➤BY DAVID GEHMAN

CONTROL GROUP

Shops have plenty to choose from when selecting a machine control.

The subject of "machine control" is a broad one. Anyone who plunges into control technology can easily spend several years studying an array of topics, from machine design to computer science to motion control to metallurgy.

Most shops looking to acquire a controller don't commit years to researching the subject. But, clearly, they have to decide how they're going to control their machines.

The decision-making process isn't easy, given the many products on the market. Among them are high-end controllers with astonishing capabilities, do-it-yourself units that can be configured on the cheap and loads of systems in-between.

This article looks at some of the options and discusses the pros and cons of each.

The High Road

Today's high-end controllers depend on proprietary hardware, as they have from the beginning of electronic controls. In the 1960s and '70s, long before the mass production of PCs, there was no option but a proprietary platform. ("Proprietary platform" refers to the controller, its cabinet, and the hardware and software inside.)

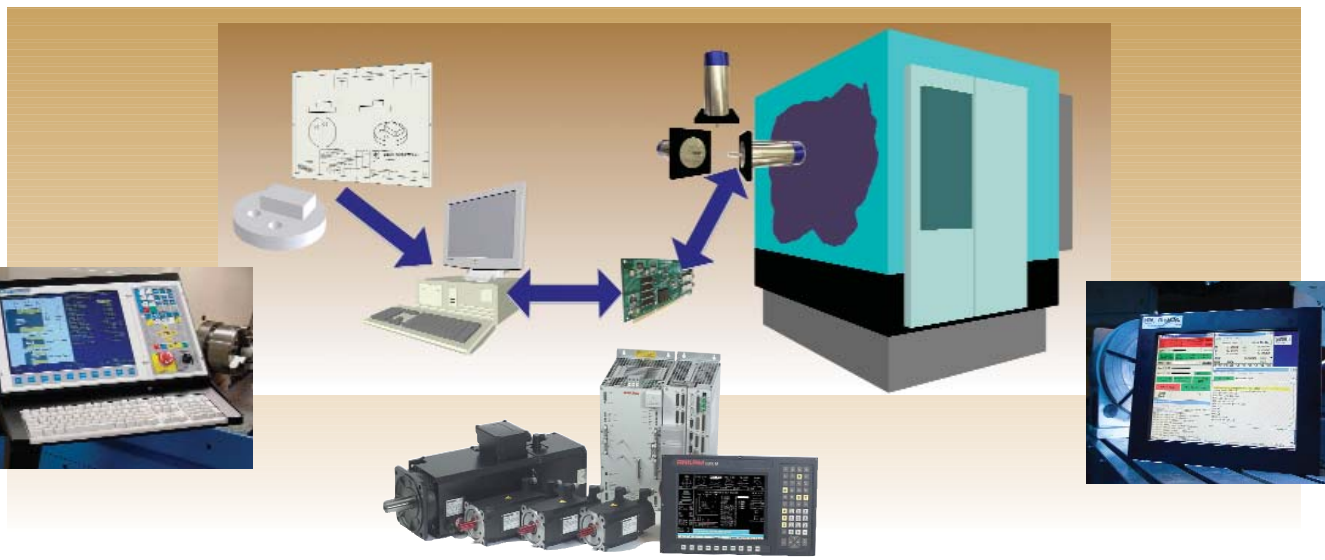
Now, of course, incredible processing power and speed are available from low-cost PCs packed full of cheap cards. So why do the big players still roll their own? Because they do things PC-based controls can't.

Proprietary circuit boards, firmware (control software embedded in hardware) and software can be optimized for precisely the cycle of input, calculation and output required for a specific machine control—even for a specific machine. Additionally, there is no need to suppress the many consumer-focused elements of the Windows operating systems.

"And there is no need to worry about viruses, hacker attacks or updates that might affect calculation routines," said the product manager at a major CNC supplier.

The considerable power of top-of-the-line controllers is designed to meet the needs of shops that operate high-accuracy, high-throughput, high-end multi-axis machines. Many enhancements and additions have been made in the past few years to the CNCs manufactured for these machines, including:

■ Automatic feed-rate control for high-precision contouring. This allows the machining of complex curves at the highest possible rate while meeting the specified tolerance.



■ Adaptive feed-rate control. The CNC monitors spindle power and adapts the feed rate to maintain constant spindle horsepower, which improves machine performance, protects tooling and extends tool life.

■ Tilted working-plane control. The machine's coordinate system can be rotated to any working plane, whereupon the CNC calculates the rotary-axis motion required to position the tool perpendicular to the new working plane.

■ Calculation of tool offsets. The CNC dynamically calculates the varying tool-length offsets and cutter compensations required for 5-axis milling. This greatly streamlines programming, as the programmer doesn't need to write the commands.

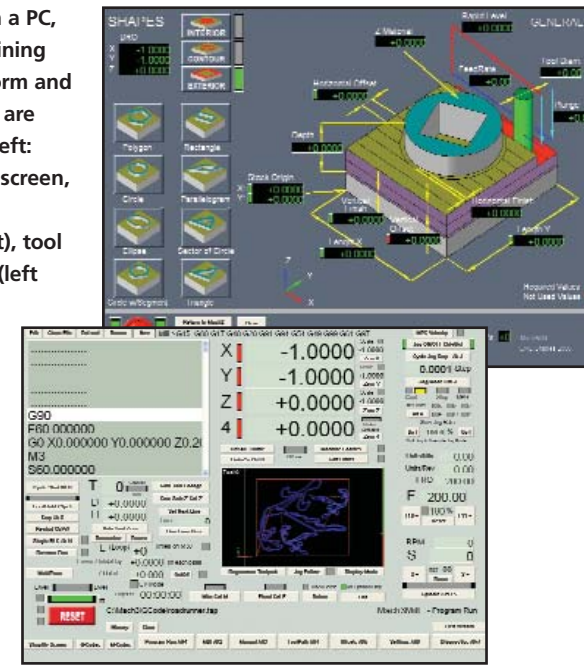
■ Nano-smoothing. This feature insulates CNC programmers and operators from the puzzles of NURBS (NonUniform Rational B-Spline), a highly accurate way of mathematically representing complex curves. The CNC takes the short linear segments put out by many CAM processors and calculates NURBS paths internally. The control's nanometer interpolation rate, which is 1,000 times finer than a CNC with a micrometer rate, results in ultrasmooth cutting paths.

■ Conversational programming. Minimizes or eliminates the need to memorize G-codes. Changing how a part is machined is done graphically, which simplifies many complicated programming tasks. An example is precision probes. They are notoriously hard to program but can dramatically reduce setup time, extend tool life and improve part quality.

A decided strength of high-end controllers is their ability to acquire and process data about the machine under control. Combined with data gathered by other CNCs, these controls provide shops with insights into the overall efficiency of their operation.

This capability dovetails with the current industry trend of measuring "overall equipment effectiveness."

"Over the last 4 or 5 years," said one CNC manufacturer, "most of our controller improvements have been based on the needs of OEE."



ArtSoft Software

Mach software runs on a PC, can control most machining operations shops perform and costs just $149. Shown are screens from Mach 2. Left: Mach 2's standard run screen, including G-code information (upper left), tool type, diameter, height (left center) and various readouts. Top: Demonstrates the ability to create custom screens; in this case, a screen for interactive input on a range of stored cutting shapes. The user inputs dimensions and data points on the 3-D representation.

OEE is a percentage derived by multiplying three ratios: equipment availability (actual scheduled time a machine could be used, excluding downtime, facility problems or malfunctions), machine performance (actual cycle times required to reach a target output vs. planned cycle times) and quality (the ratio of good parts to total parts produced by the machine).

Tracking OEE is ideal for shops serving industries that require electronic records, electronic signatures and audit trails for regulatory compliance.

The Low Road

At the other end of the control spectrum is the basic system. It's focused solely on its machine, meaning it sends pulses only to the motors that control motion. Ethernet data, ERP (Enterprise Resource Planning) transactions, data reduction internally for propagation on the shop network—all of these functions would be beyond the capability of low-end controls.

Such a system consists of an off-the-shelf PC running specialized software. An example is the Mach controller software from ArtSoft Software Inc., Halifax, Nova Scotia. First offered in 2001, the latest version, Mach 3, costs $149. (Mach 4 is scheduled to be released later this year.)

Once the software is loaded, the machine is connected to the PC's printer port. The software controls stepper motors and servos, and the control produces 45,000 pulses simultaneously in six axes.

"Mach is used for an incredible variety of things, from automotive taillight prototypes to parts for 10-ton gantry cranes to log houses," said ArtSoft President and CEO Art Fenerty.

ArtSoft is fielding an increasing number of calls from shops that purchase an older piece of equipment and then want to replace its underperforming, obsolete CNC with more up-to-date technology. "They're not happy with the way the older controller works or with turning the clock back to program it," Fenerty explained. "At the same time, they'd rather not spend more cash than necessary, given the age of the machine."

Mach comes with a full range of G-code support. In addition, it features "wizards" that produce G-code for bolthole circles, flanges, threads and other machined features. Mach supports polar coordinates, spindle controls, coolant circuits, relays and PLC input/output. Toolpath displays show the programmer the G-code or M-code being written, and users can reconfigure interface screen layouts to fit their specific needs.

"Two to 3 years ago," Fenerty said, "a person would have had to spend $15,000 to just to put controls on a stepper mill or a Bridgeport. The whole outlay today is

under $1,000. Way under if you're willing to look for good used motors and drives."

ArtSoft provides only the software, requiring users to assemble the rest of the components in their controller chain. The company does maintain an approved vendor list for the various bits and pieces required to assemble a full CNC system. This includes servo and stepper motors, kits, routing systems, tables, pumps and other components. ArtSoft also furnishes the names of firms that offer integration services for retrofits and conversions.

Middle Ground

The middle ground in machine control is occupied by PC-based controllers from companies that kit the whole works and oversee installation. Costs are correspondingly higher than the DIY option, but ease of installation and depth of support can more than make up for the higher initial outlay.

Representative of this class of control provider is CamSoft Corp., Lake Elsinore, Calif. The company's president, Gary Corey, has been active in controller design since the 1970s. The company was founded in 1981 and released a PC-based controller 10 years later.

CamSoft's approach is to install dedicated motion-control cards in the PC itself.

"We're a quarter of the cost of a proprietary CNC," Corey said, adding that CamSoft's network of 160 component suppliers offers customers a "safety net."

According to Corey, "big companies, in particular, are becoming increasingly uncomfortable about depending on the inventory of a single, proprietary supplier."

CamSoft takes advantage of the flexibility of the PC to give users choices about how the screen looks and the control's functionality. The CNC's main screen is simply a bit-mapped image with "hot spots," similar to Web graphics that the user clicks on.

"You can make the screen look like anything you want, whether that's a familiar CAM interface or some other piece of equipment you know and love," Corey said. "You don't have to use the default visuals unless you want to."

CamSoft also incorporates a graphical CAD system that lets programmers sidestep G-coding in favor of bringing up a graphic—even a digital photo—of the part to be made. That reduces programming to simply following a series of prompts. During setup, verifications and checks can be incorporated so that, for example, if a hole is sized too large, a warning pops up.

The system also includes 5-axis tool compensation for sculpted parts. "With complex parts, if there's a change to a feature, there's no need to go back to the CAD department for a new set of dimensions, then go through CAM and post-processing," Corey said. "You just go into the 3-D view and redimension the changed features, and our controller compensates for the new values."

In CamSoft's controller implementation, the PC parses the dimensions and coordinates what a part requires into G-code. The G-code output then is sent to the DSP (digital signal processing) board. Once the code resides in the motion card, it is independent of the PC's CPU.

Conceptually, this is similar to the way PCs handle screen graphics, where the CPU plays almost no part in displaying pictures (i.e., plotting pixels) on the monitor screen. Instead, a specific type of DSP in the graphic card, called a GPU (graphical processing unit), performs all the calculations needed to light the correct screen pixels at the right time.

Corey pointed out two advantages to this approach: "We can run as quickly as possible this way, because motion cards can close servo loops 12 million times a second. Furthermore, if the PC goes down, the instructions end and the machine simply stops. If the PC directly controls things, there can be some nasty, random results if the PC crashes."

What's Best?

What's the best choice when selecting a CNC: high end, mid-range or basic? It depends.

For a shop on a tight budget whose

TYPE	PLATFORM	PRO	CON	SHOP MUST KNOW	WORTH CONSIDERING
High End	Proprietary	• installs rapidly • advanced features • comprehensive support	• high price • complex • may not receive same attention as CNC makers larger customers	• process objectives, in detail • all capabilities of its machines	• can handle any metalcutting job • lets shop tap into leading-edge technologies • best choice for sophisticated work, e.g., automotive, aerospace jobs performed on multi-axis machines
Mid-Range	PC	• reasonable installation time, cost • all components are preselected • good-to-excellent range of features • responsive support	• system quality, consistency of functionality depend on integration skills of supplier	• how to evaluate systems engineering • control capabilities it needs	• often modular, capable of incremental addition of features • good for shop that makes most types of parts
Low End	PC	• low cost • good range of features • good base of support	• must assemble all components • potentially long install time • shop has to work out bugs in system • volatile supply	• how to configure and engineer entire system • potential of its equipment and its capabilities	• good for shop just starting out

Guidelines for selecting the best machine control for a shop: high end, mid-range or low end.

The following companies contributed to this report:

ArtSoft Software Inc.
(902) 454-0880
www.artofcnc.ca

CamSoft Corp.
(951) 674-8100
www.camsoftcorp.com

employees have extra time and advanced computer and machine skills, the basic controller will probably suffice. Admittedly something of a DIY project, this type of installation provides a shop with a capable controller and in-depth knowledge about how the unit works.

If, however, a shop's customers demand rapid delivery of complex parts and require the shop to meet ISO 900x process and documentation standards, the high-end option would be better.

The mid-range option offers the best of both worlds. The software and hardware in the control chain come bundled ready for installation, and operators and programmers benefit from interfaces that they can quickly master.

As with many decisions a shop must make, the answer to the "which is best" question depends on the money it is willing to spend, the skill of its programmers and how much setup time it can afford. △

About the Author

David Gehman is co-author of CTE's bimonthly software column, "Get with the Program." He has been writing about manufacturing and software for more than 20 years.