The concept of "generic motion control" combines the worlds of robotics, CNC, linked axis movements and single axis positioning in one homogenous system. Knowledge of the complex path design for robots is applied to tool and production machines. The control of anthropomorphic robots is also possible, as is complex CNC processing in 3D.

The connection of I/O nodes required for an automation solution and the direct linking of PLC functions provides additional advantages for simple implementation of automation processes.

Depending on the task, the flexible programming interface provides the possibility for high level language programming as well as the use of DIN 66025 programs or simple coordinate tables. Use of customer-specific programming languages is also possible.

Predefined visualization components can be used to view complex machine functions. In addition to "classic" components such as parameter settings and operation of movement programs, this also includes tools for simulation, logging and the diagnostics of processes. This provides the foundation for all custom visualization solutions.

Components
Generic motion control is based on a modular and therefore also scalable system architecture. This makes it possible to put together the required system functions flexibly using the least possible amount of computing power from the CPU.

The core components of the system cover all necessary functions for movement control. Through the modular architecture, components that require a large amount of computing power can be deactivated if necessary. This results in a minimum load on the target platform and allows the use of a custom control system for a machine.

Generic motion control overview
- Modular system architecture
- Open programming interface
- Motion control basic functions
- All types of kinematics
- Work area monitoring
- Open drive interface:
  - Analog
  - Stepper motor
  - ACOPOS
  - ACOPOSmulti
  - Hydraulic
Generic motion control overview

- **Programming**
  - Customer-specific
  - Coordinates
  - PLCopen
  - High level language

- **Kinematics**
  - Customer-specific Portal
  - Delta 2D
  - SCARA
  - Robotic arm

- **Generic motion controller**
  - Path design
  - Dynamics
  - Safety
  - Coupling
  - Cam profile automaton

- **Tool data**
- **Axis correction**

- **Work area**
- **Cam profile**
Integrated CNC automation

Automation system
Manufacturers of automation solutions often not only need a controller, they need a complete platform for automating machines. This includes drives, movement and path control, visualization and the necessary networking. A CNC path controller becomes an integral part of the automation system.

Soft CNC
The Soft CNC from B&R differs from conventional systems in several ways and combines all components in one system. The Soft CNC is embedded in the PLC's real-time operating system. This meets the requirements for completing even the most complex tasks.

Flexibility
Machine-specific functions are not added to the standard functions after the fact. Instead, individually pre-designed modules are integrated into the project to achieve maximum flexibility. This refers to, for example, linking of slave axes to CNC axes using cam profiles, connection of I/O using different bus systems or the use of additional terminals.

Integrated CNC automation
- Open and flexible system architecture
- Integrated CNC functions
- Cam profiles
- Integrated PLC
- Individual graphic interface
- Internet, intranet connection
CNC system functions
ARNC0 has a wide spectrum of functions. CNC programs can be processed in up to eight independent CNC channels. The movement profile is optimized using a dynamic look-ahead function over multiple path sections, which minimizes jolt (i.e. change in acceleration).

Fast scan time
CNC cycle times of 400 μs allow path precision in the sub-micron range. Generated set positions are transferred without jitter via POWERLINK to the drive being used. Processing of over 2500 NC blocks per second guarantees that free-form surfaces are processed without thinning out of coordinates.

Simultaneous interpolation
In a CNC channel, up to nine axes can be programmed for simultaneous interpolation. Three of the axes, normally X, Y and Z, define the path in the Cartesian coordinate system. One axis can be defined as tangential axis that can also be automatically aligned to the programmed contour. The rest of the axes are linear or rotational auxiliary axes.

CNC channels and axes
That means a total of up to 72 CNC axes can be defined in the CNC channels. However, it is also possible to use auxiliary axes that are independent of a CNC system. In total, ARNC0 can manage up to 100 axes.
NC programs
In the Soft CNC, part programs and movement procedures are programmed according to DIN 66025. Division into main and sub-programs allows clear management of NC programs.

Extended programming techniques
Helpful functions have been added to the basic functions defined in the standard. The extended programming techniques permit the use of elements from a high level language, such as loops, conditional statements and branches. Data from application programs on the PLC is exchanged using a powerful parameter structure.

Real-time control of program execution
Various access functions allow program execution to be controlled in real-time. Data, such as tool radius or even end points of path sections, can be changed while the program is being executed, and certain data, such as M functions and parameters or user-defined signals, are available synchronous to the path.

Path dynamics
Influencing path dynamics (i.e. characteristics such as path speed, acceleration and jolt) is especially critical when using path control in certain areas of technology. The ability to change these characteristics during runtime or automatically adjusting them depending on the path radius or curvature is essential for certain applications.

Path section transitions
Special attention is paid to the dynamic behavior in path section transitions. The behavior can be adjusted to meet the exact technological requirements specific to how the CNC controller is being used.

Override
The movement on the path can be influenced online using various override functions. It is also possible to carry out a reverse movement on the original path back to the start of the program.
Tools
The use of tools and the related correction functions is not limited to tool machines. There is much more behind tool correction than simple cutter diameter compensation for a milling cutter.

Tool data
Tool data is stored in ARNC0 in a table with up to 500 entries. This includes specifications such as tool diameter, length and offset, and the alignment of the tool can be determined freely. Additional sophisticated functions guarantee optimal results in all areas of use. Invalid intersections, notches and peaks do not necessarily require a stop along the path, which, on a torch cutting machine for example, would heavily damage the workpiece. Instead, they are automatically corrected according to the user’s specifications.

Adjustment of path dynamics
The definition of the path dynamics on the corrected path can be adjusted for use in various technologies. In this way, the programmed feed can refer either to the original or the corrected contour. Transitions that are required on outer corners can be carried out as arc or linear blocks. The feed itself can be increased or decreased according to the curvature.

Help functions
It is possible that the path geometry is influenced by factors other than the tool data. Functions such as rounding of transitions, tangential transition arcs or mirroring of coordinates can simplify programming.

Tool data and path geometry
- Tool radius can be changed during runtime
- Programmable tool orientation
- Correction functions for invalid contour elements
- Tool data table
- Optimization of path dynamics
- Rounding
- Tangential transition arcs
- Mirroring
Help and compensation functions

Align working plane
Other useful functions include free rotation and shifting of a working plane in space (3D) and skew correction for machine axes. Of course, it is also possible to adjust the tools to compensate for a non-level working plane.

Clamp position correction
Clamp position correction rotates or shifts the working plane in cases where the workpiece was not optimally placed or where a rotated plane must be processed in 3D space.

Skew
Skew correction is helpful when it is difficult or impossible to square the axes mechanically. The CNC distorts the part program so that the actual path matches the path in an ideally squared system. The skew is determined using high precision measurement of specific reference points in the machine's working area. Soft CNC uses this data to derive the corresponding compensation function.

Spindle pitch error and backlash
Soft CNC also handles correction functions at the axis level. These include spindle pitch error and backlash compensation. These functions make excellent path precision possible, even on machines that are mechanically less precise. In Soft CNC, compensation of spindle pitch error or any nonlinearities in the movement area of an axis can be unidirectional or bidirectional. In this case, the bidirectional method has the advantage that spindle backlash is automatically compensated for.

Help and compensation functions
- Zero point table with up to 200 entries
- Free rotation of working plane in space
- Clamp position correction
- Machine skew correction
- Spindle pitch error correction
- Backlash compensation
Generic motion control

PLCopen function blocks

Motion control function blocks
The creation of PLCopen motion control function blocks fulfills a long-awaited demand for a standard that can handle positioning tasks quickly, easily, and efficiently.

They can be programmed in the proven IEC 61131 standard programming languages Structured Text, Instruction List, Ladder Diagram, or Sequential Function Chart. In addition to these languages, B&R also supports programming in B&R Automation Basic and C.

PLCopen function blocks allow operation of all motor types supported by the ACOPOS and ACOPOSmulti drive systems (synchronous, asynchronous, linear and torque motors). The universal availability of PLCopen function blocks for all B&R products makes it possible to optimize the component selection to match the performance demands of every application. Like the drive firmware, the PLCopen library is included in the Automation Studio package. Selecting this library in the project automatically imports it and makes the function blocks available for programming.

<table>
<thead>
<tr>
<th>Administrative motion control function blocks</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>Description</td>
</tr>
<tr>
<td>MC_Power</td>
<td>Switches the controller on or off.</td>
</tr>
<tr>
<td>MC_ReadStatus</td>
<td>Reads the type of movement performed by the axis.</td>
</tr>
<tr>
<td>MC_ReadAxisError</td>
<td>Reads error messages.</td>
</tr>
<tr>
<td>MC_ReadParameter</td>
<td>Reads a selected PLCopen parameter.</td>
</tr>
<tr>
<td>MC_WriteParameter</td>
<td>Writes a selected PLCopen parameter.</td>
</tr>
<tr>
<td>MC_WriteBoolParameter</td>
<td>Writes a selected PLCopen parameter of data type BOOL.</td>
</tr>
<tr>
<td>MC_Reset</td>
<td>Takes the axis out of an error state. All error messages are acknowledged.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Single-axis motion control function blocks</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>Description</td>
</tr>
<tr>
<td>MC_Home</td>
<td>References the axis to a specified position.</td>
</tr>
<tr>
<td>MC_MoveAbsolut</td>
<td>Starts a movement to a target position with a predefined speed and acceleration. Motion parameters such as target position, speed, and acceleration can be modified in real time. When this is the case, the axis is driven using the new parameters without the movement being interrupted. Switching to a different single-axis movement (MC_MoveAdditive, MC_MoveVelocity) is possible at any time.</td>
</tr>
<tr>
<td>MC_MoveAdditive</td>
<td>Covers a specified path with a predefined speed and acceleration. Motion parameters such as target position, speed, and acceleration can be modified in real time. When this is the case, the axis is driven using the new parameters without the movement being interrupted. Switching to a different single-axis movement (MC_MoveAdditive, MC_MoveVelocity) is possible at any time.</td>
</tr>
</tbody>
</table>
### Single-axis motion control function blocks

<table>
<thead>
<tr>
<th>Name</th>
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</tr>
</thead>
<tbody>
<tr>
<td>MC_MoveVelocity</td>
<td>Starts a motion with a specified speed and acceleration. Motion parameters such as target position, speed, and acceleration can be modified in real time. When this is the case, the axis is driven using the new parameters without the movement being interrupted. Switching to a different single-axis movement (MC_MoveAbsolut, MC_MoveAdditive) is possible at any time.</td>
</tr>
<tr>
<td>MC_TouchProbe</td>
<td>An axis position is stored for the selected edge of the trigger input. This has to do with a highly precise measurement with a timing resolution of 50 ns. This function block is suitable e.g. for recording a print mark position. Depending on the application, this can be used to calculate a position correction. This can be brought back into the system using the MC_Phasing function block to perform the necessary correction.</td>
</tr>
<tr>
<td>MC_AbortTrigger</td>
<td>Cancels the trigger input function (MC_TouchProbe).</td>
</tr>
<tr>
<td>MC_DigitalCamSwitch</td>
<td>Switches a digital output according to an axis position (drum sequencer). Switching time compensation and hysteresis can be configured.</td>
</tr>
<tr>
<td>MC_Stop</td>
<td>Stops a movement using a predefined deceleration ramp.</td>
</tr>
</tbody>
</table>

### Multi-axis motion control function blocks

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MC_GearIn</td>
<td>Starts speed coupling to a master axis. If the master is already moving, a gentle run-in movement is calculated to reach the speed of the master axis as quickly as possible while still adhering to the specified limit values. The gear ratio can be modified anytime when the coupling is active. As with the start of the coupling, a gentle transitional movement is calculated in the new coupling ratio here as well.</td>
</tr>
<tr>
<td>MC_GearOut</td>
<td>Ends an active speed gear, and the axis continues moving at the current speed.</td>
</tr>
<tr>
<td>MC_CamTableSelect</td>
<td>ACOPOS drives use polynomial cam profiles. Their calculations take place either offline using the Automation Studio™ help system or math/kinematics programs, or online on the controller. With this function block, one of these cam profiles is transferred to a drive so that it can be used for a coupling.</td>
</tr>
<tr>
<td>MC_CamIn</td>
<td>Starts a cam profile link to a master axis with a selected cam profile. The course of the cam profile to the master or slave position is configured using offsets. Multiplication factors allow the cam profile dimensions to be adjusted at any time. Switching the cam profile is also possible at any time, even if the coupling is active. When doing so, the currently active curve is driven to the end before before switching to the newly started curve. When using periodic axes (e.g. packaging machines), this method ensures that the axes remain synchronous to one another.</td>
</tr>
<tr>
<td>MC_CamOut</td>
<td>Ends an active cam profile coupling, and the axis continues moving at the current speed.</td>
</tr>
<tr>
<td>MC_Phasing</td>
<td>Applies a phase shift on the master's side for the drive and cam profile coupling with a predefined speed and acceleration.</td>
</tr>
</tbody>
</table>
Generic motion control

Intelligent servo drives
Increased production quantities, reduced production cycles and improved quality with greater precision become a reality with servo drives from the ACOPOS series.

Efficient system architecture
Controlling a power transmission system with ACOPOS servo drives from B&R opens up the advantages of an optimized system architecture. Applications that require additional positioning tasks such as torque limitation or torque control can be created quickly and elegantly.

Powerful inverters
The flexible system concept for B&R servo drives is made possible by coordinated hardware and software components. You can select the optimal system configuration for your application and increase your competitiveness.

Compact technology
The ACOPOS servo drive series covers a current range from 1.0 to 128 A and a power range from 0.5 to 64 kW with 11 devices in 4 groups. They offer connection possibilities for all standard encoder systems and modular fieldbus interfaces. ACOPOS servo drives are suitable for both synchronous and induction servo motors and have built-in line filters to meet the limit values for CISPR11, Group 2, Class A.

The ACOPOS servo drives detect a power failure and can immediately initiate active braking of the motor. The brake energy that occurs when braking is returned to the DC bus and the DC bus power supply can use it to create the 24 VDC supply voltage. An external DC bus power supply must be used for ACOPOS servo drives 8V1010 to 8V1090. A DC bus power supply is integrated in ACOPOS servo drives 8V1180 to 8V128M. The ACOPOS servo drives with an integrated DC bus power supply provide the 24 VDC supply for the servo drive and also a 24 VDC output to supply encoders, sensors and the safety circuit. In may cases, it is not necessary to use an uninterruptible power supply (UPS) which is otherwise needed.

ACOPOS servo drives
- Perfect integration in all B&R product families
- Object-oriented axis programming minimizes development time and increases reusability
- Integrated technology functions for industry-specific tasks
- Operation of synchronous and induction motors possible
- Outstanding Dynamic and accuracy due to 50μs current controller sampling time
- CAN bus and POWERLINK network connection
ACOPOSmulti

Efficient and compact with a high degree of availability, the drive system for maximum customer benefits - ACOPOSmulti

In today's market, customers demand more than simply meeting technical requirements. Above all, customers require cost-effective solutions, investment security and a high degree of availability. ACOPOSmulti, the new drive generation from B&R, possesses these characteristics. Designed for implementation in processing machines, the ACOPOSmulti drive family (with a power range from 1.4 A to 167 A) plays a significant role in the efficiency of the entire solution.

Modular cooling design
The use of fans and climate control units in the switching cabinet means considerable expenses on the one hand, and additional maintenance requirements on the other. ACOPOSmulti gives the designer the free space for conventional heat dissipation in the switching cabinet, a feed-through cooler with IP65 protection for releasing heat outside the switching cabinet and a cold plate variant for connecting to a cooling circulation system (water, oil).

Trend-setting power supply
Conventional drive systems convert only half of the applied power from the mains into actual mechanical power.

The ACOPOSmulti drive system treading a new path:

Power factor correction
This means that only effective power is taken from the power supply. This reduces the connected load and power consumption of the machine by approximately a factor of 2. This means smaller fuses and wire cross-sections.

Stable voltage conditions
The DC bus voltage remains constant regardless of the mains supply voltage, which means maximum utilization by the inverter modules and motors no matter what country they are operating in.

Integrated power regeneration unit
All of the power supply modules are able to regenerate power. Instead of being converted to heat as is usually the case, kinetic energy generated during braking is converted to electrical energy that is regenerated into the power supply system.

Sophisticated diagnostics
The intelligent power supply modules with network connection via POWERLINK offer completely new options for machine and system diagnostics.

Handling power failures safely
Modern production machines rely on flexibility. Mechanical cam profiles are replaced by electronic cam profiles. The well-known advantages of flexibility and wear-free electronics also have a disadvantage: Loss of the cam profile link when a power failure occurs. This is not the case with the ACOPOSmulti drive system - the integrated 24V auxiliary supply module makes it possible to maintain a coordinated movement until the system reaches a standstill.

Compact, scalable performance
Compact, high-performance drive technology is the latest trend. The main reason for this is to achieve the best possible use of production halls, which requires small machine dimensions. Based on this principle, ACOPOSmulti offers maximum performance with minimum space requirements. The range of applications includes sensor-free induction motors, permanent magnet servo motors in standard torque or linear motor versions, and ultra-dynamic ironless linear motors.
Generic motion control

Integrated safety technology
Trend-setting safety technology communicates via one network, POWERLINK Safety. By integrating this open standard, the ACOPOSmulti drive system, together with the B&R safety-related components, has raised the bar in the area of secure automation solutions.

Integrated technology
Modern marketing demands individualization of the end product. Machine flexibility is therefore one of the decisive factors in order to gain a competitive edge.

Modern machine concepts replace mechanical process technologies with sophisticated mechatronic concepts. As a result, the role of software in the process is constantly increasing in importance. B&R offers a multitude of industry-specific technology functions to simplify automation even for complex applications. These intuitively built and easy-to-operate software components guarantee a cost-effective solution.

 Outstanding usability
The ACOPOSmulti drive system is designed to provide the highest degree of usability throughout the entire life cycle.

It is designed for simple management of machine variations. An ACOPOSmulti mounting plate is the basis for different variations of the machine. The design of the machine determines which devices are used. The software recognizes the design automatically and provides the necessary functions.

Ideally suited for industrial switching cabinet construction. The ACOPOSmulti is designed with connection technology that allows rewiring of complete switching cabinets - ideal for manufacturing series machines.

ACOPOSmulti highlights:
- Easy wiring
  - Integrated power distribution
  - Plug-in motor and encoder connections
  - Sufficiently dimensioned work area
  - Ideally suited for industrial switching cabinet construction

- Trend-setting power supply
  - Power factor correction
  - Stable voltage conditions
  - Integrated power regeneration unit

Integrated 24 V supply
- Handling power failures safely
- Compact book-size design

Compact, scalable inverter
- Induction motors, servo motors, linear and torque motors
- Outstanding performance

High level of availability
- Thermal models replace limit values
- Safe operation regardless of the type of load
- Preventive overload detection (simulation of the load cycle in real-time)

Safety technology
- SIL3 (Cat 4 EN954) safety functions
- Based on POWERLINK Safety
ACOPOSmulti – 8LSA synchronous servo motors
The new 8LSA line of servo motors feature more torque at smaller volumes. The new motor design, combined with neodymium iron boron magnets, delivers extraordinary drive qualities. Modern processing machines demand compact, reliable servo motors. With their new design and robust structure, the 8LSA servo motors are an ideal solution to these demands. The ACOPOSmulti drive system and the 8LSA servo motor line make up an unbeatable team for high performance dynamics, precision, and operating safety.

Accurate
The use of 19-bit encoders as a standard feature ensures consistent movements and accurate positioning. Encoders with up to 25-bit resolution are available for higher demands. Both types are also available as multi-turn encoders. This means that inconvenient homing procedures and additional sensors are no longer necessary. The absolute encoder functions without a battery and is therefore absolutely maintenance free. Versions are also available with resolvers for applications with lower precision and speed requirements.

Reliable
Other than the bearings, permanent magnet servo motors have no mechanical parts that are subject to wear. The bearings in the 8LSA servo motors are sufficiently dimensioned and filled with high quality synthetic lubricant. For unusually high demands, such as those that occur in belt drives, the motors are available with reinforced bearings that withstand high radial forces. The temperature levels in the motor are monitored with two independently functioning systems. A linear temperature sensor is located in the motor winding. This sends the temperature, measured to the degree, to the higher-level inverter. A second temperature model in the inverter calculates a virtual motor temperature from the process data. A combination of the data from both sources ensures all around protection of the motor winding even during heavy operation.

CE conformity and UL certification
All B&R servo motors were designed for international use, and in addition to the obligatory CE conformity they are also certified as a UL “Recognized Component”.

Embedded parameter chip included
All relevant mechanical and electrical information and data is stored in the encoder used for the 8LSA servo motors.

Flexibility
The motors are available in a number of variations, which enables them to provide the best possible solution for any drive task.

Motor highlights
- Modern compact motor technology
- 19-bit encoder technology available in single/multiturn designs
- Embedded parameter chip
- Sufficiently dimensioned bearings
- CE, UL certified
B&R Automation Studio is comprised of all the software tools that the user will require for the entire machine life-cycle. It covers configuration, programming, and diagnostics as well as operation and maintenance of the controllers, the integrated drive technology, and the visualization. Support for all IEC 61131-3 programming languages is a given. ANSI C and Automation Basic offer an additional degree of freedom.

Complex drive solutions can be created after a short orientation period. Hardware components and prefabricated program sections and technology functions are added and configured in dialog boxes; this reduces project development times considerably.

**Integrated diagnostics**
The diagnostics integrated in Automation Studio offer more detailed information about the system and assist in the optimization of controller and drive to help achieve maximum performance and operating safety. Various watch and trace functions are available, especially in the areas of positioning and diagnostics. Specifications such as current position, speed or acceleration of individual axes as well as the CNC path can be displayed and recorded.

**Logger with online diagnostics and archiving**
The new expanded logger enables you to diagnose the state of the system in detail, and also to trace errors in the program back to their causes.

The following functionalities facilitate the analysis:
- Additional system information with "Backtracing"
- Cycle time violation with display of the program code causing it
- Invalid memory access is localized with "backtracing"
- Memory dump for analysis of system states
- Function call parameter for identifying faulty calls
- User-specific logs for diagnosing user applications
- Clearer overview by separating system and user data
- Clear and easy archiving and display of assorted analyses
- Sorting according to various criteria