The Premier Gear and Machine Works controller is a mix of old and new that works in harmony with a PLC. It is new in that it uses the latest computer hardware and it runs new software that was developed using Visual C and running under Windows. It is old because it uses the algorithms employed in the old DEC controllers, which work so well with that hardware. The algorithms themselves are timeless, but in our system they are realized using C rather than assembly, and are therefore are not so tightly bound to the hardware.

This computer-based industrial control system is on an Intel platform computer running Windows. It has been created to be versatile, so that any mill electrician can add independent axes of control to the PLC, using any of the many PID controllers available. Our cPCI/PCI system is, very simply, a specialized PID controller that is easy to use for the specific application of controlling greenend subsystems.

Our system utilizes the latest hardware and runs on an OS with which most people are familiar. The hardware components are easy to replace as needed – we buy them all off-the-shelf so that you can modify the system to your needs.

Hardware Specs

The computer lives on a compact-PCI bus, which is an industrial-grade PCI-bus platform. This makes it electrically identical to the standard PCI bus present in the vast majority of all desktop computers. Aside from the usual devices one would expect to find on a computer (disk drives, CD, network channels, etc), the controller has small modules, called IP modules, plugged into a carrier cards, called IP carrier cards. The IP modules have specific functions: 6 or 8 channels of D/A, 3 channels of Temposonic inputs, 4 channels of quadrature or pulse generator encoder inputs, and various formats of discrete I/O. Each carrier card fields up to four IP modules, and occupies a single PCI slot in the computer. All standard desktop computers have PCI slots. The software is written to communicate with the IP modules on the carrier cards in the PCI slots to control the collection of drives and monitors that make up the specific machine controller.

The preferred computer is called a compact PCI-bus computer, or cPCI computer. This is an industrial-grade backplane and enclosure, which holds the processor card and up to 14 IP carrier cards. The processor card has two 1 GHz Pentium processors, 1 GB memory, a 40 GB hard drive, USB and Ethernet channels, and the usual keyboard/video/mouse channels. It can also accommodate up to 2 PMC modules, one of which we use for two extra channels of VGA video. This provides the lathe operator with an independent screen/window, and the computer operator with two parameter or statistics screens/windows.

The cPCI backplane is electrically and functionally identical to the standard desktop PCI bus. Also, the IP carrier cards come in multiple formats to accommodate the various buses. In particular, there is a standard PCI bus version of the IP carrier card that we use, which is functionally identical to its cPCI bus counterpart. As a result, the controlling software can run in a cPCI bus computer or a standard desktop computer with no modification. This allows smaller systems, under 12 axis of control, to run from a desktop computer.

Utilizing this desktop computers functionality can significantly reduce the cost of the hardware, and increase the availability of spares. The downside is that greater attention needs to be paid to isolating the computer from vibration and assuring adequate cooling and air flow.

The other shortcoming is that desktop computers usually have only 2 or 3 available PCI slots. Depending upon how the discrete I/O is handled, this would restrict the number of axis of control. If we assume that:

- The bulk of the discrete I/O is communicated via ethernet with the PLC
- 48 discrete I/O is sufficient for external interlocks and high-speed operator controls (e.g., knife drive jog levers)
- And the desktop has two available PCI slots

The system would be limited to 12 to 15 axis of control, depending upon the encoder sources (Temposonic or pulse generators/quadratures).

With the 3 GHz Pentium available in desktops now, processor speed is not a limitation. We currently have a 5-axis system (2-axis backup roll, roll drive, gap drive, and knife tilt) running out of a 255 MHz single processor utilizing about 15% of the processor time. A larger system, consisting of a 1-axis knife drive, 3-axis backup roll, 2 roll drives, 2-axis gap drive, and 1-axis knife tilt, running on a dual 933 MHz processor, uses 8% of available processor time on controls and, depending upon which displays are active, 15% to 25% on human interface (which operates at a lower priority to the controls).

By running in the cPCI system, neither PCI slot availability nor processor time become factors. The smaller cPCI backplane has 7 cPCI slots available; the larger has 14. Either one can use the most powerful cPCI processor currently available: a dual 1 GHz Pentium. The larger cPCI can have two such dual 1 GHz processors, although the need for such horsepower is not there. In fact, a system consisting of a single dual 1 GHz running in the larger cPCI backplane, accommodating the necessary IP carrier cards, could control the XY (drive positioning, data acquisition, and solution calculations), vees, charger, charger clamps, high speed spindles, all the lathe functions (backup roll, powered rolls, powered big bar, bar height, knife drive (DC or hydraulic), gap drive, and knife tilt), and the follower system (lathe drive, tipple, dual trays, clipper infeed, clipper outfeed, and strip storage trays), along with managing the necessary discrete I/O channels to PLC, interlocks, and operator controls (ethernet and hardwired).

Software Specs

The application software is written in Visual C and runs under Windows NT or Windows 2000. The software is designed to load and run even with the PCI-bus devices absent, which makes it possible to load and run the software on any PCI desktop running Windows NT or Windows 2000. This makes it easy to familiarize oneself with the software without running the risk of interrupting production.

The human interface consists of three or more windows, each showing any of the various status and parameter displays. All system and drive parameters are presented in these displays, allowing non-technical personnel to change them without having access to a PLC. This allows production or management to change critical aspects of the system without interrupting technical staff.

Running under Windows as a high priority application, the control software can share available memory and processor time with other applications or Windows processes, such as network services or word processors. Multiple VGA display drivers can be installed to allow for dedicated display channels, such as a lathe operator display. This allows the other applications running on the system to use the primary display monitor without disrupting the lathe operator.

The software components include a device driver, or kernel level program, known as the IOE (I/O Engine); and a user application program, known as the USR. Both of these, of course, run under Windows.

The IOE lives at a low level under Windows, and is driven by device interrupts and interrupt service requests (ISRs) from the USR. Windows gives high priority to interrupt handlers, so the IOE cannot be preempted by activity at the user application level, such as other application programs, including the USR, or system services such as Explore. All the motion control processing is performed in the IOE.

The USR mainly handles the human interface subsystems: the keyboard, video, and mouse. It also processes any discrete I/O passed to and from the PLC via ethernet (RsLinx), distributing it to the IOE by internal (software) discrete I/O. The USR and the IOE are in constant communication via ISRs passed between the two. Watchdog handshakes are set up between the USR and the PLC, and between the USR and the IOE. Any of the three agencies can shut all the drives down in the event one of them detects a watchdog failure.

The look and feel of the human interface is very similar to the DEC systems: same command format, similar commands and calibration procedures, similar displays and display format). This makes the transition from a PGW DEC system to a PGW cPCI or PCI system simple.

Like the DEC systems, all operational parameters are brought out to a series of parameter displays, and all drive statistics are brought out to status displays. Parameters are logically clustered in the various displays, making it easy to find a particular parameter, given the drive or functional subsystem in need of adjustment. The system is not a “black box”, but rather a translucent box. Parameters presented in these displays have text descriptors associated with them, making it easy to determine the functional role of the parameter, allowing non-technical mill personnel to modify operational aspects of the system. Of course, a security system exists that can be set up to lock out certain displays and commands from modification and use unless the operator logs on and enters the proper password.

A keyboard activity log is maintained as a text file on the hard drive, which shows all keyboard activity, any resultant command error messages, and all parameter modifications, including old and new parameter values. All system profiles can be dumped to text files in a format easily picked up and plotted by any spreadsheet program. Production data is gathered and saved, per block, to text files on the hard drive in subfolders identifying the date, shift, and sub-shift (resulting from a species change that may require a shift subtotal, for example). This data is saved in a manner that can again be picked up by a spreadsheet program for further analysis. The system produces a shift report at the end-of-shift, and old shift reports are available from any shift for which data exists.

Parameter changes and lathe setup parameters are logged to text files on the hard drive. Should the system be restarted, these log files are read to update system and setup parameters. As a result, the lathe operator need not “re-square” or calibrate any drive, including re-establishing knife tilt vertical, nor does the computer operator need to enter parameter changes whenever a restart occurs, either from a power failure, voluntary restart, or program version update.

Both system programs, the IOE and the USR, and all parameter setup files reside on the hard drive. These can easily be backed-up. Furthermore, system updates can be emailed from PGW to the mill site when program modifications are needed. Both programs are around 1MB in size, making it easy for them to be emailed as uncompressed attachments, even over the slowest of lines.