RosettaCNC

IMPORTANT

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User Manual - Milling Machine

Firmware 1.76

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1

Fundamentals

1.1 This manual

Safety standards

Adhere to all safety standards mentioned in this documentation and in the documentation provided by the machine manufacturer.

The safety standards inform about potential dangers in handling the software and equipment and provide guidelines for their prevention.

They are classified according to the severity of the danger and divided into the following groups:

DANGER

Danger indicates risks to people. Non-compliance with the instructions **will certainly result in death or serious physical injury**.

WARNING

Warning indicates risks to people. Non-compliance with the instructions **will probably result in death or serious physical injury**.

CAUTION

Caution indicates risks to people. Non-compliance with the instructions **will probably result in minor physical injuries**.

NOTE

Note indicates risks to objects or data. Non-compliance with the instructions **will probably result in material damage**.

Sequence of information within the safety standards

All safety standards contain the following four sections:

- The signal word indicates the severity of the hazard
- Type and source of the hazard
- Consequences if the hazard is not heeded, e.g., "There is a risk of collision in the following operations"
- Measures to avert the hazard

Informative indications

Adhere to the informative indications given in this manual for efficient and fault-free use of the software.

The following informative indications are given in this manual:

The information symbol signals a **tip**.

A tip provides important additional or supplementary information.

This symbol requires adherence to the machine manufacturer's safety standards. The symbol also refers to machine-related functions.

Possible hazards for the operator and the machine are described in the machine manual.

The book symbol indicates a **reference** to external documentation, such as documentation from the machine manufacturer or a third-party producer.

Need for changes and error identification

We are committed to continually perfecting the documentation aimed at users and therefore invite them to cooperate in this sense by sending any requests for changes to the following email address:
support@rosettacnc.com

2

The NC System

2.1 Type of numerical control, software, and functions

This manual describes the functions for configuring the machine and for testing and executing NC programs, available in numerical controls from the following firmware and control software versions.

Type of numerical control	NC firmware name	NC firmware version
RosettaCNC-A	RosettaCNC-A	1.76
RosettaCNC-B	RosettaCNC-B	1.76
RosettaCNC-BA	RosettaCNC-BA-01	1.76
RosettaCNC-BE	RosettaCNC-BE-01 RosettaCNC-BE-02 RosettaCNC-BE-03	1.76 1.76 1.76

Standard versions of numerical control

The numerical control is available in two basic versions:

- RosettaCNC-A Control up to 4 axes in STEP/DIR mode
- RosettaCNC-B Control up to 6 axes in STEP/DIR mode

and two variants of version B:

- RosettaCNC-BA Control up to 5 axes in position loop control
- RosettaCNC-BE Control up to 7 axes, one of which is Gantry, with EtherCAT Fieldbus

Custom versions of numerical control

There are custom versions of the numerical control that are created specifically for a certain manufacturer. These versions may differ in both hardware and implemented functionalities. Although the custom versions are not listed in this document, they partially share the functionalities illustrated, making it a reference manual for these versions as well.

NC firmware note for RosettaCNC-BE numerical control

The RosettaCNC-BE numerical control can manage up to six axes with EtherCAT Fieldbus, with a seventh axis in Gantry Slave mode. It is useful to summarize the fundamental concepts of this technology, even for those who are already experts:

- Description of EtherCAT
  EtherCAT (Ethernet for Control Automation Technology) is an open and flexible communication standard, originally developed by Beckhoff Automation. It was designed for industrial automation and applications requiring very short cycle times and low communication latency. It uses standard Ethernet topology and can therefore be easily integrated into existing Ethernet networks.
- EtherCAT as a standard
  As a standard, EtherCAT offers numerous advantages. First, it follows a series of guidelines, protocols, and specifications that allow interoperability between different devices and control systems. This means that EtherCAT can be used in a variety of industrial applications without facing compatibility issues. Standardization also ensures that EtherCAT hardware and software are widely available, making it easier for companies to adopt this technology.
- Variations in EtherCAT drivers
  Despite the standard nature of EtherCAT, there is an aspect that is often overlooked: the specificity of the device drivers. Although EtherCAT provides a common set of specifications that all devices must follow, hardware manufacturers often add proprietary features or specifications to their drivers.
- Non-standard registers and features in EtherCAT
  A servo-drive manufacturer might, for example, include custom registers in its EtherCAT driver to provide special functionalities, such as advanced motor control, diagnostics, or performance measurements. These registers are not part of the standard EtherCAT set and, as a result, are not immediately accessible from any numerical control system.
- Need for custom firmware for EtherCAT
  Because of these variations in drivers, it is often necessary for numerical control system suppliers to develop firmware specific to each type of EtherCAT driver. This custom firmware allows the CNC system to effectively communicate with the driver, exploiting all the proprietary features it offers.

This scenario can add a level of complexity in the design and implementation of EtherCAT systems. In other words, while EtherCAT is a standard, specific implementations of that standard can vary significantly. Consequently, adopting EtherCAT in an industrial setting requires careful planning and may necessitate custom software development to ensure that all system components are fully compatible with each other.

NC firmware versions for RosettaCNC-BE numerical control

To simplify the use of EtherCAT and manage the various system setup compatibilities in the RosettaCNC-BE numerical control, standard axis configurations linked to a specific manufacturer/model driver have been created.

Currently, there are three NC firmware versions for the RosettaCNC-BE numerical control:

- RosettaCNC-BE-01
  The configuration consists of a series of Delta servo-drives model ASD-A2-xxxx-E.
  Up to 7 servo-drives can be connected, one of which as an axis in Gantry Slave mode.
  The spindle is driven via an analog output of the numerical control.
  No EtherCAT device is provided for the spindle in this configuration.
  Manufacturer product reference link (EN): ASDA-A2 Series
  Configuration reference link (EN): AN009 - EtherCAT - Configuration 01
- RosettaCNC-BE-02
  The configuration consists of a series of Inovance servo-drives model SV660N.
  Up to 7 servo-drives can be connected, one of which as an axis in Gantry Slave mode.
  The spindle is driven via an analog output of the numerical control.
  No EtherCAT device is provided for the spindle in this configuration.
  Manufacturer product reference link (EN): SVN660N Servo Drives
  Configuration reference link (EN): AN014 - EtherCAT - Configuration 02
- RosettaCNC-BE-03
  The configuration consists of a series of HiWin E1 Series servo-drives.
  Up to 7 servo-drives can be connected, one of which as an axis in Gantry Slave mode.
  The spindle is driven via an analog output of the numerical control.
  No EtherCAT device is provided for the spindle in this configuration.
  Manufacturer product reference link (EN): E1 Series
  Configuration reference link (EN): AN018 - EtherCAT - Configuration 03

Main features of the RosettaCNC-A numerical control

Indicative list of the key features of numerical control including available hardware options. For the complete list, please refer to the comprehensive documentation of the RosettaCNC-A product and NC language.

Features	Description
Number of Axes	3 (XYZ) or 4 (XYZA) interpolated axes
Number of Gantry Axes	1 Gantry axis, using axis A as the Gantry Slave *1)
Minimum Axis Movement	0.001 mm (0.000039 in)
Type of Axis Control	Digital signals for motor drivers with STEP/DIR commands Type : PNP or Line-Driver Signals per axis : 4 (DIR-, DIR+, STEP-, STEP+) Maximum frequency : from 125kHz to 2MHz depending on order code Voltage : selectable with a dip-switch between: 1] 5 VDC, generated by the numerical control 2] 12 VDC, generated by the numerical control 3] External reference VDx (27 VDC max) Maximum current : 20 mA Isolation : 1000 VPP Configurable via NC control software: ■ Minimum duration of DIR signals, from 1000 nS to 100000 nS ■ Inversion of DIR signal logical state ■ Inversion of STEP signal logical state
NC Programming Language	Programming based on an extended dialect of the RS274-D standard Pre-processing analysis and simulation of NC programs Unlimited number of blocks per NC/Macro/MDI program Dynamic tool length and radius compensation 3 different tool radius compensation entry modes M commands set for interactive operator interface G commands set for RTCP control and kinematic configuration Macro programming with control flow functionalities Expandable G/M command set via macro programming System macros for customizing numerical control functionalities Ability to encrypt custom macro programs and G/M commands
Main Features of the Interpolator	Look-ahead 2000 blocks BPS (Blocks Per Second) 250 *2) Implemented in the numerical control Interpolated rapid movements Smoothing and point removal algorithm Jerk control on the interpolated TCP point RTCP (Rotating Tool Center Point) Control support Fixed or local kinematic RTCP parameterization via G commands Customization of interpolation characteristics via G commands Local control of the interpolated point's accel/decel via G commands Feedrate compensation for rotational axis A without RTCP Automatic retract along the tool vector at STOP and end of program
Supported Kinematics	The numerical control supports the following kinematics: ■ Trivial ■ Independent rotational axes ■ Rotary table A *3) ■ Titling head A *3)
NC Startup Phase Management	Customizable via `start` system macro
Pallet Change Management	Customizable via `pallet_shuttle` system macro
Recovery from STOP Management	Customizable via `restart` system macro

Features	Description
Spindle Management	Spindle speed control via dedicated analog output. Spindle modes: ■ Normal ■ With automatic gear change Analog output modes for spindle: ■ Mode A: CW+ e CCW+ : 0/+10V per CW, 0/+10V CCW ■ Mode B: CW+ e CCW- : 0/+10V per CW, 0/-10V CCW Common spindle management functionalities: ■ Maximum spindle motor speed ■ Speed change settling time ■ Manual spindle start input for CW rotation ■ Manual spindle start input for CCW rotation ■ Manual spindle stop rotation input ■ Spindle speed reached confirmation input ■ Spindle zero speed (stop) confirmation input ■ Spindle not ready state input ■ Feedback signals from spindle with cone engagement, S1, S2, S4, S5 constantly monitored by the numerical control Common spindle management feedback: ■ Tachometer function enabled with input on signal S3 (I/O Expansion option) ■ Real spindle rotation speed analog input ■ Spindle current consumption analog input ■ Spindle torque analog input Additional features for spindle with automatic gear change: ■ 5 speed ranges ■ 5 digital outputs for gear change command ■ 5 digital inputs for selected gear feedback ■ Spindle motor speed at gear change Cooling system management features: ■ Cooling pump output ■ Cooling pump time (after spindle stop) Support for CNC machines with spindle for milling or tracing + laser/plasma torch on the same Z-axis. Support for CNC machines with multiple spindles on the same Z-axis, but used one at a time.

Features	Description
Tool Change Management	Customizable among: ■ None ■ Macro (uses the `tool_change` system macro) ■ PLC (available on customized NC control firmware) The default system macro implements the following functionalities: ■ Null (dummy) tool change (NTC) ■ Manual tool change (MTC), dynamic tool length with automatic measurement ■ Manual tool change (MTC), tool length in the library ■ Manual tool change (MTC), tool length in the library with automatic measurement ■ Automatic tool change (ATC), tool length in the library, cone-holder clamp with front/vertical movement ■ Automatic tool change (ATC), tool length in the library, cone-holder bushing with vertical/vertical movement The tool change macro includes a series of functionalities callable with the NC language, of which the main ones will be listed: ■ Execution of active tool length measurement ■ Opening of the tool magazine ■ Closing of the tool magazine ■ Query on the current state of the tool magazine ■ Manual tool loading/unloading from the spindle When using an automatic tool change (ATC), a rich user interface is available that recalls specific ATC macros to perform the following operations: ■ Association of tool number ↔ location slot ■ Modification of the tool list and tool characteristics ■ Automatic measurement of selected tool lengths ■ Tool loading/unloading operations For the realization of complex tool changes, for example, where it is necessary to manage the pre-selection/unloading phase of tools from chain loaders, it is possible to integrate the functionalities implemented in the numerical control via the `tool_change` system macro with an external PLC interfaced to the numerical control via Modbus. The `tool_change` macro is included in the installation package as NC source code to allow for self-customization.

Features	Description
Axis HOMING Management	The axes HOMING procedure can be started via: ■ Digital input ■ Virtualized input on Master Modbus ■ NC language via `G102` command ■ API Server via `cnc.homing` command ■ OPC UA Server via `cnc_homing` command ■ Multifunctional button on the NC control software Supported HOMING Modes: ■ Disabled ■ No movement ■ Rising edge of the limit switch ■ Falling edge of the limit switch ■ Pushing (only for Gantry axis) ■ Pushing on the rising edge of the limit switch (only for Gantry axis) ■ Pushing on the falling edge of the limit switch (only for Gantry axis) Specifications for each axis: ■ Sequence order in the limit switch search phase ■ Initial direction of limit switch search ■ Index input for precise homing on zero motor pulse ■ Pushing output (applicable in Pushing mode) ■ Pushing position (applicable in Pushing mode) ■ Axis offset, i.e., the value loaded in the axis position ■ Final position to be reached once the search is completed ■ Feed rate during the limit switch acquisition ■ Axis acceleration and deceleration during limit switch search
Handwheel Support	Support for handwheel with 5 VDC signals provided by the numerical control on a dedicated connector. When not using the handwheel, the same connector can be used for two Joystick modes. Dedicated connector for handwheel in Handwheel model A and B modes: ■ Axis selection X/Y/Z/A ■ Multiplier selection x1/x10/x100 ■ MPG bi-directional axis position with PHA/PHB phases ■ Output for handwheel electronics power supply 5 VDC, 50 mA ■ Handwheel enable input; if the function is enabled and pressed three times in quick succession within the programmed time, it allows zeroing the selected axis position on the active WCS. Dedicated connector with Jog Controller Type set to Single Joystick: ■ Inputs for axis selection X/Y/Z/A ■ Inputs for JOG– and JOG+ ■ Input for zeroing the selected work axis position Dedicated connector with Jog Controller Type set to Multiple Joystick: ■ Inputs for JOG axis X- and X- ■ Inputs for JOG axis Y- and Y+ ■ Inputs for JOG axis Z- and Z+ ■ Inputs for JOG axis A- and A+ The handwheel MPG (MPG 1) can be configured and used as an MPG for FAST and/or FEED override when the axis selection button is not pressed and the numerical control is in RUN or PAUSE state.

Features	Description
JOG Functionality	The axis JOG is available via: ■ Inputs for JOG +/- movements ■ Virtualized inputs on Master Modbus for JOG +/- movements ■ Inputs on the handwheel connector when this is not used ■ API Server via `cnc.jog.command` command ■ OPC UA Server via the `cnc_jog_command` command ■ JOG buttons on the NC control software ■ Keyboard keys (when enabled and only for axes X/Y/Z) Axis JOG modes: ■ Normal ■ Interpolated Activation of Z-axis JOG movement along the TCP vector with tilting head: ■ Via digital input ■ Via button on NC control software Configurable functionalities: ■ Enabling axis zeroing with handwheel ■ Handwheel pulses per revolution ■ Percentage of feed rate used ■ Maximum feed rate with interpolated JOG
Laser Cutting Functionality	Laser management with the following features: ■ Coordination of movements in three dimensions during cutting ■ Fine power adjustment via 0/10V analog output ■ Dynamic power correction based on TCP speed variation
Plasma Cutting Functionality	Management of plasma torch + spindle/marker simultaneously Torch height control (THC) in three modes: ■ None: No automatic torch height control. ■ Internal with analog input for arc voltage: The internal mode uses an analog input to monitor and control arc voltage, ensuring adequate cutting power and correct torch height. The system allows choosing between three different height compensation algorithms. ■ External via THC device with UP/DOWN/ARC signals: Allows the use of an external THC device for torch control, with UP/DOWN movement commands and arc monitoring. The internal mode offers advanced features such as constant arc voltage control, cutting power adjustment, arc voltage auto-acquisition, and a set of dedicated G commands that facilitate ignition, lead-in, cutting, and lead-out phases.

Features	Description
3D Scanning Functionality	3D scanning management with the following functionalities: ■ Surface mapping with a distance measuring laser sensor ■ Surface mapping with a 3D contact spindle probe ■ Surface scanning with a distance measuring laser sensor ■ Surface scanning with a 3D contact spindle probe Characteristics of scanning with a distance measuring laser: ■ Point acquisition every 4ms (250 samples per second) ■ Analog input for reading laser probe every 2ms ■ RC software filter for analog laser probe input ■ From 2 to 20 points of analog laser probe input linearization ■ Unlimited acquisition point buffer ■ Programmable acceleration/deceleration override ■ Programmable maximum scanning speed ■ Programmable maximum movement speed ■ Coordinates of the probe position relative to the spindle nose ■ 3D preview of acquired points on NC control software Generated scan files: ■ TXT file with point cloud in MeshLab compatible format ■ STL file with scan mesh with scan block origins ■ STL file with scan mesh with origins in the active WCS ■ STL file with scan mesh with origins in MCS
Lubrication Management	The numerical control implements lubrication management for: ■ Axes ■ Spindle The axis lubrication phase is started via: ■ Manually via a digital or virtualized input ■ Automatically upon expiration of the moving axes hour counter The spindle lubrication phase is started via: ■ Manually via a digital or virtualized input ■ Automatically upon expiration of the spindle on-time hour counter The lubrication phase activates the relevant pump in two different modes: ■ For a fixed time ■ Until the programmed number of pump feedback pulses is reached with timeout control between pulses

Features	Description
Override Management	The numerical control allows the operator to adjust the override in the following modules: ■ JOG: Modification of manual positioning speed. ■ Spindle: Control of spindle rotation speed. ■ Rapid movements (FAST): Adjustment of machine rapid movement speed. ■ Feed movements (FEED): Modification of feed rate during operations. ■ Custom 1 feed rate movements: Customization of speed in positive X movements, typical of disc tool cutting. ■ Custom 2 feed rate movements: Customization of speed in negative X movements, typical of disc tool cutting. ■ Plasma cutting power: Modification of power intensity set in the NC code. ■ Plasma cutting voltage: Modification of arc voltage set in the NC code. Available override control modes: ■ None: No override control active (equivalent to override = 100%). ■ MPG1 to MPG8: Manual control via digital rotary handwheels (bi-directional MPGs). With this configuration, adjustment via the override value bar in the NC control software is also available. ■ Analog input 1 to 11: Override adjustment via potentiometers. ■ Only from override value bar on NC control software: Adjustment exclusively through the override value bar in the NC control software. Override modes on movements: ■ Speed: The override affects only the axis speed. ■ Speed and acceleration: The override affects the speed, acceleration, and deceleration of the axis. NC commands for override management: ■ The NC commands `M48`, `M49`, `M50`, and `M51` are available for temporary enabling and disabling of overrides.
Communication Port	ETHERNET 10/100 RJ45 galvanically isolated
Supported Protocols	Proprietary TCP/IP protocol for interfacing with control software Proprietary UDP protocol for system NC discovery and settings Modbus TCP/IP Slave for interfacing with PC/CNC/PLC/etc. ICMP (Internet Control Message Protocol)
Analog Inputs	Logical : 16 Physical on board : 3 with I/O Expansion Configurable operational mode for each input: ■ Potentiometric input 1K÷20KΩ ■ Voltmeter input 0÷10V ■ Ammeter input 0÷20mA

Features	Description	
Digital Inputs	Logical Physical on board Type Operating voltage Maximum voltage	: 128 : 19 or 22 (I/O Expansion option) : PNP opto-isolated : range 12÷24 VDC : 26.5 VDC
MPG Inputs for Override	Logical Physical on board	: 9 : 3, reduced to 2 if the handwheel is present
Probe Input	1 with typical reaction time of 20 nS To be used mutually exclusively as TOOL-SETTER for tool length/width acquisition or as PROBE for 3D contact spindle probe.	
Digital Outputs	Logical Physical on board Type Output voltage Maximum current Protection	: 128 : 8 or 16 (I/O Expansion option) : PNP PROFET Open Collector : from reference input, range 12÷28 VDC : 500 mA : short-circuit, overcurrent, countercurrent
Analog Outputs	Logical Physical on board Fixed function A01 Voltage range Maximum current Resolution Isolation	: 16 : 2 : spindle speed control : ± 10 VDC (minimum no-load) : 1mA : 16 bit : 1000 Vrms
Power Supply	Nominal voltage Operating range Protection	: 24 VDC : 22÷27 VDC : reverse polarity
Maximum consumption	10W	
Temperature Range	From 0° to +50° Celsius	
Enclosure Protection Grade	IP20 (as per EN-60529 standard)	

*1) **Number of Gantry Slave Axes**
The current version of the standard numerical control firmware allows the configuration and use of only one Gantry axis. Firmware versions created for custom products may support multiple Gantry axes.

*2) **Blocks Per Second (BPS)**
The maximum value of blocks per second is conditioned by specific requirements:
- The continuous path mode `G64` must be active
- A high-quality Ethernet connection is necessary to ensure the continuous flow of blocks
- `G` movement blocks must not contain `G`/`M` commands that interrupt the path

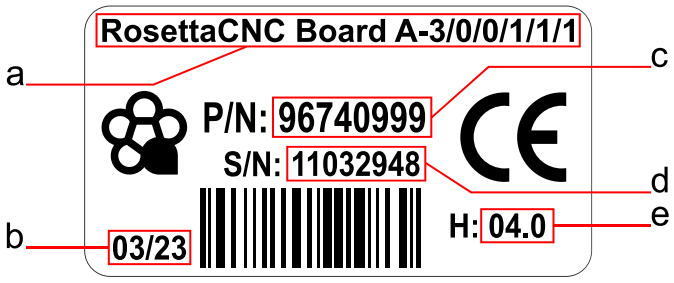
*3) **Kinematics with RTCP Mode**
For this kinematics, the RTCP mode can be activated only if this functionality is included among the selectable options in the product order code

Numerical control ordering code RosettaCNC-A

Ordering code example for **RosettaCNC Board A – 3/0/0/1/1/1/001** and the corresponding explanation table:

Code	Data	Description
Board A - **3** / 0 / 0 / 1 / 1 / 1 / 001	3	**Number of Axes** 3 = 3 axes 4 = 4 axes
Board A - 3 / **0** / 0 / 1 / 1 / 1 / 001	0	**Maximum Frequency of STEP/DIR outputs** 0 = 125 kHz 1 = 200 kHz 2 = 300 kHz 3 = 500 kHz 4 = 1 MHz 5 = 2 MHz
Board A - 3 / 0 / **0** / 1 / 1 / 1 / 001	0	**I/O Expansion** 0 = Not present 1 = Basic expansion Digital inputs : 3 (multi-function) Digital outputs : 8 2 = Analog input expansion Analog inputs : 3 3 = Full expansion (basic + analog inputs)
Board A - 3 / 0 / 0 / **1** / 1 / 1 / 001	1	**Remote Communication** 0 = No communication 1 = OPC UA **(*obsolete*)** 2 = OPC UA + RosettaCNC Data Exchange 4.0 **(*obsolete*)**
Board A - 3 / 0 / 0 / 1 / **1** / 1 / 001	1	**"Group A" Functions** 0 = No functions enabled 1 = RTCP 2 = Jerk Control 3 = RTCP + Jerk Control
Board A - 3 / 0 / 0 / 1 / 1 / **1** / 001	1	**"Group B" Functions** 0 = No functions enabled 1 = Laser Acquisition 2 = Internal THC 3 = Laser Acquisition and Internal THC
Board A - 3 / 0 / 0 / 1 / 1 / 1 / **001**	001	**Customization Code** Identifies a customized version of the numerical control. When not present, it identifies the standard version of the control.

Product Label



a - Ordering Code:
code with the hardware characteristics & options of the numerical control requested at the time of order

b - Production Date:
reports the week and year of production

c - Part Number:
unique code that identifies an ordering code

d - Serial Number:
unique serial number of the numerical control

e - Hardware Version:
version & release of the numerical control hardware

Main features of the RosettaCNC-B numerical control

Indicative list of the key features of numerical control including available hardware options. For the complete list, please refer to the comprehensive documentation of the RosettaCNC-B product and NC language.

Features	Description
Number of Axes	3 (XYZ), 4 (XYZA), 5 (XYZAB) or 6 (XYZABC) interpolated axes
Number of Gantry Axes	1 Gantry axis, using axis A, B or C as the Gantry Slave *1)
Minimum Axis Movement	0.001 mm (0.000039 in)
Type of Axis Control	Digital signals for motor drivers with STEP/DIR commands Type : PNP or Line-Driver Signals per axis : 4 (DIR-, DIR+, STEP-, STEP+) Maximum frequency : from 125kHz to 2MHz depending on order code Voltage : selectable with a dip-switch between: 1] 5 VDC, generated by the numerical control 2] 12 VDC, generated by the numerical control 3] External reference VDx (27 VDC max) Maximum current : 20 mA Isolation : 1000 VPP Configurable via NC control software: ■ Minimum duration of DIR signals, from 1000 nS to 100000 nS ■ Inversion of DIR signal logical state ■ Inversion of STEP signal logical state
NC Programming Language	Programming based on an extended dialect of the RS274-D standard Pre-processing analysis and simulation of NC programs Unlimited number of blocks per NC/Macro/MDI program Dynamic tool length and radius compensation 3 different tool radius compensation entry modes M commands set for interactive operator interface G commands set for RTCP control and kinematic configuration Macro programming with control flow functionalities Expandable G/M command set via macro programming System macros for customizing numerical control functionalities Ability to encrypt custom macro programs and G/M commands
Main Features of the Interpolator	Look-ahead 2000 blocks BPS (Blocks Per Second) 250 *2) Implemented in the numerical control Interpolated rapid movements Smoothing and point removal algorithm Jerk control on the interpolated TCP point RTCP (Rotating Tool Center Point) Control support Fixed or local kinematic RTCP parameterization via G commands Customization of interpolation characteristics via G commands Local control of the interpolated point's accel/decel via G commands Feedrate compensation for rotational axis A without RTCP Automatic retract along the tool vector at STOP and end of program

Features	Description
Supported Kinematics	The numerical control supports the following kinematics: ■ Trivial ■ Independent rotational axes ■ Rotary table A *3) ■ Rotary table B *3) ■ Titling head A *3) ■ Titling head B *3) ■ Rotary table A/B *3) ■ Rotary table B/A *3) ■ Rotary table A/C *3) ■ Rotary table B/C *3) ■ Tilting head A/B *3) ■ Tilting head B/A *3) ■ Tilting head C/A *3) ■ Tilting head C/B *3)
NC Startup Phase Management	Customizable via `start` system macro
Pallet Change Management	Customizable via `pallet_shuttle` system macro
Recovery from STOP Management	Customizable via `restart` system macro

Features	Description
Spindle Management	Spindle speed control via dedicated analog output. Spindle modes: ■ Normal ■ With automatic gear change Analog output modes for spindle: ■ Mode A: CW+ e CCW+ : 0/+10V per CW, 0/+10V CCW ■ Mode B: CW+ e CCW- : 0/+10V per CW, 0/-10V CCW Common spindle management functionalities: ■ Maximum spindle motor speed ■ Speed change settling time ■ Manual spindle start input for CW rotation ■ Manual spindle start input for CCW rotation ■ Manual spindle stop rotation input ■ Spindle speed reached confirmation input ■ Spindle zero speed (stop) confirmation input ■ Spindle not ready state input ■ Feedback signals from spindle with cone engagement, S1, S2, S4, S5 constantly monitored by the numerical control Common spindle management feedback: ■ Tachometer function enabled with input on signal S3 (I/O Expansion option) ■ Real spindle rotation speed analog input ■ Spindle current consumption analog input ■ Spindle torque analog input Additional features for spindle with automatic gear change: ■ 5 speed ranges ■ 5 digital outputs for gear change command ■ 5 digital inputs for selected gear feedback ■ Spindle motor speed at gear change Cooling system management features: ■ Cooling pump output ■ Cooling pump time (after spindle stop) Support for CNC machines with spindle for milling or tracing + laser/plasma torch on the same Z-axis. Support for CNC machines with multiple spindles on the same Z-axis, but used one at a time.

Features	Description
Tool Change Management	Customizable among: ■ None ■ Macro (uses the `tool_change` system macro) ■ PLC (available on customized NC control firmware) The default system macro implements the following functionalities: ■ Null (dummy) tool change (NTC) ■ Manual tool change (MTC), dynamic tool length with automatic measurement ■ Manual tool change (MTC), tool length in the library ■ Manual tool change (MTC), tool length in the library with automatic measurement ■ Automatic tool change (ATC), tool length in the library, cone-holder clamp with front/vertical movement ■ Automatic tool change (ATC), tool length in the library, cone-holder bushing with vertical/vertical movement The tool change macro includes a series of functionalities callable with the NC language, of which the main ones will be listed: ■ Execution of active tool length measurement ■ Opening of the tool magazine ■ Closing of the tool magazine ■ Query on the current state of the tool magazine ■ Manual tool loading/unloading from the spindle When using an automatic tool change (ATC), a rich user interface is available that recalls specific ATC macros to perform the following operations: ■ Association of tool number ↔ location slot ■ Modification of the tool list and tool characteristics ■ Automatic measurement of selected tool lengths ■ Tool loading/unloading operations For the realization of complex tool changes, for example, where it is necessary to manage the pre-selection/unloading phase of tools from chain loaders, it is possible to integrate the functionalities implemented in the numerical control via the `tool_change` system macro with an external PLC interfaced to the numerical control via Modbus. The `tool_change` macro is included in the installation package as NC source code to allow for self-customization.

Features	Description
Axis HOMING Management	The axes HOMING procedure can be started via: ■ Digital input ■ Virtualized input on Master Modbus ■ NC language via `G102` command ■ API Server via `cnc.homing` command ■ OPC UA Server via `cnc_homing` command ■ Multifunctional button on the NC control software Supported HOMING Modes: ■ Disabled ■ No movement ■ Rising edge of the limit switch ■ Falling edge of the limit switch ■ Pushing (only for Gantry axis) ■ Pushing on the rising edge of the limit switch (only for Gantry axis) ■ Pushing on the falling edge of the limit switch (only for Gantry axis) Specifications for each axis: ■ Sequence order in the limit switch search phase ■ Initial direction of limit switch search ■ Index input for precise homing on zero motor pulse ■ Pushing output (applicable in Pushing mode) ■ Pushing position (applicable in Pushing mode) ■ Axis offset, i.e., the value loaded in the axis position ■ Final position to be reached once the search is completed ■ Feed rate during the limit switch acquisition ■ Axis acceleration and deceleration during limit switch search
Handwheel Support	Support for handwheel with 5 VDC signals provided by the numerical control on a dedicated connector. When not using the handwheel, the same connector can be used for two Joystick modes. Dedicated connector for handwheel in Handwheel model A and B modes: ■ Axis selection X/Y/Z/A/B/C ■ Multiplier selection x1/x10/x100 ■ MPG bi-directional axis position with PHA/PHB phases ■ Output for handwheel electronics power supply 5 VDC, 50 mA ■ Handwheel enable input; if the function is enabled and pressed three times in quick succession within the programmed time, it allows zeroing the selected axis position on the active WCS. Dedicated connector with Jog Controller Type set to Single Joystick: ■ Inputs for axis selection X/Y/Z/A/B/C ■ Inputs for JOG– and JOG+ ■ Input for zeroing the selected work axis position Dedicated connector with Jog Controller Type set to Multiple Joystick: ■ Inputs for JOG axis X- and X- ■ Inputs for JOG axis Y- and Y+ ■ Inputs for JOG axis Z- and Z+ ■ Inputs for JOG axis A- and A+ The handwheel MPG (MPG 1) can be configured and used as an MPG for FAST and/or FEED override when the axis selection button is not pressed and the numerical control is in RUN or PAUSE state.

Features	Description
JOG Functionality	The axis JOG is available via: ■ Inputs for JOG +/- movements ■ Virtualized inputs on Master Modbus for JOG +/- movements ■ Inputs on the handwheel connector when this is not used ■ API Server via `cnc.jog.command` command ■ OPC UA Server via the `cnc_jog_command` command ■ JOG buttons on the NC control software ■ Keyboard keys (when enabled and only for axes X/Y/Z) Axis JOG modes: ■ Normal ■ Interpolated Activation of Z-axis JOG movement along the TCP vector with tilting head: ■ Via digital input ■ Via button on NC control software Configurable functionalities: ■ Enabling axis zeroing with handwheel ■ Handwheel pulses per revolution ■ Percentage of feed rate used ■ Maximum feed rate with interpolated JOG
Laser Cutting Functionality	Laser management with the following features: ■ Coordination of movements in three dimensions during cutting ■ Fine power adjustment via 0/10V analog output ■ Dynamic power correction based on TCP speed variation
Plasma Cutting Functionality	Management of plasma torch + spindle/marker simultaneously Torch height control (THC) in three modes: ■ None: No automatic torch height control. ■ Internal with analog input for arc voltage: The internal mode uses an analog input to monitor and control arc voltage, ensuring adequate cutting power and correct torch height. The system allows choosing between three different height compensation algorithms. ■ External via THC device with UP/DOWN/ARC signals: Allows the use of an external THC device for torch control, with UP/DOWN movement commands and arc monitoring. The internal mode offers advanced features such as constant arc voltage control, cutting power adjustment, arc voltage auto-acquisition, and a set of dedicated G commands that facilitate ignition, lead-in, cutting, and lead-out phases.

Features	Description
3D Scanning Functionality	3D scanning management with the following functionalities: ■ Surface mapping with a distance measuring laser sensor ■ Surface mapping with a 3D contact spindle probe ■ Surface scanning with a distance measuring laser sensor ■ Surface scanning with a 3D contact spindle probe Characteristics of scanning with a distance measuring laser: ■ Point acquisition every 4ms (250 samples per second) ■ Analog input for reading laser probe every 2ms ■ RC software filter for analog laser probe input ■ From 2 to 20 points of analog laser probe input linearization ■ Unlimited acquisition point buffer ■ Programmable acceleration/deceleration override ■ Programmable maximum scanning speed ■ Programmable maximum movement speed ■ Coordinates of the probe position relative to the spindle nose ■ 3D preview of acquired points on NC control software Generated scan files: ■ TXT file with point cloud in MeshLab compatible format ■ STL file with scan mesh with scan block origins ■ STL file with scan mesh with origins in the active WCS ■ STL file with scan mesh with origins in MCS
Lubrication Management	The numerical control implements lubrication management for: ■ Axes ■ Spindle The axis lubrication phase is started via: ■ Manually via a digital or virtualized input ■ Automatically upon expiration of the moving axes hour counter The spindle lubrication phase is started via: ■ Manually via a digital or virtualized input ■ Automatically upon expiration of the spindle on-time hour counter The lubrication phase activates the relevant pump in two different modes: ■ For a fixed time ■ Until the programmed number of pump feedback pulses is reached with timeout control between pulses

Features	Description
Override Management	The numerical control allows the operator to adjust the override in the following modules: ■ JOG: Modification of manual positioning speed. ■ Spindle: Control of spindle rotation speed. ■ Rapid movements (FAST): Adjustment of machine rapid movement speed. ■ Feed movements (FEED): Modification of feed rate during operations. ■ Custom 1 feed rate movements: Customization of speed in positive X movements, typical of disc tool cutting. ■ Custom 2 feed rate movements: Customization of speed in negative X movements, typical of disc tool cutting. ■ Plasma cutting power: Modification of power intensity set in the NC code. ■ Plasma cutting voltage: Modification of arc voltage set in the NC code. Available override control modes: ■ None: No override control active (equivalent to override = 100%). ■ MPG1 to MPG8: Manual control via digital rotary handwheels (bi-directional MPGs). With this configuration, adjustment via the override value bar in the NC control software is also available. ■ Analog input 1 to 11: Override adjustment via potentiometers. ■ Only from override value bar on NC control software: Adjustment exclusively through the override value bar in the NC control software. Override modes on movements: ■ Speed: The override affects only the axis speed. ■ Speed and acceleration: The override affects the speed, acceleration, and deceleration of the axis. NC commands for override management: ■ The NC commands `M48`, `M49`, `M50`, and `M51` are available for temporary enabling and disabling of overrides.
Communication Port	ETHERNET 10/100 RJ45 galvanically isolated
Supported Protocols	Proprietary TCP/IP protocol for interfacing with control software Proprietary UDP protocol for system NC discovery and settings Modbus TCP/IP Slave for interfacing with PC/CNC/PLC/etc. ICMP (Internet Control Message Protocol)
Analog Inputs	Logical : 16 Physical on board : 3 with I/O Expansion Configurable operational mode for each input: ■ Potentiometric input 1K÷20KΩ ■ Voltmeter input 0÷10V ■ Ammeter input 0÷20mA

Features	Description	
Digital Inputs	Logical Physical on board Type Operating voltage Maximum voltage	: 128 : 19 or 21 : PNP opto-isolated : range 12÷24 VDC : 26.5 VDC
MPG Inputs for Override	Logical Physical on board	: 9 : 3, reduced to 2 if the handwheel is present
Probe Input	1 with typical reaction time of 20 nS To be used mutually exclusively as TOOL-SETTER for tool length/width acquisition or as PROBE for 3D contact spindle probe.	
Digital Outputs	Logical Physical on board Type Output voltage Maximum current Protection	: 128 : 8 or 16 (option I/O Expansion = 1) : PNP PROFET Open Collector : from reference input, range 12÷28 VDC : 500 mA : short-circuit, overcurrent, countercurrent
Analog Outputs	Logical Physical on board Fixed function A01 Voltage range Maximum current Resolution Isolation	: 16 : 4 or 6 (option I/O Expansion = 1) : spindle speed control : ± 10 VDC (minimum no-load) : 1mA : 16 bit : 1000 Vrms
Power Supply	Nominal voltage Operating range Protection	: 24 VDC : 22÷27 VDC : reverse polarity
Maximum consumption	12W	
Temperature Range	From 0° to +50° Celsius	
Enclosure Protection Grade	IP20 (as per EN-60529 standard)	

*1) **Number of Gantry Slave Axes**
The current version of the standard numerical control firmware allows the configuration and use of only one Gantry axis. Firmware versions created for custom products may support multiple Gantry axes.

*2) **Blocks Per Second (BPS)**
The maximum value of blocks per second is conditioned by specific requirements:
- The continuous path mode `G64` must be active
- A high-quality Ethernet connection is necessary to ensure the continuous flow of blocks
- `G` movement blocks must not contain `G`/`M` commands that interrupt the path

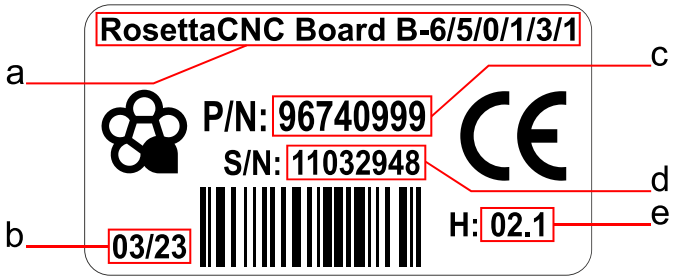
*3) **Kinematics with RTCP Mode**
For this kinematics, the RTCP mode can be activated only if this functionality is included among the selectable options in the product order code

Numerical control ordering code RosettaCNC-B

Ordering code example for **RosettaCNC Board B – 6/5/0/1/3/1/001** and the corresponding explanation table:

Code	Data	Description
Board B - **6** / 5 / 0 / 1 / 3 / 1 / 001	6	**Number of axes** 3 = 3 axes 4 = 4 axes 5 = 5 axes 6 = 6 axes
Board B - 6 / **5** / 0 / 1 / 3 / 1 / 001	5	**Maximum frequency of STEP/DIR outputs** 0 = 125 kHz 1 = 200 kHz 2 = 300 kHz 3 = 500 kHz 4 = 1 MHz 5 = 2 MHz
Board B - 6 / 5 / **0** / 1 / 3 / 1 / 001	0	**I/O Expansion** 0 = Not present 1 = CN21-CN22-CN24 Expansion
Board B - 6 / 5 / 0 / **1** / 3 / 1 / 001	1	**Remote Communication** 0 = No communication 1 = OPC UA **(*obsolete*)** 2 = OPC UA + RosettaCNC Data Exchange 4.0 **(*obsolete*)**
Board B - 6 / 5 / 0 / 1 / **3** / 1 / 001	3	**"Group A" Functions** 0 = No functions enabled 1 = RTCP 2 = Jerk Control 3 = RTCP + Jerk Control
Board B - 6 / 5 / 0 / 1 / 3 / **1** / 001	1	**"Group B" Functions** 0 = No functions enabled 1 = Laser Acquisition 2 = Internal THC 4 = A/B Tilt Head (Bevel) 6 = Internal THC and A/B Tilt Head (Bevel) 7 = Laser Acquisition, Internal THC, and A/B Tilt Head (Bevel)
Board B - 6 / 5 / 0 / 1 / 3 / 1 / **001**	001	**Customization Code** Identifies a customized version of the numerical control. When not present, it identifies the standard version of the control.

Product Label



a - Ordering Code:
code with the hardware characteristics & options of the numerical control requested at the time of order

b - Production Date:
reports the week and year of production

c - Part Number:
unique code that identifies an ordering code

d - Serial Number:
unique serial number of the numerical control

e - Hardware Version:
version & release of the numerical control hardware

Main features of the RosettaCNC-BA numerical control

Indicative list of the key features of numerical control including available hardware options. For the complete list, please refer to the comprehensive documentation of the RosettaCNC-BA product and NC language.

Features	Description
Number of Axes	3 (XYZ), 4 (XYZA) or 5 (XYZAB) interpolated axes
Number of Gantry Axes	1 Gantry axis, using axis A or B as the Gantry Slave *1)
Minimum Axis Movement	0.001 mm (0.000039 in)
Type of Axis Control	Closed-loop position control on numerical control Axis position inputs on bidirectional ABZ encoders, max 200kHz Analog outputs +/- 10V, with high-precision 16-bit DAC converters
NC Programming Language	Programming based on an extended dialect of the RS274-D standard Pre-processing analysis and simulation of NC programs Unlimited number of blocks per NC/Macro/MDI program Dynamic tool length and radius compensation 3 different tool radius compensation entry modes M commands set for interactive operator interface G commands set for RTCP control and kinematic configuration Macro programming with control flow functionalities Expandable G/M command set via macro programming System macros for customizing numerical control functionalities Ability to encrypt custom macro programs and G/M commands
Main Features of the Interpolator	Look-ahead 2000 blocks BPS (Blocks Per Second) 250 *2) Implemented in the numerical control Interpolated rapid movements Smoothing and point removal algorithm Jerk control on the interpolated TCP point RTCP (Rotating Tool Center Point) Control support Fixed or local kinematic RTCP parameterization via G commands Customization of interpolation characteristics via G commands Local control of the interpolated point's accel/decel via G commands Feedrate compensation for rotational axis A without RTCP Automatic retract along the tool vector at STOP and end of program
Supported Kinematics	The numerical control supports the following kinematics: ■ Trivial ■ Independent rotational axes ■ Rotary table A *3) ■ Rotary table B *3) ■ Titling head A *3) ■ Titling head B *3) ■ Rotary table A/B *3) ■ Rotary table B/A *3) ■ Tilting head A/B *3) ■ Tilting head B/A *3)
NC Startup Phase Management	Customizable via `start` system macro
Pallet Change Management	Customizable via `pallet_shuttle` system macro
Recovery from STOP Management	Customizable via `restart` system macro

Features	Description
Spindle Management	Spindle speed control via dedicated analog output. Spindle modes: ■ Normal ■ With automatic gear change Analog output modes for spindle: ■ Mode A: CW+ e CCW+ : 0/+10V per CW, 0/+10V CCW ■ Mode B: CW+ e CCW- : 0/+10V per CW, 0/-10V CCW Common spindle management functionalities: ■ Maximum spindle motor speed ■ Speed change settling time ■ Manual spindle start input for CW rotation ■ Manual spindle start input for CCW rotation ■ Manual spindle stop rotation input ■ Spindle speed reached confirmation input ■ Spindle zero speed (stop) confirmation input ■ Spindle not ready state input ■ Feedback signals from spindle with cone engagement, S1, S2, S4, S5 constantly monitored by the numerical control Common spindle management feedback: ■ Tachometer function enabled with input on signal S3 (I/O Expansion option) ■ Real spindle rotation speed analog input ■ Spindle current consumption analog input ■ Spindle torque analog input Additional features for spindle with automatic gear change: ■ 5 speed ranges ■ 5 digital outputs for gear change command ■ 5 digital inputs for selected gear feedback ■ Spindle motor speed at gear change Cooling system management features: ■ Cooling pump output ■ Cooling pump time (after spindle stop) Support for CNC machines with spindle for milling or tracing + laser/plasma torch on the same Z-axis. Support for CNC machines with multiple spindles on the same Z-axis, but used one at a time.

Features	Description
Tool Change Management	Customizable among: ■ None ■ Macro (uses the `tool_change` system macro) ■ PLC (available on customized NC control firmware) The default system macro implements the following functionalities: ■ Null (dummy) tool change (NTC) ■ Manual tool change (MTC), dynamic tool length with automatic measurement ■ Manual tool change (MTC), tool length in the library ■ Manual tool change (MTC), tool length in the library with automatic measurement ■ Automatic tool change (ATC), tool length in the library, cone-holder clamp with front/vertical movement ■ Automatic tool change (ATC), tool length in the library, cone-holder bushing with vertical/vertical movement The tool change macro includes a series of functionalities callable with the NC language, of which the main ones will be listed: ■ Execution of active tool length measurement ■ Opening of the tool magazine ■ Closing of the tool magazine ■ Query on the current state of the tool magazine ■ Manual tool loading/unloading from the spindle When using an automatic tool change (ATC), a rich user interface is available that recalls specific ATC macros to perform the following operations: ■ Association of tool number ↔ location slot ■ Modification of the tool list and tool characteristics ■ Automatic measurement of selected tool lengths ■ Tool loading/unloading operations For the realization of complex tool changes, for example, where it is necessary to manage the pre-selection/unloading phase of tools from chain loaders, it is possible to integrate the functionalities implemented in the numerical control via the `tool_change` system macro with an external PLC interfaced to the numerical control via Modbus. The `tool_change` macro is included in the installation package as NC source code to allow for self-customization.

Features	Description
Axis HOMING Management	The axes HOMING procedure can be started via: ■ Digital input ■ Virtualized input on Master Modbus ■ NC language via `G102` command ■ API Server via `cnc.homing` command ■ OPC UA Server via `cnc_homing` command ■ Multifunctional button on the NC control software Supported HOMING Modes: ■ Disabled ■ No movement ■ Rising edge of the limit switch ■ Falling edge of the limit switch ■ Pushing (only for Gantry axis) ■ Pushing on the rising edge of the limit switch (only for Gantry axis) ■ Pushing on the falling edge of the limit switch (only for Gantry axis) Specifications for each axis: ■ Sequence order in the limit switch search phase ■ Initial direction of limit switch search ■ Index input for precise homing on zero motor pulse ■ Pushing output (applicable in Pushing mode) ■ Pushing position (applicable in Pushing mode) ■ Axis offset, i.e., the value loaded in the axis position ■ Final position to be reached once the search is completed ■ Feed rate during the limit switch acquisition ■ Axis acceleration and deceleration during limit switch search
Handwheel Support	Support for handwheel with 5 VDC signals provided by the numerical control on a dedicated connector. When not using the handwheel, the same connector can be used for two Joystick modes. Dedicated connector for handwheel in Handwheel model A and B modes: ■ Axis selection X/Y/Z/A/B ■ Multiplier selection x1/x10/x100 ■ MPG bi-directional axis position with PHA/PHB phases ■ Output for handwheel electronics power supply 5 VDC, 50 mA ■ Handwheel enable input; if the function is enabled and pressed three times in quick succession within the programmed time, it allows zeroing the selected axis position on the active WCS. Dedicated connector with Jog Controller Type set to Single Joystick: ■ Inputs for axis selection X/Y/Z/A/B ■ Inputs for JOG– and JOG+ ■ Input for zeroing the selected work axis position Dedicated connector with Jog Controller Type set to Multiple Joystick: ■ Inputs for JOG axis X- and X- ■ Inputs for JOG axis Y- and Y+ ■ Inputs for JOG axis Z- and Z+ ■ Inputs for JOG axis A- and A+ The handwheel MPG (MPG 1) can be configured and used as an MPG for FAST and/or FEED override when the axis selection button is not pressed and the numerical control is in RUN or PAUSE state.

Features	Description
JOG Functionality	The axis JOG is available via: ■ Inputs for JOG +/- movements ■ Virtualized inputs on Master Modbus for JOG +/- movements ■ Inputs on the handwheel connector when this is not used ■ API Server via `cnc.jog.command` command ■ OPC UA Server via the `cnc_jog_command` command ■ JOG buttons on the NC control software ■ Keyboard keys (when enabled and only for axes X/Y/Z) Axis JOG modes: ■ Normal ■ Interpolated Activation of Z-axis JOG movement along the TCP vector with tilting head: ■ Via digital input ■ Via button on NC control software Configurable functionalities: ■ Enabling axis zeroing with handwheel ■ Handwheel pulses per revolution ■ Percentage of feed rate used ■ Maximum feed rate with interpolated JOG
Laser Cutting Functionality	Laser management with the following features: ■ Coordination of movements in three dimensions during cutting ■ Fine power adjustment via 0/10V analog output ■ Dynamic power correction based on TCP speed variation
Plasma Cutting Functionality	Management of plasma torch + spindle/marker simultaneously Torch height control (THC) in three modes: ■ None: No automatic torch height control. ■ Internal with analog input for arc voltage: The internal mode uses an analog input to monitor and control arc voltage, ensuring adequate cutting power and correct torch height. The system allows choosing between three different height compensation algorithms. ■ External via THC device with UP/DOWN/ARC signals: Allows the use of an external THC device for torch control, with UP/DOWN movement commands and arc monitoring. The internal mode offers advanced features such as constant arc voltage control, cutting power adjustment, arc voltage auto-acquisition, and a set of dedicated G commands that facilitate ignition, lead-in, cutting, and lead-out phases.

Features	Description
3D Scanning Functionality	3D scanning management with the following functionalities: ■ Surface mapping with a distance measuring laser sensor ■ Surface mapping with a 3D contact spindle probe ■ Surface scanning with a distance measuring laser sensor ■ Surface scanning with a 3D contact spindle probe Characteristics of scanning with a distance measuring laser: ■ Point acquisition every 4ms (250 samples per second) ■ Analog input for reading laser probe every 2ms ■ RC software filter for analog laser probe input ■ From 2 to 20 points of analog laser probe input linearization ■ Unlimited acquisition point buffer ■ Programmable acceleration/deceleration override ■ Programmable maximum scanning speed ■ Programmable maximum movement speed ■ Coordinates of the probe position relative to the spindle nose ■ 3D preview of acquired points on NC control software Generated scan files: ■ TXT file with point cloud in MeshLab compatible format ■ STL file with scan mesh with scan block origins ■ STL file with scan mesh with origins in the active WCS ■ STL file with scan mesh with origins in MCS
Lubrication Management	The numerical control implements lubrication management for: ■ Axes ■ Spindle The axis lubrication phase is started via: ■ Manually via a digital or virtualized input ■ Automatically upon expiration of the moving axes hour counter The spindle lubrication phase is started via: ■ Manually via a digital or virtualized input ■ Automatically upon expiration of the spindle on-time hour counter The lubrication phase activates the relevant pump in two different modes: ■ For a fixed time ■ Until the programmed number of pump feedback pulses is reached with timeout control between pulses

Features	Description
Override Management	The numerical control allows the operator to adjust the override in the following modules: ■ JOG: Modification of manual positioning speed. ■ Spindle: Control of spindle rotation speed. ■ Rapid movements (FAST): Adjustment of machine rapid movement speed. ■ Feed movements (FEED): Modification of feed rate during operations. ■ Custom 1 feed rate movements: Customization of speed in positive X movements, typical of disc tool cutting. ■ Custom 2 feed rate movements: Customization of speed in negative X movements, typical of disc tool cutting. ■ Plasma cutting power: Modification of power intensity set in the NC code. ■ Plasma cutting voltage: Modification of arc voltage set in the NC code. Available override control modes: ■ None: No override control active (equivalent to override = 100%). ■ MPG1 to MPG8: Manual control via digital rotary handwheels (bi-directional MPGs). With this configuration, adjustment via the override value bar in the NC control software is also available. ■ Analog input 1 to 11: Override adjustment via potentiometers. ■ Only from override value bar on NC control software: Adjustment exclusively through the override value bar in the NC control software. Override modes on movements: ■ Speed: The override affects only the axis speed. ■ Speed and acceleration: The override affects the speed, acceleration, and deceleration of the axis. NC commands for override management: ■ The NC commands `M48`, `M49`, `M50`, and `M51` are available for temporary enabling and disabling of overrides.
Communication Port	ETHERNET 10/100 RJ45 galvanically isolated
Supported Protocols	Proprietary TCP/IP protocol for interfacing with control software Proprietary UDP protocol for system NC discovery and settings Modbus TCP/IP Slave for interfacing with PC/CNC/PLC/etc. ICMP (Internet Control Message Protocol)
Analog Inputs	Logical : 16 Physical on board : 3 with I/O Expansion Configurable operational mode for each input: ■ Potentiometric input 1K÷20KΩ ■ Voltmeter input 0÷10V ■ Ammeter input 0÷20mA

Features	Description	
Digital Inputs	Logical Physical on board Type Operating voltage Maximum voltage	: 128 : 19 or 21 : PNP opto-isolated : range 12÷24 VDC : 26.5 VDC
MPG Inputs for Override	Logical Physical on board	: 9 : 3, reduced to 2 if the handwheel is present
Probe Input	1 with typical reaction time of 20 nS To be used mutually exclusively as TOOL-SETTER for tool length/width acquisition or as PROBE for 3D contact spindle probe.	
Digital Outputs	Logical Physical on board Type Output voltage Maximum current Protection	: 128 : 8 or 16 (option I/O Expansion = 1) : PNP PROFET Open Collector : from reference input, range 12÷28 VDC : 500 mA : short-circuit, overcurrent, countercurrent
Analog Outputs	Logical Physical on board Fixed function A01 Voltage range Maximum current Resolution Isolation	: 16 : 4 or 6 (option I/O Expansion = 1) : spindle speed control : ± 10 VDC (minimum no-load) : 1mA : 16 bit : 1000 Vrms
Power Supply	Nominal voltage Operating range Protection	: 24 VDC : 22÷27 VDC : reverse polarity
Maximum consumption	12W	
Temperature Range	From 0° to +50° Celsius	
Enclosure Protection Grade	IP20 (as per EN-60529 standard)	

*1) **Number of Gantry Slave Axes**
The current version of the standard numerical control firmware allows the configuration and use of only one Gantry axis. Firmware versions created for custom products may support multiple Gantry axes.

*2) **Blocks Per Second (BPS)**
The maximum value of blocks per second is conditioned by specific requirements:
- The continuous path mode `G64` must be active
- A high-quality Ethernet connection is necessary to ensure the continuous flow of blocks
- `G` movement blocks must not contain `G`/`M` commands that interrupt the path

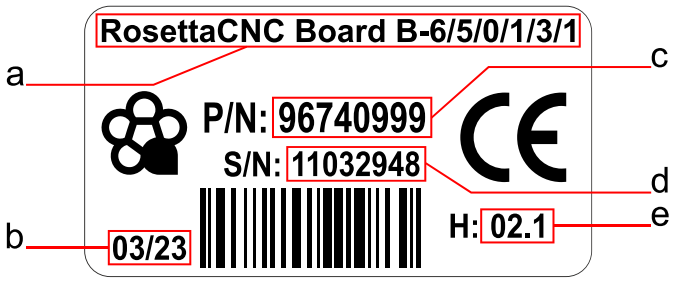
*3) **Kinematics with RTCP Mode**
For this kinematics, the RTCP mode can be activated only if this functionality is included among the selectable options in the product order code

Numerical control ordering code RosettaCNC-BA

Ordering code example for **RosettaCNC Board BA – 6/A/0/1/3/1/001** and the corresponding explanation table:

Code	Data	Description
Board BA - **6** / 5 / 0 / 1 / 3 / 1 / 001	6	**Number of axes** 3 = 3 axes 4 = 4 axes 5 = 5 axes 6 = 6 axes
Board BA - 6 / **A** / 0 / 1 / 3 / 1 / 001	A	**Position loop control for analog outputs/encoders axes**
Board BA - 6 / A / **0** / 1 / 3 / 1 / 001	0	**I/O Expansion** 0 = Not present 1 = CN21-CN22-CN24 Expansion
Board BA - 6 / A / 0 / **1** / 3 / 1 / 001	1	**Remote Communication** 0 = No communication 1 = OPC UA **(*obsolete*)** 2 = OPC UA + RosettaCNC Data Exchange 4.0 **(*obsolete*)**
Board BA - 6 / A / 0 / 1 / **3** / 1 / 001	3	**"Group A" Functions** 0 = No functions enabled 1 = RTCP 2 = Jerk Control 0 = RTCP + Jerk Control
Board BA - 6 / A / 0 / 1 / 3 / **1** / 001	1	**"Group B" Functions** 0 = No functions enabled 1 = Laser Acquisition 2 = Internal THC 4 = A/B Tilt Head (Bevel) 6 = Internal THC and A/B Tilt Head (Bevel) 7 = Laser Acquisition, Internal THC, and A/B Tilt Head (Bevel)
Board BA - 6 / A / 0 / 1 / 3 / 1 / **001**	001	**Customization Code** Identifies a customized version of the numerical control. When not present, it identifies the standard version of the control.

Product Label



a - Ordering Code:
code with the hardware characteristics & options of the numerical control requested at the time of order
b - Production Date:
reports the week and year of production
c - Part Number:
unique code that identifies an ordering code
d - Serial Number:
unique serial number of the numerical control
e - Hardware Version:
version & release of the numerical control hardware

Main features of the RosettaCNC-BE numerical control

Indicative list of the key features of numerical control including available hardware options. For the complete list, please refer to the comprehensive documentation of the RosettaCNC-BE product and NC language.

Features	Description
Number of Axes	3 (XYZ), 4 (XYZA), 5 (XYZAB) or 6 (XYZABC) interpolated axes 3 (UVW) interpolated axes usable as Gantry Slave axes
Number of Gantry Axes	1 Gantry axis, using axis A, B, C, U, V, or W as Gantry Slave *1)
Minimum Axis Movement	0.001 mm (0.000039 in)
Type of Axis Control	EtherCAT Master implemented on numerical control
NC Programming Language	Programming based on an extended dialect of the RS274-D standard Pre-processing analysis and simulation of NC programs Unlimited number of blocks per NC/Macro/MDI program Dynamic tool length and radius compensation 3 different tool radius compensation entry modes M commands set for interactive operator interface G commands set for RTCP control and kinematic configuration Macro programming with control flow functionalities Expandable G/M command set via macro programming System macros for customizing numerical control functionalities Ability to encrypt custom macro programs and G/M commands
Main Features of the Interpolator	Look-ahead 2000 blocks BPS (Blocks Per Second) 250 *2) Implemented in the numerical control Interpolated rapid movements Smoothing and point removal algorithm Jerk control on the interpolated TCP point RTCP (Rotating Tool Center Point) Control support Fixed or local kinematic RTCP parameterization via G commands Customization of interpolation characteristics via G commands Local control of the interpolated point's accel/decel via G commands Feedrate compensation for rotational axis A without RTCP Automatic retract along the tool vector at STOP and end of program
Supported Kinematics	The numerical control supports the following kinematics: ■ Trivial ■ Independent rotational axes ■ Rotary table A *3) ■ Rotary table B *3) ■ Titling head A *3) ■ Titling head B *3) ■ Rotary table A/B *3) ■ Rotary table B/A *3) ■ Rotary table A/C *3) ■ Rotary table B/C *3) ■ Tilting head A/B *3) ■ Tilting head B/A *3) ■ Tilting head C/A *3) ■ Tilting head C/B *3)
NC Startup Phase Management	Customizable via `start` system macro
Pallet Change Management	Customizable via `pallet_shuttle` system macro
Recovery from STOP Management	Customizable via `restart` system macro

Features	Description
Spindle Management	Spindle speed control via dedicated analog output. Spindle modes: ■ Normal ■ With automatic gear change Analog output modes for spindle: ■ Mode A: CW+ e CCW+ : 0/+10V per CW, 0/+10V CCW ■ Mode B: CW+ e CCW- : 0/+10V per CW, 0/-10V CCW Common spindle management functionalities: ■ Maximum spindle motor speed ■ Speed change settling time ■ Manual spindle start input for CW rotation ■ Manual spindle start input for CCW rotation ■ Manual spindle stop rotation input ■ Spindle speed reached confirmation input ■ Spindle zero speed (stop) confirmation input ■ Spindle not ready state input ■ Feedback signals from spindle with cone engagement, S1, S2, S4, S5 constantly monitored by the numerical control Common spindle management feedback: ■ Tachometer function enabled with input on signal S3 (I/O Expansion option) ■ Real spindle rotation speed analog input ■ Spindle current consumption analog input ■ Spindle torque analog input Additional features for spindle with automatic gear change: ■ 5 speed ranges ■ 5 digital outputs for gear change command ■ 5 digital inputs for selected gear feedback ■ Spindle motor speed at gear change Cooling system management features: ■ Cooling pump output ■ Cooling pump time (after spindle stop) Support for CNC machines with spindle for milling or tracing + laser/plasma torch on the same Z-axis. Support for CNC machines with multiple spindles on the same Z-axis, but used one at a time.

Features	Description
Tool Change Management	Customizable among: ■ None ■ Macro (uses the `tool_change` system macro) ■ PLC (available on customized NC control firmware) The default system macro implements the following functionalities: ■ Null (dummy) tool change (NTC) ■ Manual tool change (MTC), dynamic tool length with automatic measurement ■ Manual tool change (MTC), tool length in the library ■ Manual tool change (MTC), tool length in the library with automatic measurement ■ Automatic tool change (ATC), tool length in the library, cone-holder clamp with front/vertical movement ■ Automatic tool change (ATC), tool length in the library, cone-holder bushing with vertical/vertical movement The tool change macro includes a series of functionalities callable with the NC language, of which the main ones will be listed: ■ Execution of active tool length measurement ■ Opening of the tool magazine ■ Closing of the tool magazine ■ Query on the current state of the tool magazine ■ Manual tool loading/unloading from the spindle When using an automatic tool change (ATC), a rich user interface is available that recalls specific ATC macros to perform the following operations: ■ Association of tool number ↔ location slot ■ Modification of the tool list and tool characteristics ■ Automatic measurement of selected tool lengths ■ Tool loading/unloading operations For the realization of complex tool changes, for example, where it is necessary to manage the pre-selection/unloading phase of tools from chain loaders, it is possible to integrate the functionalities implemented in the numerical control via the `tool_change` system macro with an external PLC interfaced to the numerical control via Modbus. The `tool_change` macro is included in the installation package as NC source code to allow for self-customization.

Features	Description
Axis HOMING Management	The axes HOMING procedure can be started via: ■ Digital input ■ Virtualized input on Master Modbus ■ NC language via `G102` command ■ API Server via `cnc.homing` command ■ OPC UA Server via `cnc_homing` command ■ Multifunctional button on the NC control software Supported HOMING Modes: ■ Disabled ■ No movement ■ Rising edge of the limit switch ■ Falling edge of the limit switch ■ Pushing (only for Gantry axis) ■ Pushing on the rising edge of the limit switch (only for Gantry axis) ■ Pushing on the falling edge of the limit switch (only for Gantry axis) Specifications for each axis: ■ Sequence order in the limit switch search phase ■ Initial direction of limit switch search ■ Index input for precise homing on zero motor pulse ■ Pushing output (applicable in Pushing mode) ■ Pushing position (applicable in Pushing mode) ■ Axis offset, i.e., the value loaded in the axis position ■ Final position to be reached once the search is completed ■ Feed rate during the limit switch acquisition ■ Axis acceleration and deceleration during limit switch search
Handwheel Support	Support for handwheel with 5 VDC signals provided by the numerical control on a dedicated connector. When not using the handwheel, the same connector can be used for two Joystick modes. Dedicated connector for handwheel in Handwheel model A and B modes: ■ Axis selection X/Y/Z/A/B/C ■ Multiplier selection x1/x10/x100 ■ MPG bi-directional axis position with PHA/PHB phases ■ Output for handwheel electronics power supply 5 VDC, 50 mA ■ Handwheel enable input; if the function is enabled and pressed three times in quick succession within the programmed time, it allows zeroing the selected axis position on the active WCS. Dedicated connector with Jog Controller Type set to Single Joystick: ■ Inputs for axis selection X/Y/Z/A/B/C ■ Inputs for JOG– and JOG+ ■ Input for zeroing the selected work axis position Dedicated connector with Jog Controller Type set to Multiple Joystick: ■ Inputs for JOG axis X- and X- ■ Inputs for JOG axis Y- and Y+ ■ Inputs for JOG axis Z- and Z+ ■ Inputs for JOG axis A- and A+ The handwheel MPG (MPG 1) can be configured and used as an MPG for FAST and/or FEED override when the axis selection button is not pressed and the numerical control is in RUN or PAUSE state.

Features	Description
JOG Functionality	The axis JOG is available via: ■ Inputs for JOG +/- movements ■ Virtualized inputs on Master Modbus for JOG +/- movements ■ Inputs on the handwheel connector when this is not used ■ API Server via `cnc.jog.command` command ■ OPC UA Server via the `cnc_jog_command` command ■ JOG buttons on the NC control software ■ Keyboard keys (when enabled and only for axes X/Y/Z) Axis JOG modes: ■ Normal ■ Interpolated Activation of Z-axis JOG movement along the TCP vector with tilting head: ■ Via digital input ■ Via button on NC control software Configurable functionalities: ■ Enabling axis zeroing with handwheel ■ Handwheel pulses per revolution ■ Percentage of feed rate used ■ Maximum feed rate with interpolated JOG
Laser Cutting Functionality	Laser management with the following features: ■ Coordination of movements in three dimensions during cutting ■ Fine power adjustment via 0/10V analog output ■ Dynamic power correction based on TCP speed variation
Plasma Cutting Functionality	Management of plasma torch + spindle/marker simultaneously Torch height control (THC) in three modes: ■ None: No automatic torch height control. ■ Internal with analog input for arc voltage: The internal mode uses an analog input to monitor and control arc voltage, ensuring adequate cutting power and correct torch height. The system allows choosing between three different height compensation algorithms. ■ External via THC device with UP/DOWN/ARC signals: Allows the use of an external THC device for torch control, with UP/DOWN movement commands and arc monitoring. The internal mode offers advanced features such as constant arc voltage control, cutting power adjustment, arc voltage auto-acquisition, and a set of dedicated G commands that facilitate ignition, lead-in, cutting, and lead-out phases.

Features	Description
3D Scanning Functionality	3D scanning management with the following functionalities: ■ Surface mapping with a distance measuring laser sensor ■ Surface mapping with a 3D contact spindle probe ■ Surface scanning with a distance measuring laser sensor ■ Surface scanning with a 3D contact spindle probe Characteristics of scanning with a distance measuring laser: ■ Point acquisition every 4ms (250 samples per second) ■ Analog input for reading laser probe every 2ms ■ RC software filter for analog laser probe input ■ From 2 to 20 points of analog laser probe input linearization ■ Unlimited acquisition point buffer ■ Programmable acceleration/deceleration override ■ Programmable maximum scanning speed ■ Programmable maximum movement speed ■ Coordinates of the probe position relative to the spindle nose ■ 3D preview of acquired points on NC control software Generated scan files: ■ TXT file with point cloud in MeshLab compatible format ■ STL file with scan mesh with scan block origins ■ STL file with scan mesh with origins in the active WCS ■ STL file with scan mesh with origins in MCS
Lubrication Management	The numerical control implements lubrication management for: ■ Axes ■ Spindle The axis lubrication phase is started via: ■ Manually via a digital or virtualized input ■ Automatically upon expiration of the moving axes hour counter The spindle lubrication phase is started via: ■ Manually via a digital or virtualized input ■ Automatically upon expiration of the spindle on-time hour counter The lubrication phase activates the relevant pump in two different modes: ■ For a fixed time ■ Until the programmed number of pump feedback pulses is reached with timeout control between pulses

Features	Description
Override Management	The numerical control allows the operator to adjust the override in the following modules: ■ JOG: Modification of manual positioning speed. ■ Spindle: Control of spindle rotation speed. ■ Rapid movements (FAST): Adjustment of machine rapid movement speed. ■ Feed movements (FEED): Modification of feed rate during operations. ■ Custom 1 feed rate movements: Customization of speed in positive X movements, typical of disc tool cutting. ■ Custom 2 feed rate movements: Customization of speed in negative X movements, typical of disc tool cutting. ■ Plasma cutting power: Modification of power intensity set in the NC code. ■ Plasma cutting voltage: Modification of arc voltage set in the NC code. Available override control modes: ■ None: No override control active (equivalent to override = 100%). ■ MPG1 to MPG8: Manual control via digital rotary handwheels (bi-directional MPGs). With this configuration, adjustment via the override value bar in the NC control software is also available. ■ Analog input 1 to 11: Override adjustment via potentiometers. ■ Only from override value bar on NC control software: Adjustment exclusively through the override value bar in the NC control software. Override modes on movements: ■ Speed: The override affects only the axis speed. ■ Speed and acceleration: The override affects the speed, acceleration, and deceleration of the axis. NC commands for override management: ■ The NC commands `M48`, `M49`, `M50`, and `M51` are available for temporary enabling and disabling of overrides.
Communication Port	ETHERNET 10/100 RJ45 galvanically isolated
Supported Protocols	Proprietary TCP/IP protocol for interfacing with control software Proprietary UDP protocol for system NC discovery and settings Modbus TCP/IP Slave for interfacing with PC/CNC/PLC/etc. ICMP (Internet Control Message Protocol)
Analog Inputs	Logical : 16 Physical on board : 3 with I/O Expansion Configurable operational mode for each input: ■ Potentiometric input 1K÷20KΩ ■ Voltmeter input 0÷10V ■ Ammeter input 0÷20mA

Features	Description	
Digital Inputs	Logical Physical on board Type Operating voltage Maximum voltage	: 128 : 19 or 21 : PNP opto-isolated : range 12÷24 VDC : 26.5 VDC
MPG Inputs for Override	Logical Physical on board	: 9 : 3, reduced to 2 if the handwheel is present
Probe Input	1 with typical reaction time of 20 nS To be used mutually exclusively as TOOL-SETTER for tool length/width acquisition or as PROBE for 3D contact spindle probe.	
Digital Outputs	Logical Physical on board Type Output voltage Maximum current Protection	: 128 : 8 or 16 (option I/O Expansion = 1) : PNP PROFET Open Collector : from reference input, range 12÷28 VDC : 500 mA : short-circuit, overcurrent, countercurrent
Analog Outputs	Logical Physical on board Fixed function A01 Voltage range Maximum current Resolution Isolation	: 16 : 4 or 6 (option I/O Expansion = 1) : spindle speed control : ± 10 VDC (minimum no-load) : 1mA : 16 bit : 1000 Vrms
Power Supply	Nominal voltage Operating range Protection	: 24 VDC : 22÷27 VDC : reverse polarity
Maximum consumption	12W	
Temperature Range	From 0° to +50° Celsius	
Enclosure Protection Grade	IP20 (as per EN-60529 standard)	

*1) **Number of Gantry Slave Axes**
The current version of the standard numerical control firmware allows the configuration and use of only one Gantry axis. Firmware versions created for custom products may support multiple Gantry axes.

*2) **Blocks Per Second (BPS)**
The maximum value of blocks per second is conditioned by specific requirements:
- The continuous path mode `G64` must be active
- A high-quality Ethernet connection is necessary to ensure the continuous flow of blocks
- `G` movement blocks must not contain `G`/`M` commands that interrupt the path

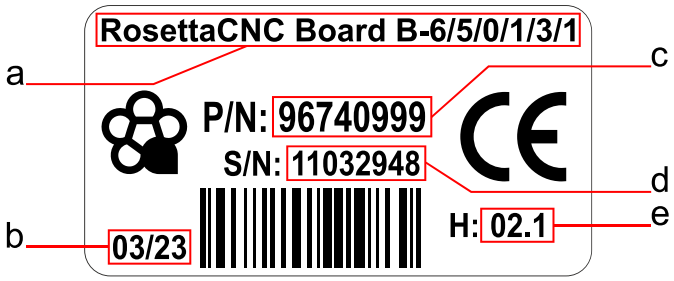
*3) **Kinematics with RTCP Mode**
For this kinematics, the RTCP mode can be activated only if this functionality is included among the selectable options in the product order code

Numerical control ordering code RosettaCNC-BE

Ordering code example for **RosettaCNC Board BE – 6/E/0/1/3/1/001** and the corresponding explanation table:

Code	Data	Description
Board BE - **6** / E / 0 / 1 / 3 / 1 / 001	6	**Number of axes** 3 = 3 axes 4 = 4 axes 5 = 5 axes 6 = 6 axes
Board BE - 6 / **E** / 0 / 1 / 3 / 1 / 001	E	**Master EtherCAT Axis Control**
Board BE - 6 / E / **0** / 1 / 3 / 1 / 001	0	**I/O Expansion** 0 = Not present 1 = CN21-CN22-CN24 Expansion
Board BE - 6 / E / 0 / **1** / 3 / 1 / 001	1	**Remote Communication** 0 = No communication 1 = OPC UA **(*obsolete*)** 2 = OPC UA + RosettaCNC Data Exchange 4.0 **(*obsolete*)**
Board BE - 6 / E / 0 / 1 / **3** / 1 / 001	3	**"Group A" Functions** 0 = No functions enabled 1 = RTCP 2 = Jerk Control 3 = RTCP + Jerk Control
Board BE - 6 / E / 0 / 1 / 3 / **1** / 001	1	**"Group B" Functions** 0 = No functions enabled 1 = Laser Acquisition 2 = Internal THC 4 = A/B Tilt Head (Bevel) 6 = Internal THC and A/B Tilt Head (Bevel) 7 = Laser Acquisition, Internal THC, and A/B Tilt Head (Bevel)
Board BE - 6 / E / 0 / 1 / 3 / 1 / **001**	001	**Customization Code** Identifies a customized version of the numerical control. When not present, it identifies the standard version of the control.

Product Label



a - Ordering Code:
code with the hardware characteristics & options of the numerical control requested at the time of order

b - Production Date:
reports the week and year of production

c - Part Number:
unique code that identifies an ordering code

d - Serial Number:
unique serial number of the numerical control

e - Hardware Version:
version & release of the numerical control hardware

Software options

The numerical control is equipped with optional support software, such as the OPC UA infrastructure for Industry 4.0. Please refer to the external documentation for a list and description of optional software solutions.

USB license key

Some functionalities and software programs of the NC system are available only with an optional usage license, issued via an enabling USB dongle. This dongle can contain licenses for various software or additional functions of the NC system.

If you already have the dongle, for example because you are already using NC control software for PPH or PPV versions, it is important to communicate this when ordering a new product with a license for the same system. This way, it will be possible to avoid receiving another dongle and instead activate the new license on the current one, reducing the accumulation of dongles to be inserted into the computer that manages the numerical control machine.

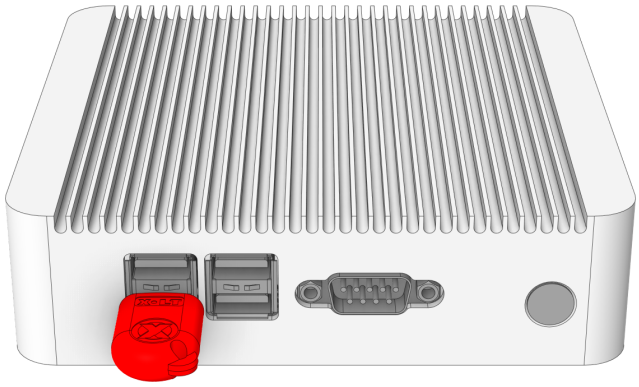


Figure 2.1: Example of USB dongle connection

Before starting programs that require a software license, connect the USB dongle to a USB port on the PC.

The dongle is compatible with USB-2 and USB-3 ports and is automatically recognized by the Windows operating system and does not require any installation software to be used.

Currently, the dongle is not compatible with the Linux + WINE system.

List of programs that require a license on a USB dongle

The following list is indicative as it relates to the date this manual was written:

- Control software version PPH (Horizontal Panel PC)
- Control software version PPV (Vertical Panel PC)
- NC vision system, Find Markers program
- OPC UA infrastructure server
- Work order management

2.2 Product compliance

CE marking and regulatory references

The numerical control has been designed for industrial use in compliance with directive 2004/108/EC.

EN 61000-6-4: Electromagnetic compatibility - Generic emission standard for industrial environments

- EN55011 Class A: Limits and measurement methods

EN 61000-6-2: Electromagnetic compatibility - Generic immunity standard for industrial environments

- EN 61000-4-3: Radio-frequency electromagnetic field immunity
- EN 61000-4-4: Electrical fast transients/burst immunity
- EN 61000-4-5: Surge immunity
- EN 61000-4-6: Conducted radio-frequency disturbances immunity

The numerical control is also compliant with the following standards:

- EN 60068-2-1: Cold resistance testing
- EN 60068-2-2: Dry heat resistance testing

3

Fundamental NC Principles

3.1 Introduction

The current version of the numerical control system is designed and optimized specifically for milling.

In this context, the descriptions, designations, and axis conventions discussed in the following chapters are exclusively related to CNC milling machines.

It is important to note that these are not directly applicable to other applications or configurations, such as turning machines.

3.2 Programmable axes

The programmable axes of the numerical control system conform to the axis definitions of the DIN 66217 standard.

However, for the **UVW** axes, the following exceptions should be noted:

- They can only be used as Gantry Slave axes within a Fieldbus EtherCAT configuration
- They are not accessible via the NC language
- They are not displayed in the NC control software user interface
- They are not exposed in the Modbus Slave, API Server, and OPC UA Server
- They do not have their own machine/work origins but inherit those of the Gantry Master axis to which they are connected

3.3 Axis designation

The programmable axes are designated as described in the following table:

Axis	Linear	Rotational	Gantry Slave
X	*		
Y	*		
Z	*		
A		*	Can be configured as Gantry Axis *1), *3)
B		*	Can be configured as Gantry Axis *1), *3)
C		*	Can be configured as Gantry Axis *1), *3)
U	*		Gantry only in EtherCAT configuration *2), *3)
V	*		Gantry only in EtherCAT configuration *2), *3)
W	*		Gantry only in EtherCAT configuration *2) *3)

*1) When a rotational axis is not used by the set kinematics, it can be employed as a Gantry Slave axis to support the linear **XYZ** axes with independent multi-drive.

*2) When using a Fieldbus EtherCAT configuration, the **YVW** axes can be used as Gantry Slave axes to support the linear **XYZ** axes with independent multi-drive.

*3) The current version of the standard numerical control firmware allows the configuration and use of a single Gantry axis. However, the firmware versions for customized products can support up to three Gantry axes.

3.4 Gantry axes

When constructing a large-scale CNC machine, there is often the need to move considerable masses in one or more linear axes. In such situations, the use of a two-motor per axis configuration, known as a Gantry axis or independent multi-drive axis, provides a simple and efficient solution to problems such as stress distribution, movement vibrations, misalignment of travels, and distortion of movement components.

The Gantry axis consists of two fundamental movement components: the Gantry Master axis (linear axis) and the Gantry Slave axis. The former, connected to a linear axis of the CNC, guides the movement, while the latter provides support to the Master axis, following its trajectory and distributing efforts evenly along the entire path.

Thanks to this configuration, the Gantry axis allows optimal stress distribution on the machine, minimizing deviations from the intended path and mechanical stress on the CNC. This approach is particularly advantageous in long-duration operations or with extended travels, as it reduces the risk of errors and ensures precise machining.

In conclusion, the Gantry axis represents a strategic resource in CNC machines, allowing for more efficient machine use, extending operational life, and enhancing the quality of the produced work.

Gantry axes in numerical control

<for SID: add here a description of the types of gantry axes managed by the numerical control system>

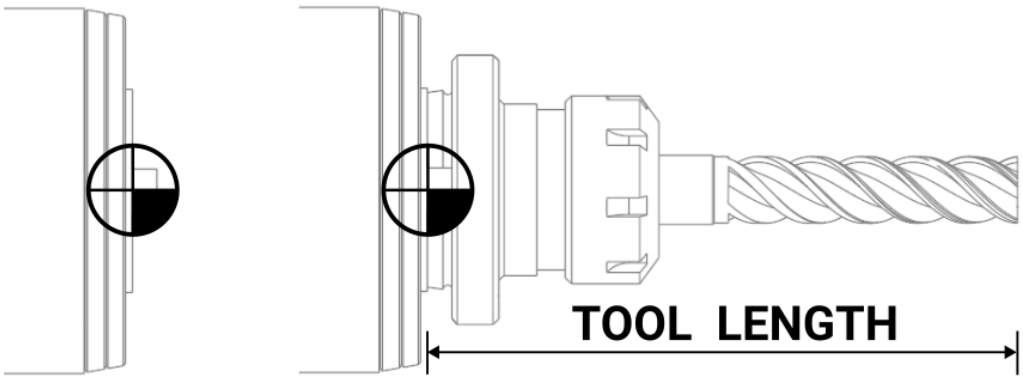
3.5 Machine reference points

The table below provides an overview of the machine and workpiece reference points.

Icon		Origin
	MCS	**Machine zero point** The machine zero point represents the origin of the machine coordinate system (MCS), to which all other reference points are related.
	WCS	**Workpiece/work zero point** The workpiece zero point represents the origin of the workpiece or work coordinate system (WCS) and is relative to the machine zero point. The numerical control system has 9 configurable and selectable WCS.
	MRP	**Machine reference point** In numerical control, there are two machine reference points, represented in machine coordinates (MCS). These points can be called up using G28 and G30 commands. Although they are generic points, they are often used for various functions, such as: ■ In CAD/CAM systems like Fusion 360, to indicate the G28 command to safely retract the machine from the workpiece at the end of a work phase and before the start of the next phase. ■ To manually position the machine for tool change. ■ To return the machine to the zero position, i.e., the origin of the MCS coordinates. ■ To move the machine to a safe position during pallet change. ■ To safely access the worktable for material placement or interventions during machining.

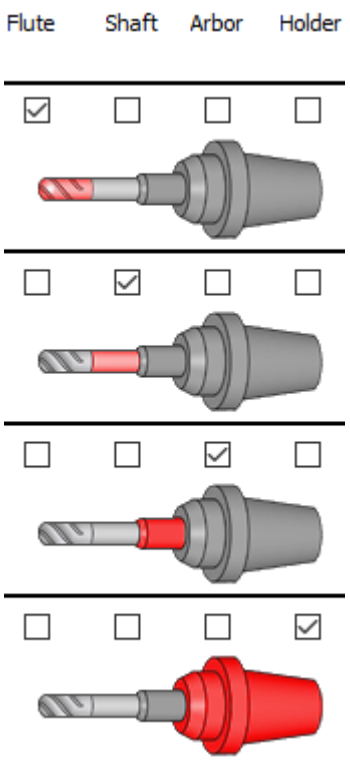
Tool reference points

The table below provides an overview of the reference points on the tools.

Icon		Origin
	TZP	**Tool length zero point** The tool length zero point is not directly related to the machine or work coordinate system but indicates where the zero point for measuring tool length is located. It usually corresponds to the spindle nose position when no tool is mounted, or to the edge of the clamping collar of the tool in spindles with a fixed collar for manual change. **Example with ATC spindle, with and without tool holder cone** 

Tool terminology

The table below provides an overview of the terminology used for tool components.

Tool Component Name	Description
	Tool terminology: ■ Flute: This is the cutting part of the tool that performs the cutting work. The grooves on tools like mills allow chips to be evacuated from the cutting area. A tool can have from one to many grooves. For example, a mill can have 2, 3, 4, or more grooves. The higher the number of grooves, the smoother the finish of the machined surface, but it can reduce the space for chip evacuation. ■ Shaft: This is the cylindrical part of the tool that connects the cutting part (flute) to the holder. It is the body of the tool. ■ Arbor: In some tools, especially in disk mills or turning tools, the arbor is the part that supports the cutting tool. It can be considered as an intermediate part between the shank and the holder. ■ Holder / Tool Holder: This is the part of the tool that is attached to the CNC machine. It holds the tool in place and stabilizes it during machining, ensuring precision during cutting operations.

Axis direction and rotation conventions

The convention for the direction and rotation of axes in numerical control adheres to the right-hand rule, following international standards ISO 841, DIN 66217, or EIA RS-267-A. These standards establish the specific assignment of a rotary axis for each of the three linear axes and define the direction of rotation for the rotary axes relative to the associated linear axis.

However, the rotation direction can be customized in the numerical control configuration by selecting between "Direct" and "Inverse" options. This flexibility allows for better adaptation to the NC code produced by CAD/CAM software.

Additionally, the numerical control system provides the ability to modify the assignment of rotary axes to the standard linear axes when operating with a kinematic setup that includes "Independent Rotary Axes." For example, the rotary axis A can be assigned to the linear axis Y, facilitating the use of CAD/CAM software that does not handle the B axis but requires the A axis to move along the B axis.

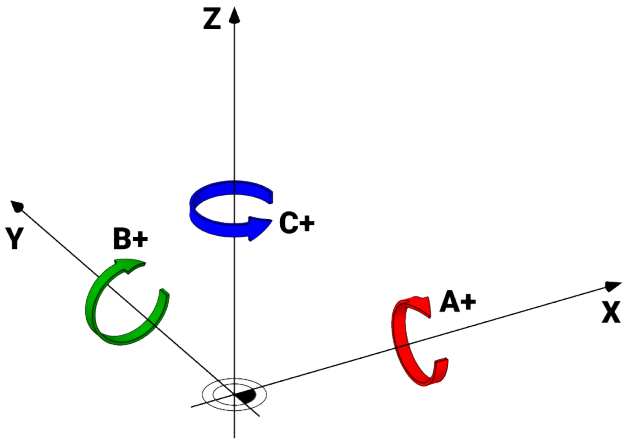


Figure 3.1 : Axis direction and rotation conventions

The arrangement and assignment of rotary axes to linear axes are as follows:

Rotary axes are assigned to the following linear axes:

- The rotary axis A is assigned to the linear axis X
- The rotary axis B is assigned to the linear axis Y
- The rotary axis C is assigned to the linear axis Z

The figure demonstrates that, taking the vertex of the axis as a reference and looking towards the zero point, the rotation of the axis occurs counterclockwise, in accordance with the right-hand rule.

The 5-Step G-Code Coordinate Pipeline

We begin our overview with a graphical diagram of the 5 steps involved in transforming a coordinate from the number typed in the G-Code program to the actual machine coordinates that will be used:

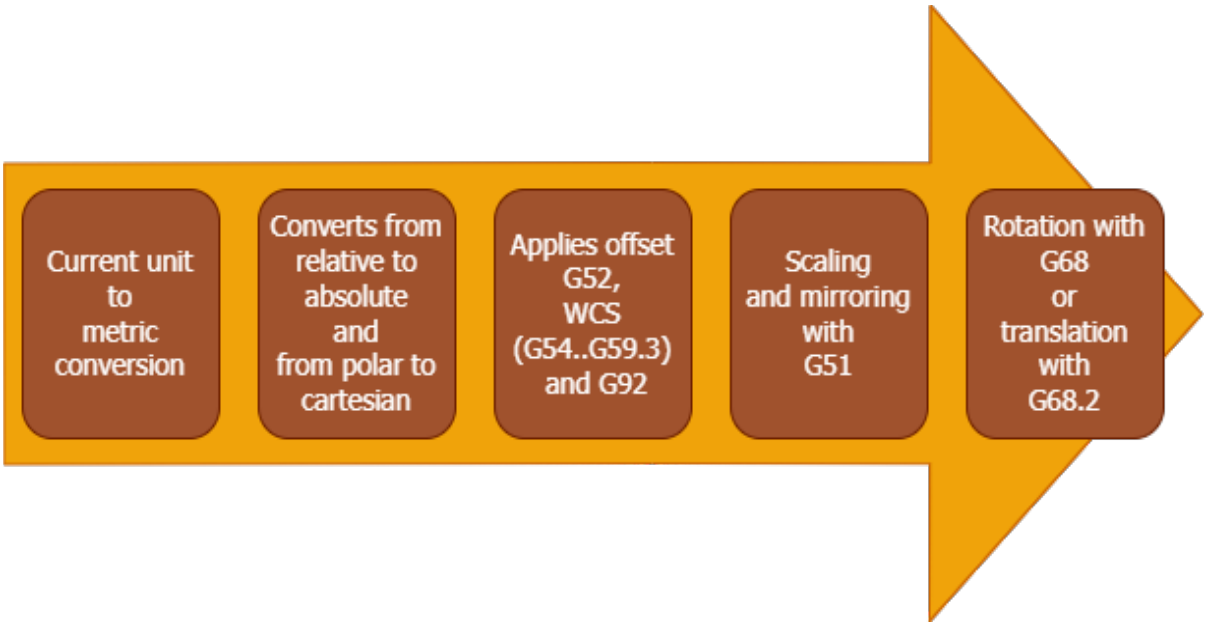


Figure 3.2 : Coordinate transformation pipeline in numerical control

The following terms are used in the manual:

Term	Meaning
In Fast	Indicates a rapid movement of the axes involved in the command.
In Feed	Indicates a feedrate (F) movement of the axes involved in the command.

Coordinate systems

G-Code has some powerful operations that allow you to transform coordinates and shape them according to your needs. This chapter introduces the various types of transformations that can be performed on G-Code coordinates and how they fit together. Subsequent chapters will provide details on each specific type of operation.

<SID: add description of coordinate systems here>

4

API Server

4.1 Description

4.2 System Overview

4.3 Configuration of the API Server

By default, after the installation of the NC control software, the API Server for the default `machine` or demonstration machines is disabled. The configuration and management of the server's start and stop status must be carried out through the "*Program Settings*" panel.

Opening the "Program Settings" Panel

Access to the settings panel varies depending on the version of the control software:

- STD version Control Software:
  Select the "*Settings → Program Settings...*" menu from the main menu bar.
- PPH/PPV version Control Software:
  Press the "*Program*" button on the "*Monitor & Settings*" tab of the main page.

Once opened, the "*Program Settings*" panel displays a list of folders on the left that organize the settings into groups, while the remaining area of the window shows the tabs with the parameters of the selected folder.

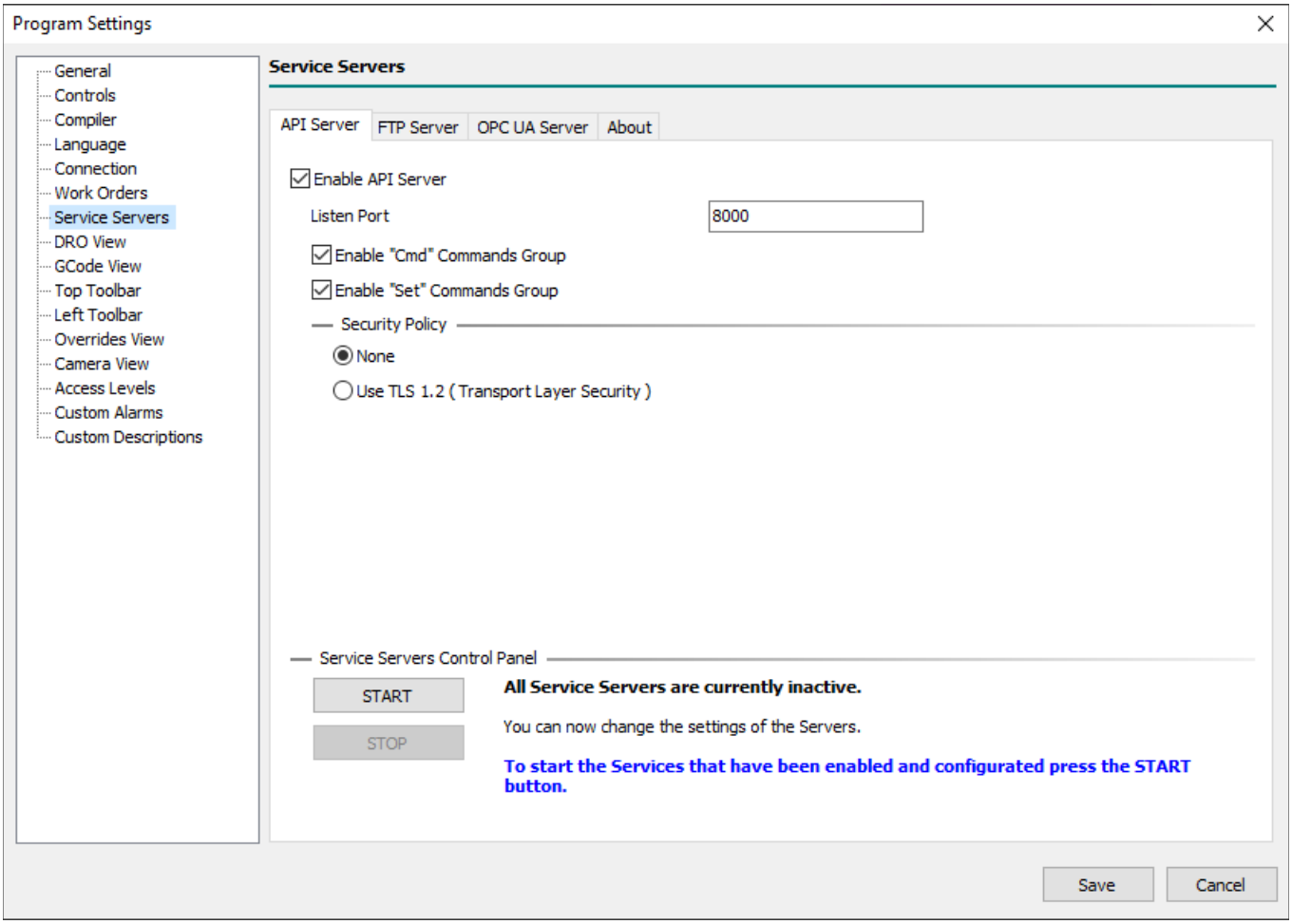


Figure 4.3.1: Program Settings Panel (STD Version)

Configuration and Management of the API Server Start/Stop State

The "*Service Server*" folder offers four tabs: the first three are dedicated to the configuration and management of the API, FTP, and OPC UA servers, while the last one provides information on the status of the related services. In this chapter, we will focus on the "*API Server*" tab. Each tab related to a server type has two buttons: **START** and **STOP**, which allow you to start and stop the server services, respectively. The action of the buttons affects all services simultaneously.

When the control software is started, the enabled server services are automatically started and are stopped when the program is closed. To modify the server service settings, they must be stopped; therefore, before making any configuration changes, you need to use the **STOP** button and then restart them with the **START** button.

To use the API Server service, follow these steps:

1. Stop the server services, if active, by pressing the **STOP** button.
2. Check the "*Enable API Server*" checkbox to enable the API Server, which also implicitly enables the "`GET`" command group.
3. Set the API Server listening port in the corresponding input field. By default, port `8000` is used. However, if this port is already in use by other programs or NC control software on the same computer, you must choose an available port.
4. Check the "*Enable CMD Command Group*" checkbox to enable the "`CMD`" command group (optional).
5. Check the "*Enable SET Command Group*" checkbox to enable the "`SET`" command group (optional).
6. Select the connection security policy, as needed.
7. Restart the server services by pressing the **START** button.

Quick Verification of API Server Functionality

To verify the API Server's functionality, open a terminal and run the following command:

```
$telnet localhost 8000      < -- Press the ENTER key to enter the telnet session.
                            < -- Press the ENTER key again to send an invalid request.
{"res":null}                < -- The server will respond with {"res":null}, indicating an invalid request.
```

> The **telnet** program **does not support** the **TLS 1.2** security protocol.
>
> For a quick verification of server functionality, it is necessary to set the security policy to "*None*."

4.4 API Server Protocol

The version of the API Server described in this document is 1.5.1 and implements three groups of commands or requests:

- `GET` request group
- `CMD` request group
- `SET` request group

In the following sections, the term "*request*" will often be used, which essentially refers to a command to the API Server. This distinction is made to clarify when referring to commands sent to the API Server versus commands that the API Server sends to the numerical control.

Notes on the Application Protocol

Before delving into the details of the commands supported by the API Server, it is important to pay attention to the following notes on the application protocol used, to simplify the implementation of your API Client.

Notes on the Application Protocol

CMD Request Group

Requests belonging to the GET group are used to send commands to the numerical control or the NC control software. In this document, the term "*API command xxx*" refers to "*a CMD group request xxx to the API Server.*"

CMD Request Group List

Request	Description
`cnc.continue`	
`cnc.homing`	
`cnc.jog.command`	
`cnc.mdi.command`	
`cnc.pause`	
`cnc.resume`	
`cnc.resume.from.line`	
`cnc.resume.from.point`	
`cnc.start`	
`cnc.start.from.line`	
`cnc.start.from.point`	
`cnc.stop`	
`program.analysis`	
`program.analysis.abort`	
`program.gcode.add.text`	
`program.gcode.clear`	
`program.gcode.set.text`	
`program.load`	
`program.new`	
`program.save`	
`work.order.add`	
`work.order.delete`	

GET Request Group

Requests belonging to the `GET` group are used to obtain information from the numerical control or the NC control software.

GET Request Group List

Request	Response Content Description
`analog.inputs`	Values of the analog inputs monitored by the numerical control.
`analog.outputs`	Values of the analog outputs controlled by the numerical control.
`axes.info`	Information about the axes of the numerical control.
`cnc.info`	System information of the numerical control.
`cnc.parameters`	Values of the numbered (`#`) parameters of the numerical control.
`compile.info`	Information regarding the most recent analysis performed on the NC program.
`digital.inputs`	Status of the digital inputs monitored by the numerical control.
`digital.outputs`	Status of the digital outputs controlled by the numerical control.
`enabled.commands`	List of the enablement statuses of `CMD` requests (commands).
`machining.info`	Information about the machining operations of the analyzed NC program.
`programmed.points`	List of programmed points (`G100 P0`) present in the analyzed NC program.
`scanning.laser.info`	Values from the scanning laser module of the numerical control.
`system.info`	Information about the NC System.
`tools.info`	Information about the tools available in the numerical control.
`vm.geometry.info`	Information about the geometries of the numerical control's virtual machine.
`work.info`	List of work orders managed by the NC control software.
`work.order.code.list`	*< to be documented >*
`work.order.data`	*< to be documented >*
`work.order.file.list`	*< to be documented >*

GET – analog.inputs

Requests the API Server to retrieve values of the analog inputs monitored by the numerical control.

API get	Client request and Server response model

`analog.inputs`	**C:** `{"get":"analog.inputs"}`
	S: `{"res":{`
	`"value" :[<byte>[16]]`
	`}}`

value

Array of 16 floating-point values representing the analog inputs monitored by the numerical control.

Each analog input is normalized to a range between 0.00 and 100.00 (percentage value represented with two decimal places). Although the numerical control supports up to 16 analog inputs, some are directly available on the NC board, while others are accessible only through external accessories as an extension of the NC system.

> **Note**
> If the connection between the NC control software and the numerical control is not active, the server will return the response `{"res":false}`.

GET – analog.outputs

Requests the API Server to retrieve values of the analog outputs controlled by the numerical control.

API get	Client request and Server response model

`analog.outputs`	**C:** `{"get":"analog.outputs"}`
	S: `{"res":{`
	`"value" :[<byte>[16]]`
	`}}`

value

Array of 16 floating-point values representing the analog outputs controlled by the numerical control.

Each analog output is normalized to a range between -100.00 and 100.00 (percentage value represented with two decimal places). Although the numerical control supports up to 16 analog outputs, some are directly available on the NC board, while others are accessible only through external accessories as an extension of the NC system.

> **Note**
> If the connection between the NC control software and the numerical control is not active, the server will return the response `{"res":false}`.

GET – axes.info

Requests the API Server to retrieve information about the axes of the numerical control.

API get	Client request and Server response model

`axes.info`	**C:** `{"get":"axes.info"}`
	S: `{"res":{`
	`"joint.position" :[<float>[6]],`
	`"machine.position" :[<float>[6]],`
	`"program.position" :[<float>[6]],`
	`"machine.target.position" :[<float>[6]],`
	`"program.target.position" :[<float>[6]],`
	`"actual.velocity" :[<int32>[6]],`
	`"working.wcs" :<byte>,`
	`"working.offset" :[<float>[3]],`
	`"dynamic.offset" :[<float>[3]],`
	`"homing.done" :<bool>,`
	`"homing.done.mask" :<axes_mask>,`
	`}}`

joint.position
Array containing the joint (physical axes) positions in the machine coordinate system (`MCS`).

machine.position
Array containing the positions relative to the tool center point in the machine coordinate system (`MCS.TCP`).
When no compensation is active (`G49`), this is equivalent to the `joint.position` field.

program.position
Array containing the positions relative to the tool center point in the active work coordinate system (`WCS.TCP`).
When no compensation is active (`G49`), this is equivalent to the positions of the joints (physical axes) referred to the active work coordinate system (`WCS`).

machine.target.position
Array containing the target positions of the current motion block, relative to the tool center point position in the machine's mechanical coordinate system (`MCS.TCP`).
When no compensation is active (`G49`), these correspond to the target positions of the current motion block relative to the joints (physical axes) in the machine coordinate system (`MCS`).

program.target.position
Array containing the target positions of the current motion block, relative to the tool center point position in the active work coordinate system (`WCS.TCP`).
When no compensation is active (`G49`), these correspond to the target positions of the current motion block relative to the joints (physical axes) in the active work coordinate system (`WCS`).

actual.velocity
Array containing the current velocities of the joints (physical axes).

working.wcs
Contains the number of the active work coordinate system.

working.offset
Array containing the current offsets applied in the active work coordinate system.

dynamic.offset
Array containing the dynamic offsets applied to the machine axes.
These offsets are typically applied by the operator during machining to make small adjustments to the toolpath's final position without interrupting the machining process.

homing.done
Contains the value `true` if the HOMING procedure has been completed for all enabled axes.

homing.done.mask
Contains an axes bitmask specifying which axes have completed the HOMING procedure.

GET – cnc.info

Requests the API Server to retrieve information about the axes of the numerical control.

API get	Client request and Server response model

cnc.info	**C:** {"get":"cnc.info"}
	S: {"res":{
	"units.mode" :<int32>,
	"axes.mask" :<int32>,
	"state.machine" :<int32>,
	"gcode.line" :<int32>,
	"worked.time" :<stime>,
	"hud.user.message" :<string>,
	"coolant":{
	"mist" :<bool>,
	"flood" :<bool>
	},
	"lube":{
	"axis.cycles.made" :<int16>,
	"axis.time.to.next.cycle" :<int16>,
	"spindle.cycles.made" :<int16>,
	"spindle.time.to.next.cycle" :<int16>
	},
	"feed":{
	"programmed" :<int32>,
	"target" :<int32>,
	"reference" :<int32>
	},
	"spindle":{
	"programmed" :<int32>,
	"target" :<int32>,
	"actual" :<int32>,
	"load" :<int16>,
	"torque" :<int16>,
	"direction" :<int32>,
	"not.ready" :<bool>,
	"shaft" :<int16>,
	"status" :<int16>,
	"voltage" :<int16>
	},
	"override":{
	"jog" :<int16>,
	"jog.min" :<int32>,
	"jog.max" :<int32>,
	"jog.enabled" :<bool>,
	"jog.locked" :<bool>,
	"spindle" :<int16>,
	"spindle.min" :<int32>,
	"spindle.max" :<int32>,
	"spindle.enabled" :<bool>,
	"spindle.locked" :<bool>,
	"fast" :<int16>,
	"fast.min" :<int32>,
	"fast.max" :<int32>,
	"fast.enabled" :<bool>,
	"fast.locked" :<bool>,
	"feed" :<int16>,
	"feed.min" :<int32>,
	"feed.max" :<int32>,
	"feed.enabled" :<bool>,
	"feed.locked" :<bool>,
	"feed.custom.1" :<int16>,
	"feed.custom.1.min" :<int32>,
	"feed.custom.1.max" :<int32>,

API get	Client request and Server response model

```
                "feed.custom.1.enabled"      :<bool>,
                "feed.custom.1.locked"       :<bool>,
                "feed.custom.2"              :<int16>,
                "feed.custom.2.min"          :<int32>,
                "feed.custom.2.max"          :<int32>,
                "feed.custom.2.enabled"      :<bool>,
                "feed.custom.2.locked"       :<bool>,
                "plasma.power"               :<int16>,
                "plasma.power.min"           :<int32>,
                "plasma.power.max"           :<int32>,
                "plasma.power.enabled"       :<bool>,
                "plasma.power.locked"        :<bool>,
                "plasma.voltage"             :<int16>,
                "plasma.voltage.min"         :<int32>,
                "plasma.voltage.max"         :<int32>,
                "plasma.voltage.enabled"     :<bool>,
                "plasma.voltage.locked"      :<bool>
        },
        "tool":{
                "id"                         :<int32>,
                "slot"                       :<int32>,
                "slot.enebled"               :<bool>,
                "type"                       :<int32>,
                "diameter"                   :<float>,
                "offset.x"                   :<float>,
                "offset.y"                   :<float>,
                "offset.z"                   :<float>,
                "param.1"                    :<float>,
                "param.2"                    :<float>,
                "param.3"                    :<float>,
                "description"                :<string>
        }
}}
```

SET Request Group

The `SET` request group is used to send settings to the numerical control or the NC control software.

SET Request Group List

Request	Description
`cnc.parameters`	
`override`	
`program.position`	
`server.settings`	
`work.order.data`	
`vm.geometry.info`	

5

References

Documentation Reference List

[1] RosettaCNC Classroom on YouTube (LINK)

[2] RosettaCNC Online Documentation (LINK)

[3] Modbus Organization: MODBUS Messaging on TCP/IP Implementation Guide V1.0b (LINK)

Programs and Libraries Reference List

[4] RosettaCNC Classroom on GitHub (LINK)

[5] cnc-api-client-core package for Python on PyPI (LINK)

[6] MeshLab, open-source mesh processing software (STL) (LINK)

RosettaCNC Classroom Channels Reference List

[7] RosettaCNC Classroom on YouTube (LINK)

[8] RosettaCNC Classroom on github (LINK)

[9] RosettaCNC Classroom on Telegram (LINK)

CAD/CAM References Used for Classroom Examples

[10] BobCAD-CAM by BobCAD-CAM Inc (LINK)
European Distributor DataCAD Software & Service GmbH (LINK)

[11] DeskProto by Delft Spline System (LINK)

[12] SheetCAM (LINK)

[13] eCAM – Easy CNC Programming System (LINK)

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