



Rise of the robot

Celebrating 40 years
of industrial robotics
at ABB

DAVID MARSHALL, NICK CHAMBERS – In this centenary edition of *ABB Review*, one other important anniversary can be celebrated: It has been 40 years since ABB (then ASEA) introduced its first robot, the ASEA IRB 6, thus launching ABB's fascinating story in robotics. As the world's first all-electric, microprocessor-controlled, commercially available industrial robot, the IRB 6 was a historically significant machine. Since its launch, the field of robotics has changed drastically – almost beyond recognition. While many new and groundbreaking robotic developments have come along over the years, it is the technologies that have made robots easier to use and that have lowered the barriers to robot implementation that have made the biggest difference and accelerated the pace of robotic adoption.



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Industrial robots can now be found in discrete manufacturing environments across the world. They increase productivity, ensure consistently high quality and improve workplace safety. The advances made in robotic technology over the past four decades have been astounding: Where once single robots performed relatively simple and monotonous tasks in hazardous environments, now multirobot synchronized systems deal with sophisticated assignments in flexible production cells. ABB has played a major role in driving this robot revolution.

Title picture

Robotics technology has progressed dramatically in the past four decades. In particular, robots have become much simpler to implement and use.

The first-ever industrial robot appeared in 1961 when a hydraulically driven “Unimate” was supplied to General Motors for tending a die casting machine. Hydraulics dominated robotics until, in 1974, the Swedish company ASEA (later to merge with Brown Boveri to form ABB) developed the IRB 6, the first all-electric, microprocessor-controlled and commercially available industrial robot → 1. This 6 kg payload capacity machine was unique, not only in its drive system but also in its anthropomorphic configuration and its innovative use of a microprocessor for accurate control.

It set new standards in footprint size, speed of movement and repeatability, and gave rise to a number of imitators.

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Spot welding soon became a prime application area and the IRB 90, launched in 1982, was designed specifically for this task. This full six-axis device, with integrated water, air and electrical feeds built into the arm, made

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1 First IRB 6 customer – overview of cell



major inroads into the spot welding business.

Robots for painting

It did not take long for robots to move into the painting arena and, in 1985, ASEA released its first electric drive painting robot, the TR 5000. Later, in the 1990s, ABB invented the cartridge bell system (CBS) for painting car parts. The system utilizes easily replaced paint cartridges to reduce paint and solvent waste, thereby cutting costs and reducing emissions, while at the same time offering a wider choice in paint colors.

The most recent addition to ABB's range of painting robots is the compact and all-new IRB 5500 FlexPainter → 2. The unique design and configuration of the wall-mounted FlexPainter has created the largest and most flexible robot working envelope of any exterior car body paint robot. Two FlexPainter IRB 5500s can handle jobs that, until now, required four paint robots. The results are lower costs, both initially and in the long run, faster installation, high uptime and better reliability.

Robot mechanics

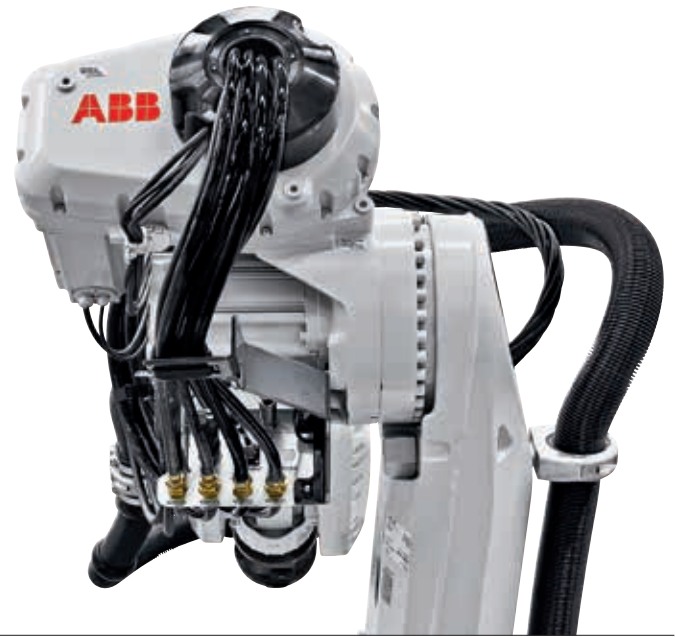
Such was the elegance of the IRB 6 design that its basic anthropomorphic kinematics with rotary joint movements can be seen in today's range of ABB robots. What has changed over the years is speed, accuracy and space efficiency.

Backlash-free gearboxes replaced ball screw drives for the "hip" and "shoulder" axes early on, resulting in better space kinematics. But the other significant

change was the switch from direct current (DC) to alternating current (AC) drive motors, which are smaller, brushless (easier to maintain), more powerful and they have a longer life – all features demanded by industrial users.

Heavy-duty robots

Flexibility and adaptability are features constantly called for by robot users. In 1991, ABB met these demands head-on with the heavy-duty (150 kg payload capacity) IRB 6000. Aimed primarily at spot welding and large component handling, the IRB 6000 was built on a modular concept with a range of base, arm and wrist modules so that it could be optimized for each user's needs – a design philosophy that ABB still uses today. With features that appealed to a broad range of customers, the IRB 6000 was an instantly successful spot-welding robot. The newest model in this family, the IRB 6700, follows in the IRB 6000's footsteps as the highest-performance robot in the 150 to 300 kg segment. The IRB 6700 has a 20 percent lower total cost of ownership (TCO) than its immediate predecessor, the IRB 6640, thanks to a more robust design, longer service intervals and simplified maintenance. Reliability was a key design consideration for the IRB 6700 – it is designed for a mean time between failures (MTBF) of 400,000 hours. To achieve this level of reliability, each and every IRB 6640 failure report was analyzed and the lessons learned were used for the IRB 6700 design. With 15 percent less power consumption, it is also easier on the environment and on the utility bills.



Well dressed

The reliability of a robot's dressing – the cables and hoses that deliver air, electricity, fluids, welding wire, etc. to the end of the arm – is at least as important as the robot itself. In many cases, dressing wear is what causes the most service headaches. Swinging cables not only wear faster, but also limit the free movement of the robot. Fully integrated dressings (IDs) – ie, those internal to the robot – are costly and can be limiting in terms of what can be run through them. ABB's new LeanID achieves a balance between cost and durability by integrating the most exposed parts of the dress pack into the robot → 3. This makes programming and simulation more predictable, creates a more compact footprint and, because wear and tear is reduced, lengthens service intervals. ABB's newest robot, the IRB 6700, has been designed to accommodate LeanID from the start.

Small is also beautiful

Sometimes robots have to be small. ABB's smallest-ever multipurpose industrial robot, the IRB 120, weighs just 25kg and can handle a payload of 3kg (4kg for a vertical wrist) with a reach of 580mm → 4. A white-finish cleanroom ISO 5 (class 100) version, certified by the IPA (Fraunhofer-Institut Produktionstechnik und Automatisierung), is also available.

The IRB 120T variant is for rapid pick and place applications that require extreme flexibility combined with industry-leading 10µm repeatability. The six-axis IRB 120T delivers a substantial increase in the maximum speeds of axes four, five and six, resulting in cycle-time improvements of up to 25 percent.

High-speed pick and place robots

ABB introduced the IRB 340 FlexPicker® robot in 1998 – another historically significant robot in that it was the first “delta-style” robot available for pick-and-place applications. It was capable of an impressive 10 G acceleration and 150 picks per minute, bettering human operators by orders of magnitude in both speed and versatility when handling small items, such as electronic components and food products.

The FlexPicker's software offers a combination of high-performance motion control with integrated vision guidance and conveyor tracking. The current standard model (IRB 360) is also available with longer arms and multiple payload capacities from 1 to 8kg depending on needs, and a working range of up to 1.6 m → 5. These new features enable the machine to perform pick-and-place actions over longer distances than ever before and also perform well even with heavy multiple item picks.

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4 IRB 120 at ABB SACE in Frosinone



Palletizing

One application area for robots that has grown enormously in recent years is palletization → 6. ABB's new IRB 460 is the fastest palletizing robot in the world. Compact, and with a lifting capacity of 110 kg, this four-axis robot is capable of up to 2,190 cycles per hour and so is perfect for high-speed end-of-line palletizing and bag palletizing. The IRB 460 has a reach of 2.4 m, occupies 20 percent less floor space and runs 15 percent faster than its nearest rivals.

Modern robot offerings extend far beyond the robot itself and the IRB 460, for example, comes with the PalletPack 460 Function Package. This is a set of pre-engineered products configured for end-of-line palletizing that greatly improves ease of use for integrators.

For high-output, full-layer palletizing, ABB has the IRB 760 robot. With a payload capacity of 450 kg and a reach of 3.2 m, this robot features high wrist inertia – double that of competitors – that enables it to rotate heavier and larger products faster than any other robot in this class. This superior speed makes the IRB 760 especially suited for palletizing full layers of beverages, building materials and chemicals.

Advances in control systems

In 1974, the IRB 6 control system had just a single 8-bit Intel 8008 microprocessor, an HMI with a four-digit LED readout and

12 punch buttons, and rudimentary software for axis interpolation and movement control. The robot required specialist knowledge to program and operate. Forty years and four control system generation changes later the picture looks completely different: IRC 5, ABB's fifth-generation robot controller, is specifically designed to make robots easier to use and lower the barriers to integration of robots into existing factories → 7.

IRC5 offers superior motion control and rapid incorporation of additional hardware. Its motion control technology, featuring TrueMove and QuickMove, is key to the robot's performance in terms of accuracy, speed, cycle time, programmability and synchronization with external devices. QuickMove determines the maximum acceleration possible in any move and uses it on at least one axis so that the end position is reached in the shortest time. TrueMove ensures the motion path followed is the same whatever the speed and obviates the need for "path tuning" when speed parameters are adjusted online. Other features include ABB's well-known FlexPendant interface device with a touch screen and joystick programming, the flexible RAPID language, and powerful communication capabilities.

Recently, ABB introduced a compact version of the IRC5 for applications where footprint has to be minimized, but full IRC 5 functionality guaranteed.



RobotWare is at the heart of the system and features a number of optional plug-ins designed to increase functionality and ease of use for robot users. For example, multitasking, transfer of information from file to robot, communications with external systems or advanced motion tasks.

A salient feature of IRC 5 is its MultiMove function, which allows control of up to four ABB robots plus work positioners or other servo devices – a total of 36 axes – in a fully coordinated manner.

Although complex, setting up and operating such a multi-robot cell with fully coordinated motions is made easier with the FlexPendant, the world's first open robot operator interface unit, developed for IRC5.

Next-generation robot safety

To ensure the safety of people working with industrial robots, humans and robots were traditionally separated by fences, and expensive safety equipment was necessary. ABB's SafeMove reduces the requirement for such equipment. SafeMove is an independent computer housed in the IRC5 cabinet that allows the reliable, fault-tolerant monitoring of robot speed and position, and the detection of any unwanted or suspicious deviation from the norm. If a safety hazard is detected, SafeMove executes an emergency stop, halting the robot within a fraction of a second.

FlexFinishing and force control

Another recent leap forward is ABB's FlexFinishing system featuring RobotWare Machining Force Control for delicate operations – specifically, for grinding, deburring and polishing castings. This unique robot application, first launched in 2007, contains a programming environment that allows the robot to find the optimum path itself. A feedback loop controls the speed and pressure of the tool.

The application allows simple and efficient programming by using the force sensor to define the trajectory for the robot movement – the operator simply moves the robot by hand to teach it the rough path. The robot automatically follows the part, recording the exact path and generating a robot program.

This innovative approach not only improves the quality of the finished parts, but it also reduces overall programming time by up to 80 percent, reduces the cycle time of the robot by 20 percent and extends the lifetime of the grinding tools by 20 percent. Other function packages for precision work are available – for gluing, for example. The gluing package provides perfectly coordinated robot motion and adhesive dispensing with conveyor tracking. High precision and consistent robot-based gluing/dispensing not only enhances parts quality, but reduces cycle time, too → 8.



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Computer-based programming

Over the years, it has become clear that the easiest, fastest, most accurate and most flexible way to program robots is on a computer in the office before ever even touching any physical equipment in the real world.

This is the best way to maximize return on investment for robotic systems, resulting in lower costs, faster time to market and superior end products.

ABB RobotStudio allows programming to be done on a computer without committing to construction or disturbing existing production. It simplifies the process of programming robots and makes it easier to design solutions for complex production environments.

Among all computer-based robot programming solutions, RobotStudio is unique in that it is built on the ABB Vir-

configuration files identical to those used on the shop floor ensures everything in the virtual world works exactly as it will in the real world.

For developers, this method of programming is very efficient and can be done without time pressure or the constraints of pre-existing equipment locations. By lowering the barriers to robotic integration through ease of programming, customers and integrators both see reduced costs and faster times to market, resulting in a virtually instant return on investment.

Ready to go

Standardized manufacturing cells are removing some of the last barriers to the implementation of robotics. Instead of building robot cells from scratch, customers can use ABB's FlexLean concept, which offers a compact cell in which the robots, controllers and cabling

are pre-mounted on a platform. FlexLean offers automotive manufacturers both geometrical assembly and respot cells that come with a choice of pre-defined configurations and a broad range of robotic

The Flexpicker's software offers a combination of high-performance motion control with integrated vision guidance and conveyor tracking.

tual Controller, an exact copy of the real software that runs on ABB production robots. Using real robot programs and

products. This results in cells so cost-efficient that they can compete with manual labor in low-cost countries.



An addition to the range of standardized cells is ABB FlexArc® – a complete arc welding package → 9. It includes all the components necessary for robotic arc welding: Robots, IRC 5 with support for multiple-robot coordination, positioners and welding equipment. Customers can choose between several single- or multi-robot production solutions. All internal cables are routed and connected in the factory. Again, all cell components are mounted on a common base, eliminating the need for on-site engineering work. Software has been preconfigured for simple setup and operation. As a packaged solution, a FlexArc cell can be moved within or between different production facilities. This allows engineers to design highly flexible plant layouts that meet today's demands for rapid changeovers.

Robot eye

Even in the last decade, vision technology has progressed tremendously and ABB has recognized that a powerful vision-guided robotics system can help overcome many manufacturing challenges.

The ABB Integrated Vision product, which can be used in many industries, features 50 powerful vision tools, autofocus, integrated lighting and optics, faster image capture, capability to power and control a range of external lighting and enough input/output capacity for virtually any inspection scenario – all in a compact IP67 package → 10.

Integrated Vision's extensive library of vision commands makes it easy to use – even for first-time vision users. ABB's off-line 3-D programming tool, RobotStudio, offers, as standard, ready-made components for easy programming of the robot and the vision system.

Remote service

Reduced robot performance can significantly impact production. This is why ABB introduced remote service technologies and has now built up a global service with 1,200 service specialists in more than 50 countries and over 100 locations. ABB's installed base of more than 230,000 robots offers huge benefits of scale and means that world-class service can be provided at a reasonable cost. This aspect is one important market differentiator for ABB.

With remote service, robot data is sent from the controller to a service center for automatic analysis and scrutiny by a subject matter expert. The expert can remotely identify the cause of a failure and provide rapid support to the end user. Many issues can be solved without site visits. The automatic analysis can not only provide a failure alert, but can also predict future difficulties. At any time and from anywhere, a user can verify robot status and access important maintenance information about that robot system by logging into ABB's online MyRobot portal.



The age of the industrial robot

Since ASEA presented the first all-electric, microprocessor-controlled robot in 1974, industrial robotics has come a long way – and the pace of change is only accelerating. This year, ABB expects to sell its 250,000th robot and is primed to continue pioneering new developments, and building a comprehensive range of industrial robots, robot controllers, associated software and innovative service options. In 40 years, positioning accuracies have improved from 1 mm to 10 µm, user interfaces from a 4-digit LED readout to a full Windows touch-screen display and memory capacity from 8 kb to many terabytes. At the same time, reliability has increased enormously and costs have plummeted so far that, today, a robot costs less than half of what it did 10 years ago. The age of the industrial robot has arrived.

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