The future of control

Programmable Automation Controllers (PACs) are the future of control. Certainly, this is a bold statement. But how true is it? To get a feel for this we need to examine what a PAC is, how it compares to the PLC (Programmable Logic Controllers) and what benefits the PAC has for control and automation engineers.

The PLC has dominated the control and automation market for many years. Bomb-proof reliability, industrial I/O and ease of programming with ladder-logic have led to wide adoption across many industries.

In the past 10 years, an often passionate debate has raged about the advantages and disadvantages of PLCs compared to PC-based control. As the technological differences between PC and PLC have reduced, with PLCs using commercial off-the-shelf (COTS) hardware, and PC systems incorporating real-time operating systems, a new class of controller, the PAC, is emerging. The acronym, created by Automation Research Corporation (ARC), is used to describe a new generation of industrial controllers that combine the functionality of a PLC and a PC. The PAC acronym is being used both by traditional PLC vendors to describe their high-end systems and by

THE GRAPHICALLY RICH PROGRAMMING ENVIRONMENTS OF A PC, MERGED WITH THE RELIABILITY AND OF A PLC, THAT IS WHAT PACS PROMISE, BUT CAN THEY DELIVER?

By Ian Bell

> **The PC presented three main challenges: stability, reliability and unfamiliar programming environment**

PC control companies to describe their industrial control platforms. It should be noted that the use of the term PAC is not universal. Many high-end PLCs could legitimately be called PACs.

THE '80-20' RULE

During the three decades following their introduction, PLCs have evolved to incorporate analogue I/O, communication over networks, and new programming standards such as IEC 61131-3. However, engineers create 80% of industrial applications with digital I/O, a few analogue I/O points, and simple programming techniques. Experts from ARC, Venture Development Corporation (VDC), and the online PLC training source PLCS.net estimate that: 77% of PLCs are used in small applications (less than 128 I/O); 72% of PLC I/O is digital; and 80% of PLC application challenges are solved with a set of 20 ladder-logic instructions.

Because 80% of industrial applications are solved with traditional tools, there is strong demand for simple, low-cost PLCs. This has spurred the growth of low-cost micro PLCs with digital I/O that use ladder logic. It has also created a discontinuity in controller technology, where 80% of applications require simple, low cost controllers, and 20% relentlessly push the capabilities of traditional control systems. The applications that fall within the 20% are built by engineers who require higher loop rates, advanced control algorithms, more analogue capabilities and better integration with the enterprise network.

In the 1980s and 1990s these '20 percenters' evaluated PCs for industrial control. The PC provided the software capabilities to perform advanced tasks, offered a graphically rich programming and user environment, and utilised COTS components, allowing control engineers to take advantage of technologies developed for other applications. These technologies include floating point processors; high speed I/O buses, such as PCI and Ethernet; non-volatile data storage; and graphical development software tools. The PC also provided unparalleled flexibility, highly productive software and advanced, low-cost hardware.

However, PCs were still not ideal for control applications. Although many engineers used the PC when incorporating advanced functionality, such as analogue control and simulation, database connectivity, web-based functionality and communication with third party devices, the PLC still ruled the control realm. The main problem with PC-based control was that standard PCs were not designed for rugged environments.

THE PC CHALLENGE

The PC presented three main challenges: stability, reliability and unfamiliar programming environment. Often, the PC's general-purpose operating system was not stable enough for control. PC-controlled installations were forced to handle system crashes and unplanned rebooting. When it comes to reliability with rotating magnetic hard drives and non-industrially hardened components, such as power supplies, PCs were more prone to failure. In addition to that, plant operators need the ability to override a system for maintenance or troubleshooting. Using ladder logic, they can manually force a coil to a desired state, to rapidly patch the affected code and quickly override a system. However, PC systems require operators to learn new, more advanced tools.

Although some engineers use special industrial computers, with rugged hardware and special operating systems, most engineers avoided PCs for control because of problems with PC reliability. In addition, the devices used within a PC for different automation tasks, such as I/O, communications or motion, may have different development environments.

So the '20 percenters' either lived without functionality not easily accomplished with a PLC, or cobbled together a system that included a PLC for the control portion of the code and a PC for the more advanced functionality. This is the reason many factory floors today have PLCs used in conjunction with PCs for data logging, connecting to bar code scanners, inserting information into databases, and publishing data to the web. The big problem with this type of set-up is that these systems are often difficult to construct, troubleshoot and maintain. The system engineer is often left with the unenviable task of incorporating hardware and software from multiple vendors, which poses a challenge because the equipment is not designed to work together.

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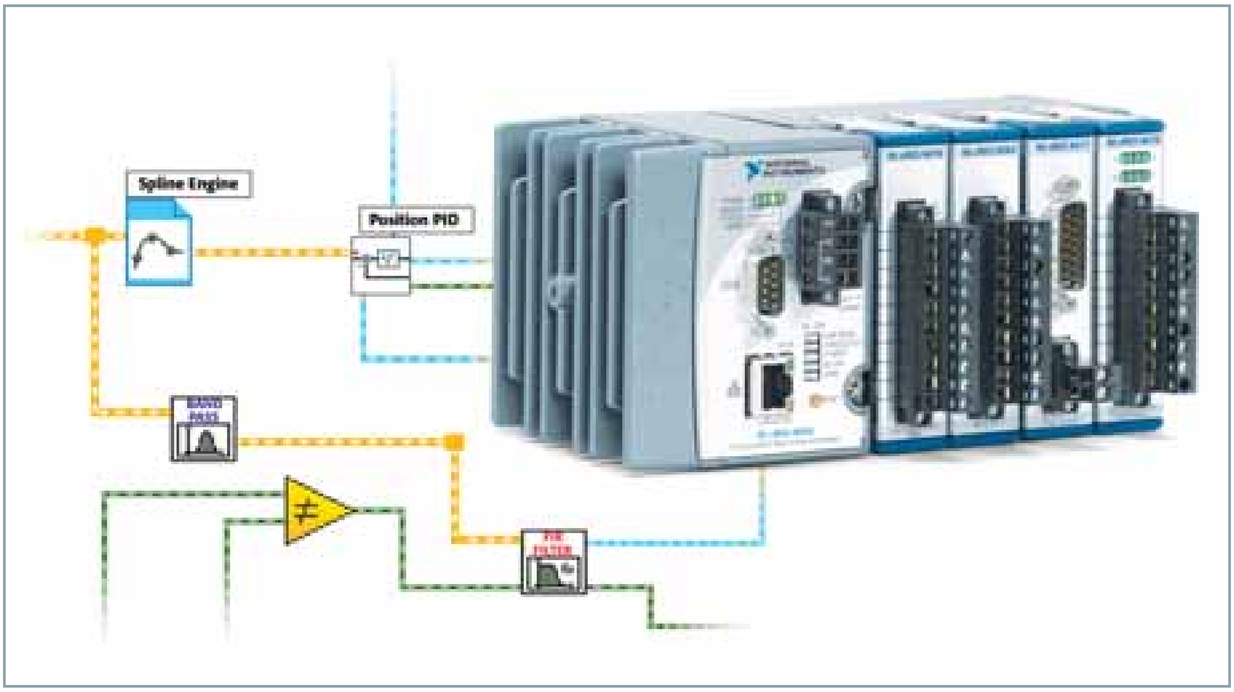

Fig 1: LabVIEW Graphical programming powers NI PAC systems

BUILDING A BETTER CONTROLLER

With no clear PC or PLC solution, engineers with complex applications worked closely with control vendors to develop new products. They requested the ability to combine the advanced software capabilities of the PC with the reliability of the PLC. These lead users helped guide product development for PLC and PC-based control companies.

The software capabilities required not only advanced software, but also an increase in the hardware capabilities of the controllers. Control vendors today are incorporating industrial versions of floating point processors, DRAM, solid-state storage devices such as CompactFlash and fast Ethernet chipsets into industrial control products. This enables vendors to develop more powerful software with the flexibility and usability of PC-based control systems that can run on real-time operating systems for reliability.

The resulting new controllers, designed to address the '20 percent' applications, combine the best PLC features with the best PC features. Industry analysts at ARC named these devices Programmable Automation Controllers, or PACs. In their 'Programmable Logic Controllers Worldwide Outlook' study, ARC identified five main PAC characteristics. These criteria characterise the functionality of the controller by defining the software capabilities: multi-domain functionality – at least two of logic, motion, PID control, drives and process on a single platform; single, multi-discipline development platform incorporating common tagging and a single database; software tools that allow the design by process flow across several machines or process units; open, modular architectures that mirror industry applications from machine layouts in factories to unit operations in process plants; and employ de-facto standards for network interfaces, languages and the like, such as TCP/IP, OPC, XML and SQL queries.

TWO APPROACHES TO SOFTWARE

While software is the key difference between PACs and PLCs, vendors vary in their approach to providing the advanced software.

Traditional PLC software vendors start with a reliable and easy-to-use scanning architecture and work to add new functionality. PLC software follows a general model of scanning inputs, running control code, updating outputs and performing housekeeping functions. With much of the work done by the vendor, this strict control architecture makes it easier and faster to create control systems. The rigidity of these systems also eliminates the need for the control engineer to completely understand the low-level operation of the PLC to create reliable programs. However, the rigid scanning architecture can

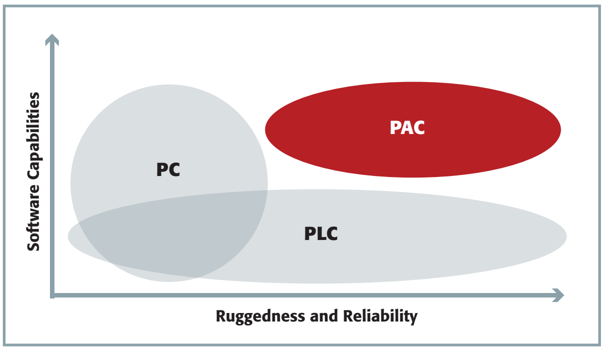

Fig 2: PAC compared to PC and PLC

also make it inflexible. Most PLC vendors create PAC software by adding into the existing scanner architecture new functionality such as Ethernet communication, motion control and advanced algorithms. They typically maintain the familiar look and feel of PLC programming and the inherent strengths in logic and control. The result is PAC software is generally designed to fit specific types of applications such as logic, motion and PID, but is less flexible for custom applications such as communication, data logging or custom control algorithms.

On the other hand, traditional PC software vendors start with a very flexible, general-purpose programming language, which provides in-depth access to the inner workings of the hardware. This software also incorporates reliability, determinism and default control architectures. Although engineers can create the scanner structure normally provided to the PLC programmer, they are not inherent to PC-based control software. This makes the PC software extremely flexible and well suited for complex applications that require advanced structures, programming techniques or system level control, but more difficult for simple applications.

The first step for these vendors is to provide reliability and determinism. This is accomplished through real-time operating systems (RTOS) such as Phar Lap from Ardence (formerly Venturcom) or VxWorks from Wind River. These RTOSs provide the capability to manage all aspects of the control system, from the I/O read and write rates to the priority of individual threads spawned on the controller. These vendors then add abstractions and I/O read/write structures to make it simpler for engineers to build reliable control applications. The result is flexible software suited for custom control, data logging and communication but lacking the familiar PLC programming architectures, making application development more demanding.

PACS ELIMINATE THE NEED FOR CUSTOM HARDWARE

Although PACs represent the latest in programmable controllers, the future for PACs hinges on the incorporation of embedded technology. One example is the ability to use software to define hardware. FPGAs are electronic components commonly used by electronics manufacturers to create custom chips, allowing intelligence to be placed in new devices. These devices consist of configurable logic blocks that can perform a variety of functions, programmable interconnects that act as switches to connect the function blocks together and I/O blocks that pass data in and out of the chip. By defining the functionality of the configurable logic blocks, and the way they are connected to each other and to the I/O, electronics designers can create custom chips

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without the expense of producing a custom ASIC. FPGAs are comparable to having a computer that literally rewires its internal circuitry to run your specific application.

Until recently, FPGA technology has only been available to hardware designers who were proficient in low level programming languages like VHDL. However, control engineers today can use LabVIEW FPGA to create custom control algorithms that are downloaded onto FPGA chips. This capability enables engineers to incorporate extremely time-critical functions to hardware, such as limit and proximity sensor detection, and sensor health monitoring. Because the control code runs directly in silicon, it is possible for engineers to quickly create applications that incorporate custom communication protocols or high speed control loops: up to 1MHz digital control loops and 200kHz analogue control loops.

THE FUTURE OF CONTROL?

So, we need to answer the original question. Are PACs the future of control? The answer is yes, but for advanced applications – the ‘20 percent’ group. PACs can deliver the sequential control which today’s low cost micro PLCs do. But, if this is all they are doing then a PAC is not cost effective and you should stick with the traditional PLC based approach. On the other hand – if your application needs more advanced control, more analogue I/O, more advanced online data processing, very high speed control, high speed data logging, advanced motion control or machine vision, or especially if it needs any of these in combination, then a PAC is going to be the best solution. In short, if you are looking at a control system where you are putting together a PLC and PC – you need to be using a PAC. ■

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Fig 3: Typical PAC Hardware