Embedded system technology in ABB

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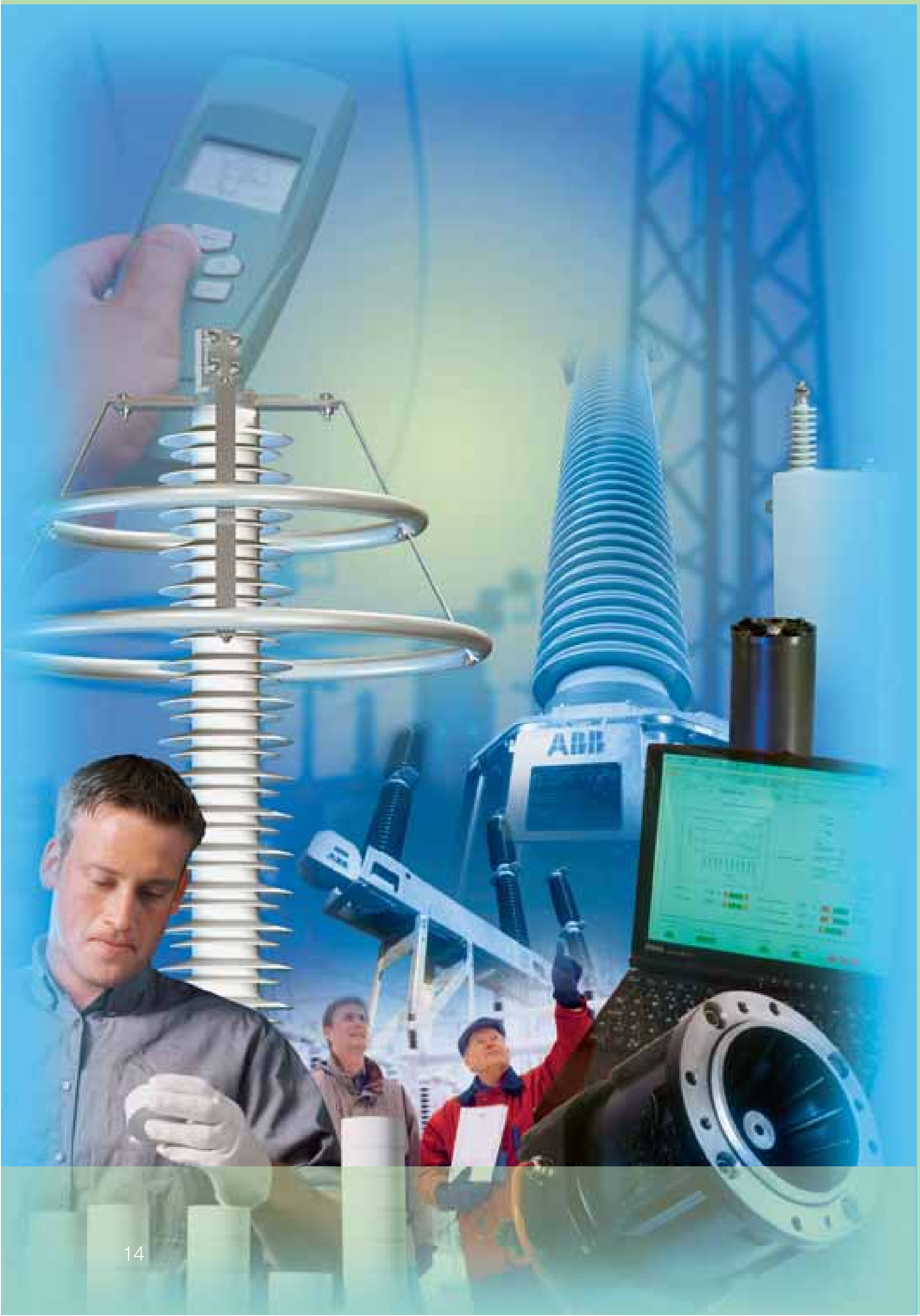

As the underlying technologies evolve, embedded systems are finding their way into an increasing range of ABB products and applications. Advances in this technology lead to higher performance and more functionality on the one hand, and reduced cost and size on the other. While this benefits the end user, the ever increasing complexity of embedded systems imposes new challenges for developers. This article provides a brief introduction to the use and application of embedded system technology in ABB's power and automation products – and the challenges being faced now and in the future.

Embedded system technologies

Embedded systems are special purpose computer systems that are totally integrated and enclosed by the devices that they serve or control – hence the term "embedded systems". While this is a generally accepted definition of embedded systems, it does not give many clues as to the special characteristics the systems possess.

Installation of advanced instrumentation in the field

How is ABB applying embedded systems?

To appreciate the purpose of embedded systems, it might be useful to answer some questions that will help to understand the underlying technology.

The first question is: How do embedded systems differ from general-purpose computer systems? The answer is, it depends. By definition, an embedded system is designed to perform a set of predefined tasks. This could range in complexity from simple supervision of the operation of an electrical switch, to controlling the movements of a powerful and highly flexible industrial robot. The two solutions, accordingly, will look completely different. The former would be optimized for very low cost, high volume production and the execution of a small set of pre-defined algorithms. The latter would be designed for computing complex, programmable movement paths and transforming the signals that control the motors of the manipulator.

The second question to ask is: Why do we need embedded systems? The answer to this is that general-purpose computers, like PCs, would be far too costly for the majority of products that incorporate some form of embedded system technology. A general-purpose solution might also fail to meet a number of functional or performance requirements such as constraints in power-consumption, size-limitations, reliability or real-time performance.

Embedded systems – where are they found?

ABB has been developing automation and power technologies for more than a hundred years. The concepts that underlie some of these technologies have evolved slowly: modern power transformers, for instance, work according to the same principles as they did in the early days of electric power transmission. And despite huge progress in switching technologies and material science, circuit breakers have been based on the same principles for the last fifty years. Now that small and powerful microcontrollers are available at low cost, embedded system components are finding their way into these long-established products. Here, the embedded systems typically perform a secondary function: they are used to supervise, protect or control the primary function of the product. The technology is a way of providing these attributes more cheaply, than the alternatives, or with new value-added features.

Modern transformer technology

Many other product families now offered by ABB could not have been conceived without embedded system technology. Examples are Distributed Control Systems (DCS) that can safely automate and control large and complex industrial plants, such as oil refineries, power plants and paper mills. In the early days of industrial automation, relay logic was used to perform simple control functions. With the advent of integrated circuits and the first commercial microcontrollers in the seventies and eighties, programmable industrial controllers were introduced to perform more complex control logic. Today, ABB's Industrial IT Extended Automation System 800xA integrates widely distributed and intelligent field devices with high-level system functions that optimize production assets, as well as the process itself.

The software part of a modern embedded system can consist of hundreds of thousand lines of code.

Challenges in industrial applications of embedded systems

This issue of ABB Review discusses the wide range of opportunities and challenges associated with the integration of embedded system technology into ABB's portfolio of products and solutions. Many of the benefits and requirements are typical of embedded systems in general – such as low cost, small size, etc. – some challenges are more specifically associated with industrial applications.

Industrial requirements

Industrial requirements vary enormously from application to application, but special industrial requirements typically include:

- Availability and reliability
- Safety

Embedded system technologies

- Real-time, deterministic response
- Power consumption
- Lifetime

Availability and reliability
Automation and power systems must have very high availability and be extremely reliable in order to minimize the cost of operation (ie to minimize scheduled as well as unplanned maintenance time).

Safety
While customers demand high quality and reliability from most of their embedded systems, it is not necessarily critical if, say, a PDA (personal digital assistant) needs to be restarted after an application causes the system to fail. For industrial applications, however, the effect of a failure in the system could be devastating. A gas leakage at an oil platform, for example, must be detected and followed by a safe shutdown of the process. Otherwise, expensive assets – or even human lives – could be at risk. Similarly, instabilities in power transmission and distribution networks should be detected before they are allowed to propagate and cause large blackouts. Economic security and personal safety depend on high-integrity systems. ABB uses embedded systems in such mission-critical configurations. Special development processes and design methodologies are implemented to provide proven and certified high-integrity products.

Real-time properties
'Real-time' is a term often associated with embedded systems. Because these systems are used to control or monitor real-time processes, they must be able to perform certain tasks reliably within a given time. But the definition of 'real-time' varies with the application. A chemical reaction, for instance, may proceed slowly, and the temperature at a given point may need to be read no more than once per second. However, the schedule must be predictable. At the other end of the scale, protection devices for high-voltage equipment need to sample currents and voltages thousands of times per second in order to detect and, where necessary, act within a fraction of a power-cycle.

Wireless power transmission
a power supply b primary coil
c switches with secondary coils

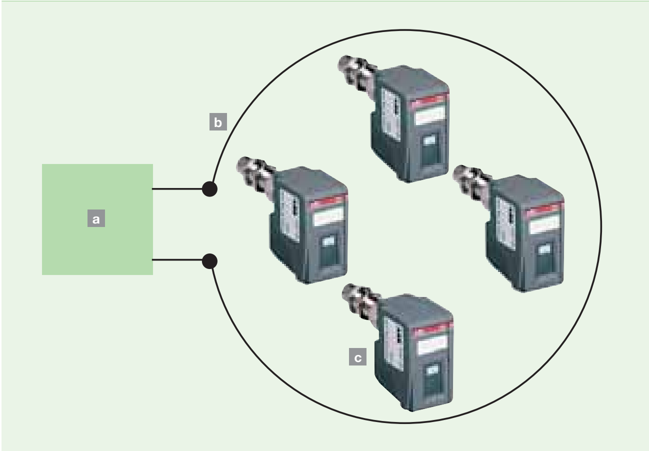

ABB utilizes its global reach to apply best practices developed in one part of its organization to others to improve overall performance.

Power consumption
At first glance, the power consumption of industrial electronics may appear insignificant because of the abundance of power that is available. However, this power is not always available, and the need to keep installation costs low has created a demand for electrical protection devices that do not require a separate power supply for the electronics; these devices are self-sufficient with respect to power and meet their needs by extracting small amounts of energy from their surroundings. Wireless sensors for building-, factory- or process-automation must offer years of battery life or a completely autonomous mode of operation. Self-sufficient power supplies can be designed to extract minute levels of energy from electromagnetic or solar power, temperature gradients or vibration in the environment. This is frequently referred to as energy "harvesting." Even when power is available, low-power design can be used to reduce the generation of excessive heat that would otherwise necessitate expensive and error-prone cooling devices.

Lifecycle issues
Yet another requirement that is frequently imposed on industrial embedded systems is a long lifetime of the product itself and the lifecycle of the product family. While modern consumer electronics may be expected to last for less than five years, most industrial devices are expected to work in the field for 20 years or more. This imposes challenges not only on the robustness of the electronics, but also on how the product should be handled throughout its lifecycle: Hardware components, operating systems and development tools are constantly evolving and individual products eventually become obsolete.

Key issues in developing embedded systems
Some challenges involved in the design of embedded systems have not really changed in the last couple of decades. The drive for increased performance at reduced cost and size, for instance, will continue as long as developments in the underlying technologies will permit. Other challenges involved in embedded system design are changing rapidly. Three areas should be given particular attention: complexity, connectivity and usability.

Complexity
While the steadily increasing transistor density and speeds of integrated circuits offer tremendous opportunities, these improvements also present developers (individuals, teams, organizations) with a huge challenge: how to handle the added complexity? A modern embedded system can consist of hundreds of thousand lines of software code.

More and more products now include complex embedded systems and the development organizations must evolve with the products and their technologies. It is necessary to establish suitable development processes, methods and tools. ABB utilizes its global reach to apply best practices developed in one part of its organization to others to improve overall performance. Developing product platforms also ensures re-use of technology and increased efficiency.

The emergence of SoC has enabled extremely powerful systems to run on configurable platforms that contain all the building blocks of an embedded system.

Connectivity

Before the widespread deployment of digital communication, most embedded systems operated in a stand-alone mode. They may have had some capabilities for remote supervision and control, but, by and large, most functions were performed autonomously.

Communication module for radio transmission

Robot arm equipped with wireless proximity switch

This is changing rapidly. Embedded systems are now often part of sophisticated distributed networks. Simple sensors with basic transmitter electronics have been replaced by complex, intelligent field devices. As a consequence, individual products can no longer be designed in isolation; they must have common components. Communication has gone from being a small part of a system to being a significant function. Where serial peer-to-peer communication was once the only way to connect a device to a control system, field buses are now able to integrate large numbers of complex devices. The need to connect different applications within a system to information and services in field devices drives the introduction of standard ICT technologies like Ethernet and web-services.

Usability

Complex field devices are often programmable or configurable. Today's pressure transmitters can contain several hundred parameters. The interaction with a device – either from a built-in panel or from a software application in the system – has become more complex. The task of hiding this complexity from the user through the creation of a user-friendly device has sometimes been underestimated. Most other requirements are easily quantifiable or absolute, but "usability" is somewhat harder to define. Yet an embedded system that is intuitive and simple to operate will reduce the cost of commissioning and maintenance. It will reduce errors and be a key factor in the overall customer satisfaction.

That is why usability is given a high priority in the design and development of ABB products, from the conceptual stage, right through to the final testing.

Embedded systems – latest trends

ABB is shaping the future of power and automation through innovative products and solutions, and embedded systems technologies are increasingly important in what the company does. That is why, to stay ahead of the game, ABB must anticipate the emerging trends and opportunities.

One such trend is SoC – Systems on Chip. The emergence of SoC has enabled extremely powerful systems – including hardware and software – to run on configurable platforms that contain all the building blocks of an embedded system; microprocessors, DSPs, programmable hardware logic, memory, communication processors and display drivers, to give but a few examples.

Other trends are related to built-in wireless communication and self-configurable networked devices. These trends enable extended use of intelligent field devices in applications where wiring costs for such devices are prohibitive. ABB is at the forefront of developing technologies and applications that benefit from the latest advances in research combined with technologies from other industries such as telecommunications and consumer electronics.

Simple sensors with basic transmitter electronics have been replaced by complex, intelligent field devices.

Exactly what power and automation systems will look like twenty years from now is impossible to predict. But whatever developments we witness, embedded systems will be key enablers and drivers for change.

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