INDUSTRIAL PROCESS AUTOMATION SYSTEMS

DESIGN AND IMPLEMENTATION

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INDUSTRIAL AUTOMATION 1

1.1 INTRODUCTION

Industrial automation of a plant/process is the application of the process control and information systems. The world of automation has progressed at a rapid pace for the past four decades and the growth and maturity are driven by the progression in the technology, higher expectations from the users, and maturity of the industrial processing technologies. Industrial automation is a vast and diverse discipline that encompasses process, machinery, electronics, software, and information systems working together toward a common set of goals – increased production, improved quality, lower costs, and maximum flexibility.

But it's not easy. Increased productivity can lead to lapses in quality. Keeping costs down can lower productivity. Improving quality and repeatability often impacts flexibility. It's the ultimate balance of these four goals – productivity, quality, cost, and flexibility that allows a company to use automated manufacturing as a strategic competitive advantage in a global marketplace. This ultimate balance is difficult to achieve. However, in this case the journey is more important than the destination. Companies worldwide have achieved billions of dollars in quality and productivity improvements by automating their manufacturing processes effectively. A myriad of technical advances, faster computers, more reliable software, better networks, smarter devices, more advanced materials, and new enterprise solutions all contribute to manufacturing systems that are more powerful and agile than ever before. In short, automated manufacturing brings a whole host of advantages to the enterprise; some are incremental improvements, while others are necessary for survival. All things considered, it's not the manufacturer who demands automation. Instead, it's the manufacturer's customer, and even the customer's customer, who have forced most of the changes in how products are currently made. Consumer preferences for better products, more variety, lower costs, and "when I want it" convenience have driven the need for today's industrial automation. Here are some of the typical expectations from the users of the automation systems.

As discussed earlier, the end users of the systems are one of the major drivers for the maturity of the automation industry and their needs are managed by the fast-growing technologies in different time zones. Here are some of the key expectations from major end users of the automation systems. The automation system has to do the process control and demonstrate the excellence in the regulatory and discrete control. The system shall provide an extensive communication and scalable architectures. In addition to the above, the users expect the systems to provide the following:

- Life cycle excellence from the concept to optimization. The typical systems are supplied with some cost and as a user, it is important to consider the overall cost of the system from the time the purchase is initiated to the time the system is decommissioned. This includes the cost of the system; cost of the hardware; and cost of services, parts, and support.

- Single integration architecture needs to be optimum in terms of ease of integration and common database and open standards for intercommunication.
- Enterprise integration for the systems needs to be available for communication and data exchange with the management information systems.
- Cyber security protection for the systems due to the nature of the systems and their deployment in critical infrastructure. Automation systems are no more isolated from the information systems for various reasons. This ability brings vulnerability in the system and the automation system's supplier is expected to provide the systems that are safe from cyber threats.
- Application integration has to be closely coupled, but tightly integrated. The systems capabilities shall be such that the integration capabilities allow the users to have flexibility to have multiple systems interconnected and function as a single system: shop floor to top floor integration or sensor to boardroom integration.
- Productivity and profitability through technology and services in the complete life cycle, in terms of ease of engineering, multiple locations based engineering, ease of commissioning, ease of upgrade, and migration to the newer releases.
- Shortening delivery time and reducing time of start-up through the use of tools and technologies. This ability clearly becomes the differentiator among the competing suppliers.
- SMART service capabilities in terms of better diagnostics, predictive information, remote management and diagnostics, safe handling of the abnormal situations, and also different models of business of services such as local inventory and very fast dispatch of the service engineers.
- Value-added services for maximization in profit, means lower product costs, scalable systems, just-in-time service, lower inventory, and technology-based services.
- Least cost of ownership of the control systems.
- Mean time to repair (MTTR) has to be minimum that can be achieved by service center at plant.

The above led to continuous research and development from the suppliers for the automation systems to develop a product that are competitive and with latest technologies and can add value to the customers by solving the main points. The following are some of the results of successful automation:

- *Consistency*: Consumers want the same experience every time they buy a product, whether it's purchased in Arizona, Argentina, Austria, or Australia.
- *Reliability*: Today's ultraefficient factories can't afford a minute of unplanned downtime, with an idle factory costing thousands of dollars per day in lost revenues.
- *Lower costs*: Especially in mature markets where product differentiation is limited, minor variations in cost can cause a customer to switch brands. Making the product as cost-effective as possible without sacrificing quality is critical to overall profitability and financial health.
- *Flexibility:* The ability to quickly change a production line on the fly (from one flavor to another, one size to another, one model to another, and the like) is critical at a time when companies strive to reduce their finished goods inventories and respond quickly to customer demands.

The earliest "automated" systems consisted of an operator turning a switch on, which would supply power to an output – typically a motor. At some point, the operator would turn the switch off, reversing the effect and removing power. These were the light-switch days of automation.

Manufacturers soon advanced to relay panels, which featured a series of switches that could be activated to bring power to a number of outputs. Relay panels functioned like switches, but allowed for more complex and precise control of operations with multiple outputs. However, banks of relay panels generated a significant amount of heat, were difficult to wire and upgrade, were prone to failure, and occupied a lot of space. These deficiencies led to the invention of the programmable controller – an electronic device that essentially replaced banks of relays – now used in several forms in millions of today's automated operations. In parallel, single-loop and analog controllers were replaced by the distributed control systems (DCSs) used in the majority of contemporary process control applications.

These new solid-state devices offered greater reliability, required less maintenance, and had a longer life than their mechanical counterparts. The programming languages that control the behavior of programmable controls and DCSs could be modified without the need to disconnect or reroute a single wire. This resulted in considerable cost savings due to reduced commissioning time and wiring expense, as well as greater flexibility in installation and troubleshooting. At the dawn of programmable controllers and DCSs, plant-floor production was isolated from the rest of the enterprise operating autonomously and out of sight from the rest of the company. Those days are almost over as companies realize that to excel they must tap into, analyze, and exploit information located on the plant floor. Whether the challenge is faster time-to-market, improved process yield, nonstop operations, or a tighter supply chain, getting the right data at the right time is essential. To achieve this, many enterprises turn to contemporary automation controls and networking architectures.

Computer-based controls for manufacturing machinery, material-handling systems, and related equipment cost-effectively generate a wealth of information about productivity, product design, quality, and delivery. Today, automation is more important than ever as companies strive to fine tune their processes and capture revenue and loyalty from consumers. This chapter will break up the major categories of hardware and software that drive industrial automation; define the various layers of automation; detail how to plan, implement, integrate, and maintain a system; and look at what technologies and practices impact manufacturers. Industrial automation is a field of engineering on application of control systems and information technologies to improve the productivity of the process, to improve the energy efficiency, to improve the safety of equipment and personnel, and to reduce the variance in the product quality and hence improve the quality.

The terminology and nomenclature of the industrial automation systems differ based on the industry of the applications. The term for computer-integrated manufacturing (CIM) is used in the manufacturing industry context and plant wide control in a process industry context. The essential of both these terms is to interconnection of information and control systems throughout a plant in order to fully integrate the coördination and control of operations. The automation engineering spans from the sensing technologies of the physical plant variables to the networks, computing resources, display technologies, and database technologies.

Improved human operator productivity will be realized through the implementation of individual workstations, which proved the tools for decision-making as well as information that is timely, accurate, and comprehensible. Time lines of data will be assured through the interconnection of all workstations and information processing facilities with a high-speed, plant-wide LAN network and a global relational database.

The broad goal is to improve the overall process and business operations by obtaining the benefits that will come from a completely integrated plant information system. The continual growth of the linkage of the process operations data with product line, project, and business systems data will be supported. The system will make such data readily available, interactively in real time, to any employee with a need to know, at workstations scattered throughout the plant and, above all, easy to use. The resulting comprehensive plant information management system will be the key to long-range improvements to process control, product line management, plant management, and support of business strategies.

One of the major challenges in today's automation jobs is evaluating the suppliers. This challenge is more apparent in the recent days because the systems appear same across the suppliers. Here are some of the guidelines that can be considered in the selection process.

These guidelines helps to set out your organization's needs, understand how suppliers can meet them, and identify the right supplier for you. The 10 Cs are Competency, Capacity, Commitment, Control, Cash, Cost, Consistency, Culture, Clean, and Communication. Used as a checklist, the 10 Cs model can help to evaluate potential suppliers in several ways. First it helps to analyze different aspects of a supplier's business: examining all 10 elements of the checklist will give a broad understanding of the supplier's effectiveness and ability to deliver the system on time, on budget with quality while having a sustained relationship for the rest of the life cycle including engineering, installation, precommissioning, commissioning, operation, and services.

1.2 INNOVATORS

The industrial automation cannot be described without remembering the pioneering works of the various scientists, whose contributions helped these technologies to mature and become commercially viable over a period of time. Few of the pioneering scientist's contributions are listed below.

ALESSANDRO VOLTA (1745–1827)

Alessandro Volta, Italian physicist is known for his pioneering work in electricity (Figure 1.1). Volta was born in Como and educated in public schools there. In 1800, he developed the battery called Upper Volta, a pioneer of the electric battery, which produces a constant flow of electricity. The electrical unit known as the volt was named in his honor owing to his work in the field of electricity. A year later, he improved and popularized the electrophorus, a device that produced static electricity. His promotion of it was so extensive that he is often credited with its invention, even though a machine operating on the same principle was described in 1762 by the Swedish experimenter Johan Wilcke.

ANDRE MARIE AMPERE (1775–1836)

Andre Marie Ampere was a French physicist and mathematician who was generally regarded as one of the main founders of the science of classical electromagnetism, which he referred to as electrodynamics (Figure 1.2). The SI unit of the measurement of electric current, the ampere is named after him. Ampere showed that two parallel wires carrying electric currents attract or repel each other, depending on whether the currents flow in the same or opposite directions, respectively – this laid the foundation of electrodynamics. The most important of these was the principle that came to be known as Ampere's law, which states that the mutual action of two lengths of current-carrying wire is proportional to their lengths and to the intensities of their currents.

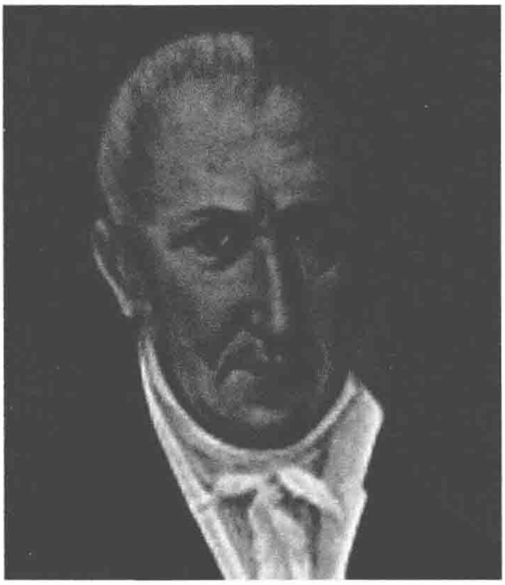

FIGURE 1.1 Alessandro Volta

FIGURE 1.2 Andre Marie Ampere

GEORG SIMON OHM (1789–1854)

Ohm was a German physicist and mathematician who conducted research using the electrochemical cells (Figure 1.3). Using equipment of his own, Ohm found a directly proportional relationship between the potential difference (voltage) applied across a conductor and the resultant electric current. This relationship is called the Ohm's law. In his work (1827), the galvanic circuit investigated mathematically gave complete theory of electricity. In this work, he stated that the electromotive force acting between the extremities of any part of a circuit is the product of the strength of the current and the resistance of that part of the circuit.

WERNER VON SIEMENS (1815–1892)

Siemens was a German inventor and industrialist (Figure 1.4). Siemens name has been adopted as the SI unit of electrical conductance, the Siemens. He was also the founder of the electrical and telecommunications company Siemens.

THOMAS ALVA EDISON (1847–1931)

He is an American inventor and businessman (Figure 1.5). He developed many devices that greatly influenced life around the world, including the phonograph, the motion picture camera, and a long-lasting, practical electric light bulb. He was one of the first inventors to apply the principles of mass production and large-scale teamwork to the process of invention, and because of that, he is often credited with the creation of the first industrial research laboratory.

Edison is the fourth most prolific inventor in history, holding 1093 U.S. patents in his name, as well as many patents in the United Kingdom, France, and Germany. More significant than the number of

FIGURE 1.3 Georg Simon Ohm

FIGURE 1.4 Werner Von Siemens

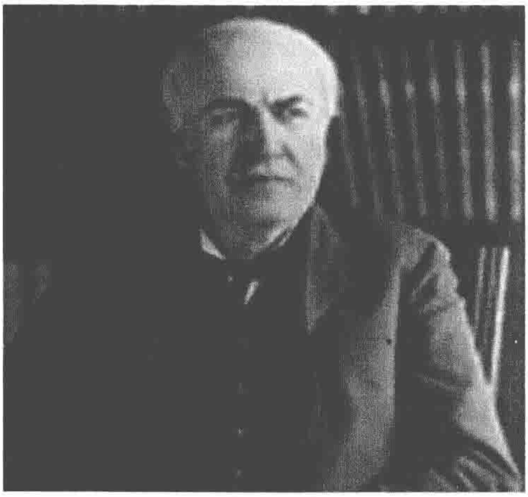

FIGURE 1.5 Thomas Alva Edison

Edison's patents are the impacts of his inventions because Edison not only invented things, his inventions established major new industries worldwide, notably, electric light and power utilities, sound recording, and motion pictures. Edison's inventions contributed to mass communication and, in particular, telecommunications.

Edison developed a system of electric power generation and distribution to homes, businesses, and factories – a crucial development in the modern industrialized world. His first power station was on Pearl Street in Manhattan, New York.

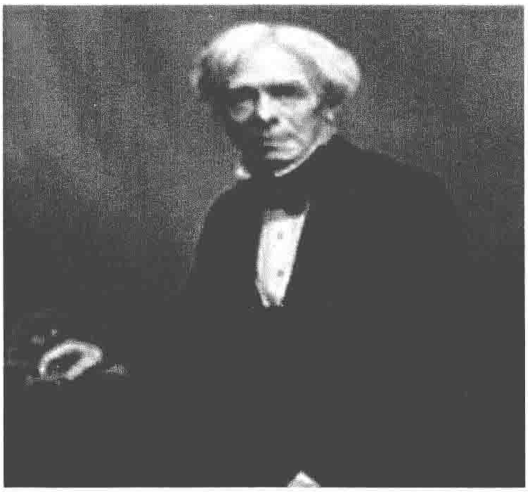

FIGURE 1.6 Michael Faraday

MICHAEL FARADAY (1791–1867)

He is an English scientist who contributed to the fields of electromagnetism and electrochemistry (Figure 1.6). His main discoveries include those of electromagnetic induction, diamagnetism, and electrolysis. He was one of the most influential scientists in history. It was by his research on the magnetic field around a conductor carrying a direct current that Faraday established the basis for the concept of the electromagnetic field in physics. Faraday also established that magnetism could affect rays of light and that there was an underlying relationship between the two phenomena. He similarly discovered the principle of electromagnetic induction, diamagnetism, and the laws of electrolysis. His inventions of electromagnetic rotary devices formed the foundation of electric motor technology, and it was largely due to his efforts that electricity became practical for use in technology.

JOHN BERDEEN (1908–1991)

He is an American physicist and electrical engineer, the only person to have won the Nobel Prize in Physics twice: first in 1956 with William Shockley and Walter Brattain for the invention of the transistor; and again in 1972 with Leon N. Cooper and John Robert Schrieffer for a fundamental theory of conventional superconductivity known as the BCS theory (Figure 1.7). The transistor revolutionized the electronics industry, allowing the Information Age to occur, and made possible the development of almost every modern electronic device, from telephones to computers to missiles. Bardeen's developments in superconductivity, which won him his second Nobel, are used in nuclear magnetic resonance (NMR) spectroscopy or its medical subtool magnetic resonance imaging (MRI).

WALTER H. BRATTAIN (1902–1987)

He is an American physicist at Bell Labs who along with John Bardeen and William Shockley, invented the transistor (Figure 1.8). They shared the 1956 Nobel Prize in Physics for their invention. He devoted much of his life to research on surface states. His early work was concerned with thermionic