The power and the intellect

HIGH-LEVEL GRAPHICAL PROGRAMMING AND FIELD-PROGRAMMABLE GATE ARRAY (FPGA) HARDWARE IS A RELIABLE WAY TO IMPLEMENT INTELLIGENT CONTROL SYSTEMS IN AEROSPACE PRODUCT TESTING

Servo loading cylinders, which are fitted to a test rig but are controlled by a central system and manual hand wind test rig (above)

BY STUART MARTIN & PAUL RILEY

To facilitate the extensive performance, qualification, and mitigation testing carried out on components before they are applied or used on operational aircraft, Comar Fluid Power designs and engineers an extensive range of test rigs for the aerospace industry. These are managed through the use of control systems, which are generally bespoke and range from high-level machine sequencing to low-level time-critical closed-loop control and data acquisition. Comar works with its partner Computer Controlled Solutions (CCS) to provide these solutions.

Using design tools from National Instruments (Compact RIO range) and LabVIEW, along with high-level programming language, they create modular, maintainable systems with a user-friendly interface. Their design approach is highly flexible and can lead to cost savings.

Typical test requirements

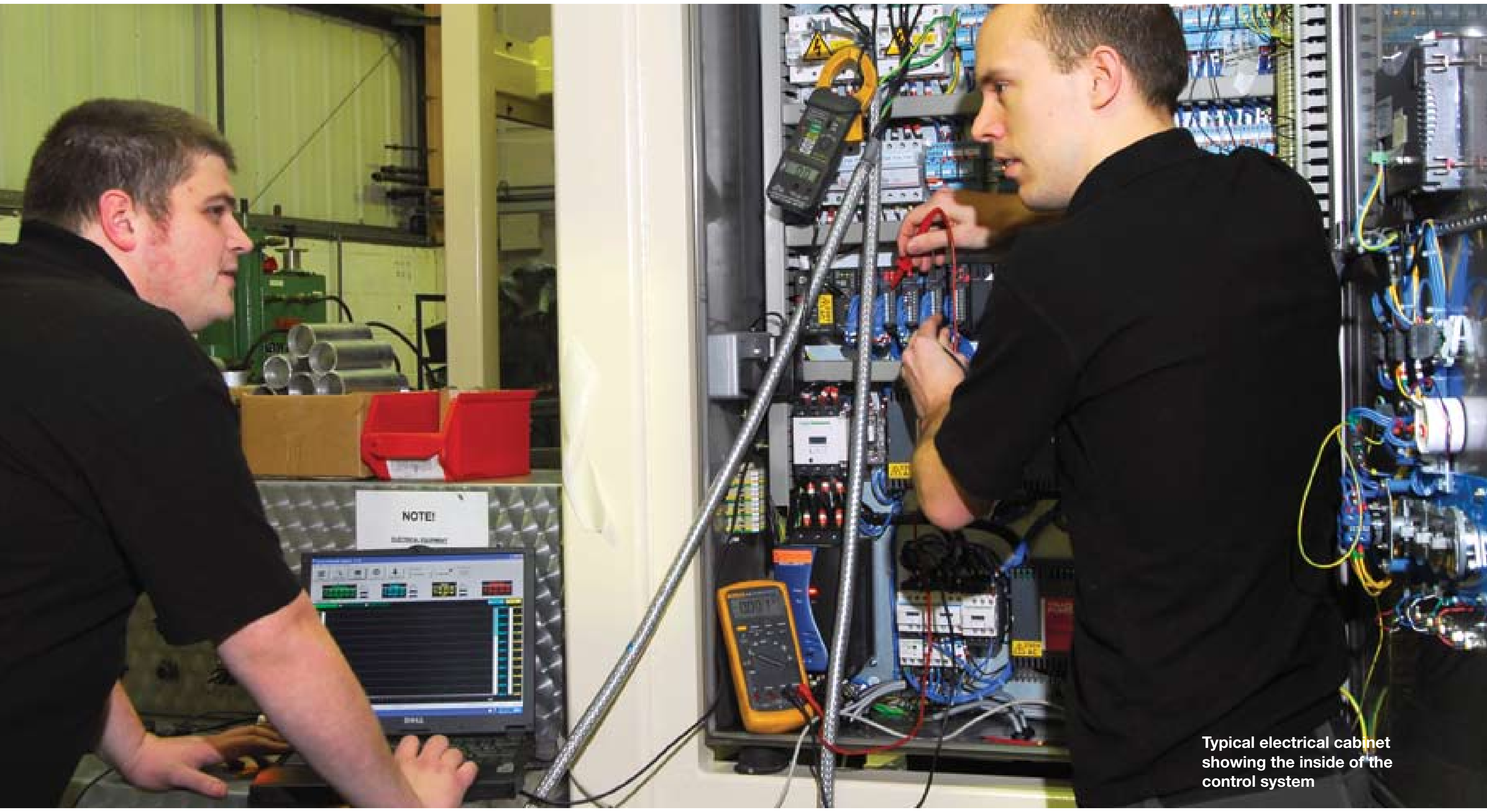
Standard tests carried out on, for example, an electric motor and clutch assembly that is used to control the wing surfaces of an aircraft, include: running the motor; applying resistive torque profiles; emulating typical load patterns; back-driving the motor; and applying various torsional-impact stresses.

Typically, a programmable logic controller (PLC) or computer may be used to run the various tests, linked to a magnetic-particle brake or loaded by a hydraulic motor or electric servo motor. A servo PID controller or motor drive is then used to apply the speed and loading settings. It would be normal to see a control system leading to control electronics and on to actuators. Signals would then be returned for measurement and control from transducers – torque, pressure, and velocity, on to signal conditioning, then to the acquisition system where it is mirrored (buffered) to calibration-monitoring points.

Comar and CCS, together, use a systematic approach to keep it simple, using off-the-shelf (OTS) proven technology and minimizing the number of brains. The inherent complexity of any machine is usually enough to create a list of problems without adding to it a multifaceted system design. The use of technology plays a very good part in maintaining this aim.

As recently as five or six years ago, OTS became a nice idea but, unfortunately, there tends to be the occasional transducer, unique operation, or control that would best be solved with a unique PCB design or extraordinary wiring method. In addition, a mix of technology and a mix of suppliers can lead to future servicing issues. However, with the joint expertise of CCS and Comar, this is kept to a minimum.

The number of embedded processors finding a place in every market is becoming an



Typical electrical cabinet showing the inside of the control system

A real family business

Founder Graham Martin has two sons who both play an active part in Comar's day-to-day activities. The elder son, Stuart, is operations director and manages business development, sales and commercial matters. The younger son, Richard, is also a company director, a design engineer and runs a team of project engineers. Graham says, "We put the customer first and nothing is too much trouble. Communication is absolutely key throughout a project, big or small, and we pride ourselves on customer satisfaction. We have a saying: 'Small enough to be responsive, large enough to be respected'. We have worked on multimillion pound systems, which have been a success technically, delivered to the customers' schedule, and we are also competitive."

ongoing issue. Companies want to make their system easy to use so transducers may have their own intelligence, servo drives have complex axis-control algorithms, and power supplies can run automated routines. This is all fine as individual systems, but as a collective the result is 'too many brains' and, like cooks in the kitchen, it does not always work, adding complexity and often lacking a clear hierarchy. The result is usually a system that no single company fully understands. A fault may take longer to isolate and expensive engineers are required from multiple sources to diagnose and repair a single part of the system. In design, the aim is to minimise this quantity.

The design strategy is to put a good brain at the top and aim for it to handle all programming, closed loops, and profiles. The aim with any brains underneath, such as a servo drive, is to run in the basic mode, speed, or current control, without use of built-in profiling or uniquely programmed conditions. The approach is ultimately for an engineer with knowledge of the top brain to visit the rig in any number of years without a manual, and to gain a good understanding of a machine operation quickly, without there being any hidden surprises, which individual brains (microprocessors) are 'good' at providing.

The real-time system and FPGA

The core of the partnership's hardware selection is the use of a field-programmable gate-array (FPGA) device for time-critical control, conditioning, and acquisition. In essence, an FPGA device consists of a slab of silicon upon which are millions of logic gates, plus some memory and control circuitry. The beauty of these devices lies in the fact that one is not programming software to be executed down one or two processors in a non-deterministic timeframe, as with a PC or DSP. Instead, the software is, in effect, written to hardwire these gates to form a hardware circuit operation that is deterministic, fast, and anywhere on the slab of silicon.

Anywhere on the silicon indicates that multiple circuits can run completely asynchronously and without the interruption of mice, virus protection software, and ever more complex underlying operating systems. The problem with FPGA development is that it needs a software engineer, highly skilled in a low-level programming, and this is costly and promotes errors. The problem is solved using the LabVIEW programming language because the same engineer designing the rig and writing computer code, can now handle the FPGA code. In this way, the whole project is opened up to a broader range of engineers.

Left: Comar Technologies founder, Graham Martin, and Stuart Martin

Seeing a bright future

Graham Martin is the managing director and chief design engineer of Comar Engineering, which specializes in the application of products for power and motion. The company has been operating for more than 30 years, and for 20 of them, it has been focused on producing turnkey aerospace solutions.

Graham, who lives with his wife and dog in Staffordshire, has two sons, Stuart and Richard, both of whom work for the company.

What was the motive behind expanding Comar into the aerospace industry?

After 10 years of business, general engineering was becoming more and more competitive. I have always been taught to try to find your niche in life, as well as in business. We had a few big players in the aerospace business on our doorstep and so I made it my mission to establish Comar as a name within the local industry. It was not an easy task and it was some years before we won our first order. From that first order we gained many more and today we continue to be a key supplier to not only the local industry, but internationally too.

Is there a particular project that stands out as one of Comar's proudest achievements?

That's a difficult question. A lot of recent ones spring to mind, but I would say that the work we have just completed on the A350 thrust reverser test rig is probably our greatest and proudest achievement. We designed and manufactured two test rigs that were almost identical; one of them was installed at Airbus in France and it actually formed part of the A350 Iron Bird. It was one of the largest orders that Comar has won over the years and was a real team effort, with both of my sons playing a key part in the success of the project.

Where do you see Comar in five years' time?

Having recently appointed both my sons as directors, I hope to see them take Comar to the next level. I believe I have given them a great foundation for success, and with their drive and hunger, I look forward to working with them on bigger and better projects as technology advances in the future.

What do you think is the key to succeeding in the aerospace industry?

Teamwork. It really is the most important part of any business, At Comar we have great staff retention, which helps the family feel of the business. We have employees that have been working for the company for 30 years, whom I value greatly. We all pull together as a team and we get results because of that. Our customers respond to the way we work and integrate as part of our team, holding meetings at Comar rather than at their own facilities because of the atmosphere and team environment.

Advantages of the approach

There are clear advantages to this approach, the first being safety. An FPGA-based program can provide a safer control system in two main ways. As mentioned earlier, the code is, in effect, running on hardware and it can be programmed to be immune to any other processes. A typical processor has to queue up all the events, some important, others not. The word 'queue' invariably means 'unknown delay' and does not have to exist here. Furthermore, because of the speed of the hardware-circuit processing, any trip conditions can be detected very quickly and acted upon. Moreover, dynamic trip conditions can be imposed to trap previously impossible-to-catch conditions.

Second, this approach enables reduced wiring and circuitry. Using the Compact RIO hardware, which contains the FPGA system, modules for analog and digital input/output can be connected to the FPGA hardware. The advantage with this approach is that a whole bank of intermediate relay hardware can be removed, and where possible, all intermediate signal conditioning can be removed. In addition, the signal conditioning for digital transducers such as encoders, tachos, some torque cells, and some displacement devices can be read directly and decoded on the FPGA. This direct connection provides a huge advantage in reducing complexity, signal noise, and phase errors between signals.

The implementation of this design approach to the motor unit under test resulted in a cost-effective and responsive rig, with increased mean time between failures and easier servicing during the lifetime of the rig. ∎

Stuart Martin is operations director, Comar Engineering, and Paul Riley is managing director, Computer Controlled Solutions. Both companies are based in the UK