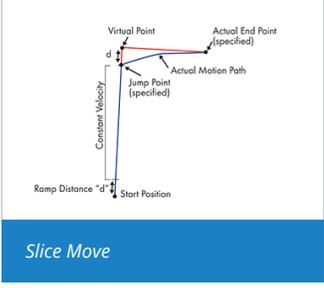

Slice Move

Limits

Spindle Control
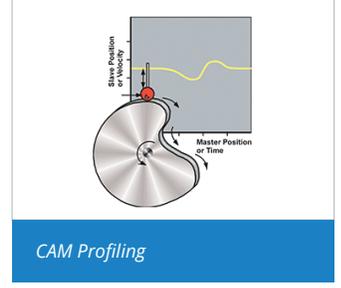
CAM Profiling
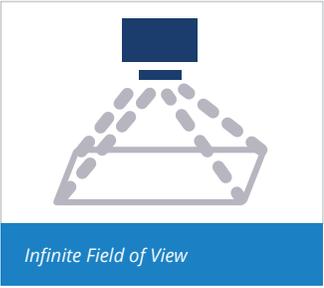
Infinite Field of View
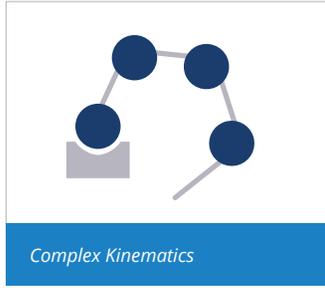
Complex Kinematics
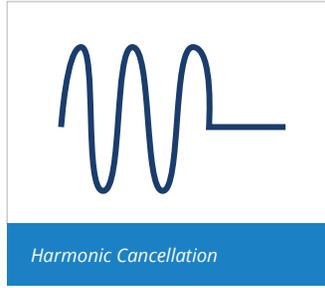
Harmonic Cancellation

Command Shaping
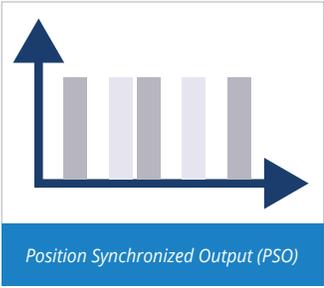
Position Synchronized Output (PSO)

EasyTune
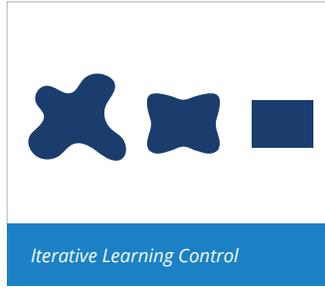
Iterative Learning Control
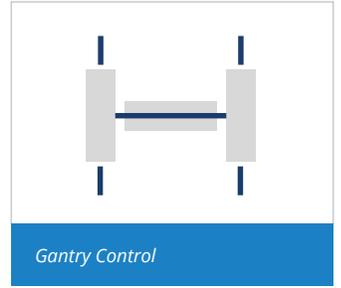
Gantry Control
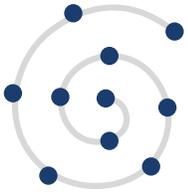
Alignment Algorithms

ThermoComp

Enhanced Throughput Module

Motion Designer

Enhanced Tracking Control

Advanced Laser Control

CADFusion

A3200 Software-Based Machine Controller **Specifications**

Specification	Description
Axes	32 axes available
Programming Tasks	32 tasks available
Position Modes	Absolute, incremental, dynamic trajectory correction
Coordinated Motion Types	**Coordinated Synchronous Motion** Coordinated motion refers to moves that follow a well-defined path in space. Coordinated moves start and stop axes at the same time. They can execute in velocity profiling mode. 　• Linear motion 　• Clockwise and counterclockwise 　• Bezier CNC Option: RS-274 standard G-code motion including linear, circular, helical, and spherical interpolation, cutter compensation, normalcy, parts rotation, mirroring, path retrace, polar transformations and cylindrical transformations, scaling.
Independent Motion Types	**Non-Coordinated Synchronous Motion** Non-coordinated motion refers to moves in which axes start at the same time but do not necessarily end at the same time. Each axis moves at its own velocity specified in the command or by axis parameters. Program execution does not continue to the next line until all axes in the move command have completed motion. 　**Homing** 　Multiple procedures are available in order to establish the home position of an axis: 　　• Home past limit switch to home marker 　　• Home to limit switch and reverse to home marker 　　• Home to home marker 　　• Home to limit switch 　　• Home at current position and set to zero 　　• Home at current position and set to nonzero 　　• Home at current position and set to absolute position 　**RAPID Command** 　Generates single or multi-axis point-to-point motion. **Asynchronous Motion** Asynchronous motion commands cause program execution to continue on to the next program block immediately after the move starts. The controller does not wait for the move to end before continuing to the next command 　• Home an axis without waiting for completion 　• Free-run an axis at the specified velocity 　• Move to an absolute position 　• Move incrementally 　• Move an axis out of a limit condition 　• Move an axis into a limit condition 　• Oscillate (cycle at the specified distance and velocity) 　• Debug Motion: 　　• Output a fixed current to the specified axis (use only with brushless motors) 　　• Output the specified electrical vector to the specified axis, typically for resolver or Hall effect device alignment
Acceleration Profiles	**Acceleration Types** • Linear: constant acceleration applied resulting in linear velocity profile. • Sine (sinusoidal half-sine): parabolic acceleration applied resulting in a sine-wave velocity profile. • Sine (sinusoidal full-sine): parabolic acceleration applied resulting in a sine-wave velocity profile. • S-curve: trapezoidal acceleration applied resulting in an "s-curve" velocity profile **Acceleration Modes** • Time based: axis acceleration takes place over a specified time • Rate based: axis acceleration takes place at a specified rate
Velocity Profiling	Blend multiple coordinated motion commands into one continuous motion path. In this velocity profiling mode, the controller does not decelerate to zero between consecutive coordinated moves. During the move sequence you can change the velocity if necessary. The axes will increase or decrease in speed in a coordinated way such that the programming path is maintained. Without Velocity Profiling　　　　With Velocity Profiling

Advanced Features		• Corner rounding • Tool normalcy control • Cutter compensation • Programmable fixture offsets • Tool tables • Part profile rotation • Part profile scaling • Polar and cylindrical transformations • Orthogonality correction • Electronic gearing • EasyTune and autotuning • Backlash compensation • Spindle motion • Autofocus • Gantry algorithms • High-speed registration • Multi-dimensional error mapping
Range Limits	**Position**	• $\pm 2^{52}$ cn
	Velocity	• 8×10^9 cnt/second
Safe Zones		Safe zones prevent motion either into or out of n-dimensional hypercubes. • Typical dimensions: 1, 2, or 3 • Maximum dimension: 32 • Maximum number of safe zones: 8 • Boundary action: When motion approaches the boundary of an area that is not permitted, the motion decelerates smoothly and stops 1 count before it gets to the boundary.
Programming		• AeroBasic • RS-274 G-code • C++/CLI, C • .NET • LabVIEW® • MATLAB®

A3200 Software-Based Motion Controller **Ordering Options and Details**

Option	Details
Fiber Optic	Searches to align fiber-optic devices. Fiber align is usually a two-step process: **Step 1: Detect initial power** You must detect initial power because it might be necessary for the peak power search routines to have an appreciable quantity of power to start. If you specify a fiber loading position where there is always an appreciable quantity of power reading, then you do not need to do the first step of the fiber align process. **Step 2a: Peak Power Searches (where initial power is necessary)** These routines are designed to get to a peak power as quickly as possible: • Fast Align (2D, 3D, 4D, 5D, 6D) • Centroid (2D, 3D, 4D) **Step 2b: Peak Power Searches (where initial power is not necessary)** These routines are designed to do a brute force search or power distribution survey: • Geo Center (2D) • Hill Climb (1D) • Spiral Fine (2D) • Spiral Rough (2D)
Dynamic Controls Toolbox	Contains a collection of controller-level algorithms that are designed to improve machine positioning, increase throughput, and reduce cycle times. Parameters supplied in the toolbox are used to configure these algorithms. **Harmonic Cancellation** Improves performance by reducing the tracking error to sinusoidal reference commands, motor force ripple or other position-dependent disturbances, and cross-axis disturbances such as that created in a linear axis by an unbalanced rotational axis. **Command Shaping** Filters undesired frequencies from the commanded position, velocity, and acceleration. **Cross-Axis Feedforward** Minimizes off-axis position errors by splitting the current generated by the feedforward gains between multiple motors on different axes.
Enhanced Throughput Module	The Enhanced Throughput Module (ETM) can improve machine throughput by measuring base or frame vibration directly and using this information in the servo control algorithm.
CNC	Includes all G- and M- code functionality as well as normalcy, cutter compensation, tool tables, polar/cylindrical coordinates, fixture offsets, inverse feedrate, spindles, reverse circular interpolation, delete block mode, optional stop, MPF, part scaling, retrace, and rotations. This module is automatically included when ordering the CNC OPERATOR INTERFACE option. For the full description of G-code and M-code syntax, refer to the RS-274D standard document. Some G-codes and M-codes have AeroBasic equivalents. You can redefine G-codes and M-codes or you can add custom G-codes and M-codes to the CNC Option programming language. In a program, you cannot issue G-codes or M-codes on the same program line as an AeroBasic command. But you can issue more than one G-code and M-code on the same program line. G-codes and M-codes do not have to be separated, or you can separate them with commas or white space. When you use more than one G-code or M-code on the same program line, obey the rules in G-code and M-code execution.
Professional	Includes 31 user tasks that run programs, 1 dedicated library task, and 16 PC Modbus connections.
EtherCAT	EtherCAT is a Fieldbus protocol built on top of Ethernet. EtherCAT provides real-time performance and a flexible network topology for connecting multiple slave devices. This protocol is tightly integrated into the A3200 and extends the I/O functions of the system. The Hilscher cifX card supplies the EtherCAT interface and connects with standard Ethernet cables to any EtherCAT slave device. You must map the topology of the slaves in a standard EtherCAT network information file. You can access the configured I/O directly from AeroBasic. Create a map file to give custom names to each I/O point. You can then use these points as variables in an AeroBasic program. The I/O is automatically synchronized between the SMC and the Fieldbus.

PROFINET	PROFINET is a Fieldbus protocol built on top of Ethernet. PROFINET provides real-time performance and a flexible network topology for connecting multiple slave devices. This protocol is tightly integrated into the A3200 and extends the I/O functions of the system. The Hilscher cifX card supplies the PROFINET interface and connects with standard Ethernet cables to any PROFINET slave device. You must map the topology of the slaves in a standard PROFINET network information file. You can access the configured I/O directly from AeroBasic. Create a map file to give custom names to each I/O point. You can then use these points as variables in an AeroBasic program. The I/O is automatically synchronized between the SMC and the Fieldbus.
Enhanced Tracking Control	Enhanced Tracking Control (ETC) improves move-and-settle times in point-to-point positioning and decreases tracking errors that occur during contoured motion. The ETC is a control algorithm that works with a conventional Proportional-Integral-Derivative (PID) servo loop and increases the ability of the servo mechanism to reject low-frequency disturbances that can cause position errors. Examples of low-frequency disturbances include friction, isolation table movement, and cable management. Use ETC only with stages that have a high encoder resolution.
Remote Server	To control the A3200 SMC remotely through an Ethernet interface, install the software in server mode on one PC and in client mode on a different PC. The PCs must be connected through Ethernet. In this configuration, Motion Composer and other applications on the client PC transparently communicate with the A3200 SMC that is running on the server PC, which is the PC that controls the motion. Because the real-time operating system is isolated from the client PC, more resources are available for your Windows applications.

PC Requirements and Configuration

Aerotech supplies free support for A3200 installation if you purchase an A3200-iPC industrial PC or an approved PC from the supplier list that is maintained on the A3200 Software-Based Motion Controller (SMC) website.

Please refer to the A3200 Software-Based Motion Controller (SMC) website for all information concerning:
- PCs approved to run the A3200 SMC
- Support costs for other PCs
- Recommended PC specifications
- General recommendations

A3200 Software-Based Machine Controller **Ordering Information**

A3200

A3200	A3200 Motion Composer Suite

License Options

License	
-Machine	A3200 software installation on a single PC
-Machine upgrade	A3200 software configuration change of license
-Machine addition	A3200 software increase license count for existing key
-License extension	A3200 software extend maintenance period of license
-Media only	A3200 software distribute current license on media

Media	
-Download	Installation media provided for download only
-USB	Installation media provided on a USB drive
-CD	Installation media provided on compact disk

Version	
-Default	Current version of software/controller
-Legacy	Legacy version of software/controller

Maintenance	
-Maintenance-X-00	Software/controller maintenance for x year(s) after purchase where X is one through seven. One year is default.

Software-Based Controller Configuration

Axes	
-2 Axes	Provides the ability to connect to 2 physical axes (default)
-4 Axes	Provides the ability to connect to 4 physical axes
-6 Axes	Provides the ability to connect to 6 physical axes
-8 Axes	Provides the ability to connect to 8 physical axes
-10 Axes	Provides the ability to connect to 10 physical axes
-12 Axes	Provides the ability to connect to 12 physical axes
-14 Axes	Provides the ability to connect to 14 physical axes
-16 Axes	Provides the ability to connect to 16 physical axes
-32 Axes	Provides the ability to connect to 32 physical axes

Fiber Optic	
-Fiber Optic	Fiber optic power scanning and virtual pivot point utilities

Dynamic Controls Toolbox	
-Dynamic Controls Toolbox	Aerotech Advanced Controls

Enhanced Throughput Module	
-Enhanced Throughput Module	Setup and monitoring screens for ETM modules

CNC	
-CNC	G and M codes plus other machine tool functionality

Professional	
-Professional	31 user tasks, 1 library task, 31 Modbus connections

EtherCAT	
-EtherCAT	EtherCAT software driver for Hilscher-RJ45 PCI card

PROFINET	
-PROFINET	PROFINET software driver for Hilscher-RJ45 PCI card

Enhanced Tracking Control	
-Enhanced Tracking Control	Reduced dynamic following error and settling times

Remote Server	
-Remote	Configure A3200 as server

Five Axes Contouring	
-Five Axes Contouring	More than 4 axes of coordinated motion with a single motion command. Note: Old part number: CNC-5

Motion Composer Suite Add-Ons

CNC Operator Interface	
-CNC Operator Interface	HMI CNC software for Windows. Includes the CNC option.

Motion Designer	
-Motion Designer	Trajectory creation and evaluation software

Motion Simulator	
-Motion Simulator	Trajectory simulation, creation, and evaluation software

LabVIEW	
-LabVIEW	Includes LabVIEW 2010 (forward compatible) VI samples

MATLAB Libraries	
-MATLAB	MATLAB library for motion, parameters and data collection

FireWire Communication Network (Items Ordered Separately)

NFire-PCIe	
NFire-PCIe	FireWire communication network PCIe card (recommended)

NFire-PCI	
NFire-PCI	FireWire communication network PCI card

NConnect-6P6P-xx*	
NConnect-6P6P-45	FireWire cable (4.50 meter length), 6P to 6P
NConnect-6P6P-30	FireWire cable (3.00 meter length), 6P to 6P
NConnect-6P6P-18	FireWire cable (1.80 meter length), 6P to 6P
NConnect-6P6P-9	FireWire cable (0.90 meter length), 6P to 6P
NConnect-6P6P-5	FireWire cable (0.50 meter length), 6P to 6P
NConnect-6P6P-2.3	FireWire cable (0.23 meter length), 6P to 6P

*Note: Aerotech strongly recommends the use of FireWire cables supplied by Aerotech (NCONNECT cables). These cables are tested to ensure proper performance. A single open PCI or PCIe card slot is required to accommodate the required FireWire PCI or PCIe card for Aerotech's motion bus.

HyperWire Communication Network (Items Ordered Separately)

HyperWire-PCIe	
NFire-PCIe	Firewire communication network PCIe card (recommended)

HyperWire-AO10-xx	
HyperWire-AO10-200	HyperWire cable (20.0 meter length), SFP to SFP
HyperWire-AO10-50	HyperWire cable (5.0 meter length), SFP to SFP
HyperWire-AO10-30	HyperWire cable (3.0 meter length), SFP to SFP
HyperWire-AO10-10	HyperWire cable (1.0 meter length), SFP to SFP
HyperWire-AO10-5	HyperWire cable (0.5 meter length), SFP to SFP