

## CNC solutions

## For milling machines

- Integrated hardware and software solution
- Ready-to-use HMI
- Simple and fast integration



# CNC solutions

## By Inovance

- Milling
- Laser cutting
- Waterjet cutting
- Plasma/ oxy fuel cutting
- Additive manufacturing
- Dental milling



Inovance Technology Europe's headquarters in Stuttgart, Germany

Inovance Technology Europe is the European division of global industrial automation group Inovance. Formerly known as Power Automation, Inovance Technology Europe has more than 20 years of extensive CNC expertise across milling, laser and waterjet cutting. The company specialises at delivering real-time machine control, and at helping OEMs to improve machine performance and productivity.

With its network of offices and R&D facilities in Germany, France, Italy and Turkey, Inovance Technology Europe is able to offer local service and support right across the European continent. Inovance has invested heavily in its European CNC R&D centre, and the company has a large engineering research team based in Germany, supported by a network of technical experts based across Europe. To learn more about Inovance Technology Europe, visit [www.inovance.eu](http://www.inovance.eu)

To learn more about Inovance – a \$1bn+ global industrial automation company offering the full range of industrial automation products from variable speed and servo drives, to PLCs to industrial IoT solutions – visit [www.inovance.com](http://www.inovance.com)



Inovance Technology Europe - CNC Technology Centre

## Milling with Inovance

Inovance offers a perfectly suited solution of hardware and software for all kinds of milling and routing machines. All relevant milling functions are included - no additional options are required to run a milling machine. The Inovance solution consists of all necessary components and functions for easy machine setup:

- Easy-to-use HMI interface with multi-touch gestures
- 3D real-time visualization of the tool, the workpiece and the machine
- Tool management via high performance PostgreSQL database
- Easily customizable HMI
- Ready to use PLC and PLC App library with multiple functions and peripherals
- Various cycles available, including drilling, pocket and advanced cycles
- CNC path optimization functions
- Various axes transformations

### Your advantages

- All relevant milling functions are included
- Simple and fast integration
- Freedom to extend or change our standard package according to your needs and requirements
- Generic PLC included
- Easy operation
- High performance
- Rapid machine start-up
- Predictable start-up and running costs
- Rapid time to market
- A one stop shop



## Software functions For milling

### General NC functions

- Block skip
- Optional stop
  - Switch optional stop to 'on' to stop the machine at an M01 command
- Program repetition
  - Programs can be repeated for a defined time, or on an endless loop
- Send messages from the NC program to the HMI
- Call up subroutines in an NC program
  - Subprogram call from every NC program possible

- Rapid traverse (interpolated) (G0)
- Linear interpolation with feed rate (G1)
- Circular interpolation (G2, G3, G12, G13)
- Plane selection (G17, G18, G19, G20)
- Path corrections (D-Corr)
  - 128 corrections per tool
- Length corrections (H-Corr)
  - Possible in one direction (128 corrections per tool) or in two directions (64 corrections per tool)
- Zero offset on the workpiece
- Homing cycles
- Different axis offsets (G92, G99)

### General machine options

- Position/lag monitoring
- Standstill monitoring
- Measuring system monitoring
- Angled wheel
- Dynamic axis allocation
- Gantry axis
- Positioning axis
- Parallel axis
- Feed rate override via external analogue signal
- Interrupt programming
- Backward on the contour

## Software functions For milling

### 5-axes transformation\*

The software package for 5-axes transformation is used for machines which have two round axes in addition to the usual three linear axes (X, Y and Z). These round axes make it possible to orient a rotation-symmetrical tool to any point relative to the workpiece. Active transformation allows programming of Cartesian workpiece coordinates without regard to the round axis. The workpiece coordinate system may be shifted and rotated to the machine coordinate system.

The orientation of the tool can be made by programming the round axis or the tool direction vector. In addition to the 5 mentioned axes, the machine can have further axes (e. g. loading axes or axes of tool changes) which are not involved in the transformation.

The 5-axes transformation allows changes of tool programs in the CNC control without changing the NC program.

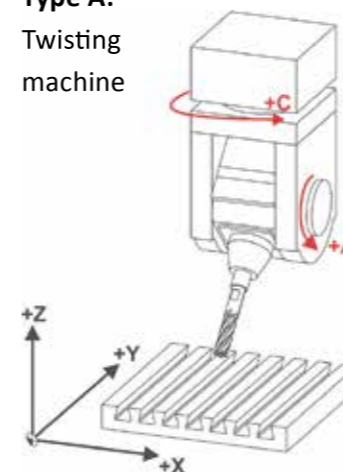
\*Subject to official export approvals if exported outside of the European Union

### Cartesian machines

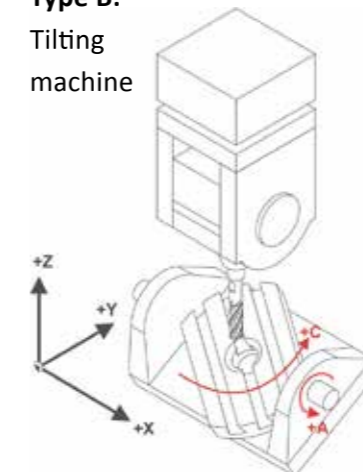
The machine kinematics must correspond to the following requirements:

The three linear X, Y and Z axes must form a clockwise cartesian coordinate system. Each of the round axes rotates around one linear axis. That means the turning vector will be parallel to the according linear axis. Both round axes must be oriented perpendicular to one other. The round axis can be used either to turn the tool or to turn the workpiece. A situation where one of the round axes moves the tool and the other one moves the workpiece is also permitted.

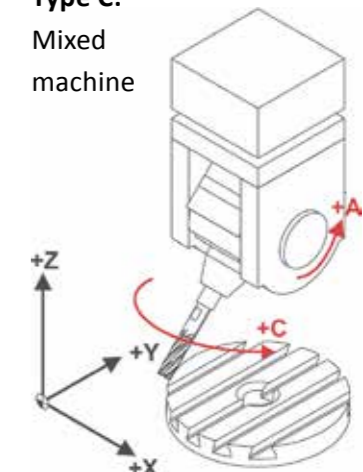
**Type A:**  
Twisting  
machine



**Type B:**  
Tilting  
machine



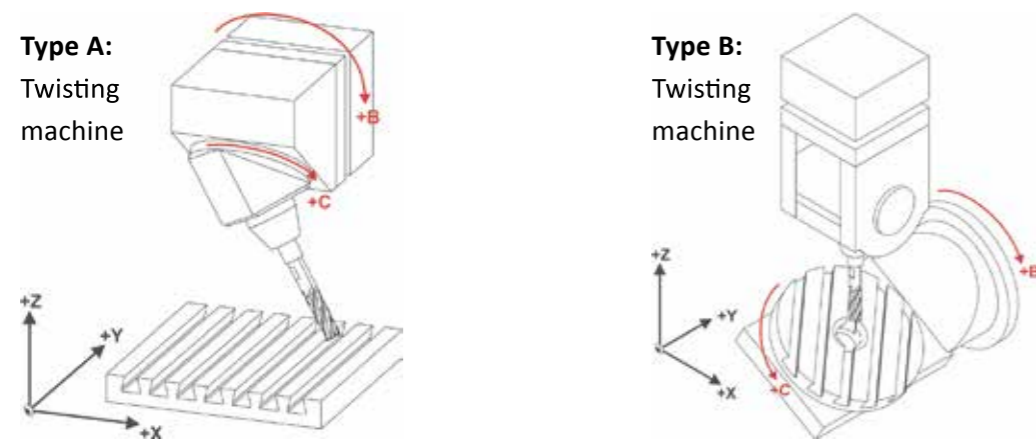
**Type C:**  
Mixed  
machine



# Advanced functions For milling

## Nutator machines

There is a special type of “5-axes-transformation” for nutator machines, where one of the turning axes is not parallel to the linear axis.



## 4- and 3- axes transformation

4- and 3-axes transformation corresponds to 5-axes transformation.

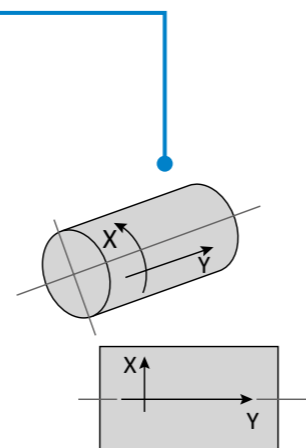
4-axes transformation: 3 linear axes and 1 round axis.

3-axes transformation: 2 linear axes and 1 round axis.

## Barrel transformation

The barrel cam transformation allows easier programming of a program path on a cylindrical part. The cylindrical part will be moved for the machining process around its centre of rotation, interpolated with the longitudinal axis.

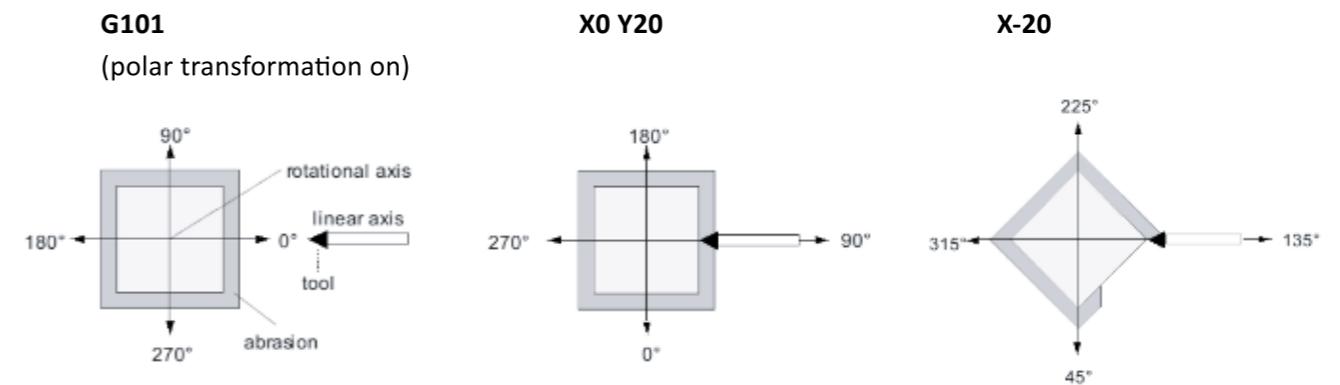
The programming is done on an “unwrapped” (or “developed”) plane surface, which serves as interpolation plane for compensations and feed rate calculations. In this developed plane, almost the complete range of geometric control options is available.



## Polar transformation

Polar transformation allows programming of a polar machine with cartesian coordinates. However, programming in polar coordinates is selectable as well if required.

A polar machine is a machine constituted from a minimum of one rotary axis (1st axis) and one radial axis (2nd axis).

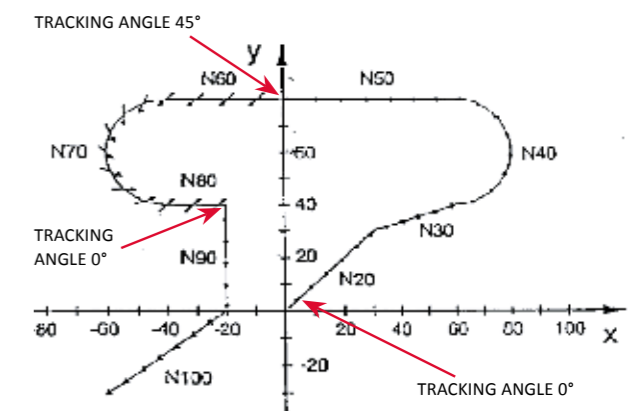


## Tangential tracking

The tangential tracking function enables a rotational axis to be oriented automatically, so that the rotational axis position matches the actual path tangent, or a defined offset to this tangent.

This function may be used for automatic orientation of non-symmetrical tools (such as cutting and welding tools).

The tangential tracking angle can be changed during the process:



## Advanced functions For milling

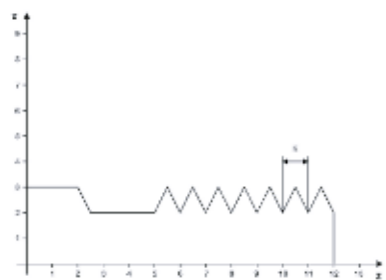
### Thread cutting

Thread cutting requires synchronization between the spindle's rotation and a cutting axis (usually Z-axis). Therefore, during thread cuts, the programmed feed rate has no effect.

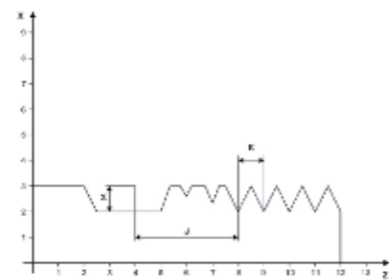
The spindle speed controls movement and the longitudinal axis moves along with the spindle in accordance with the programmed thread pitch.

As threads can be cut in several strokes if necessary, the axis will not move until the spindle marker (the 0-position of the spindle) is detected.

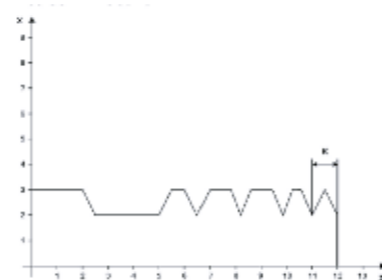
Cylindrical basic thread cut



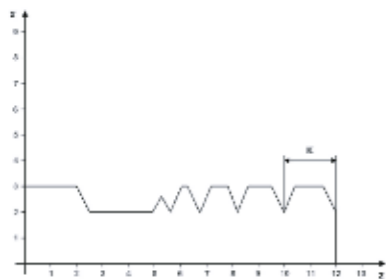
Cylindrical thread cut with runout



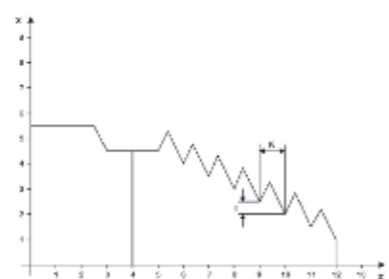
Cylindrical thread cut with increasing pitch



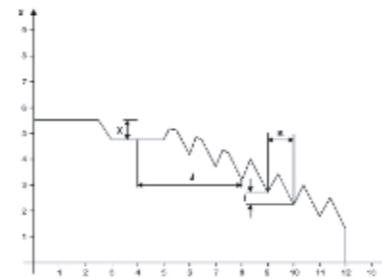
Cylindrical thread cut with decreasing pitch



Conical basic thread cut



Conical thread cut with run-out



## CNC path optimization functions For milling

### Symmetric jerk control

The symmetric jerk control function results in a smooth axis movement with continuous acceleration.

The feature also reduces machine vibrations significantly and may be used to suppress natural oscillations.

In contrast to classical S-curve acceleration, the symmetric jerk control function does not reduce productivity in sequential block processing because the effective axis ramp time is not affected by jerk control.

The symmetric jerk control function is usually set according to the axes' gains. Manual tuning and changing of settings in the NC program is also possible. Depending on the application, it may be set up either by programming parameters or by the cut-off frequency by the low-pass filter.

Setting the symmetric jerk control function for very smooth movement could result in reduced processing accuracy. To improve accuracy, the path accuracy function can be used.

### Path accuracy

The path accuracy function, used together with the symmetric jerk control function, allows smooth movement of the axis with controlled maximal path error.

Better accuracy through processing usually means more processing time. The function allows the setting of path accuracy according to processing needs (for example, low accuracy and fast speed for rough processing, and high accuracy for finishing). Symmetric jerk control and path accuracy can be changed dynamically e. g. to achieve **optimum performance for different milling processes (roughing, finishing, fine finishing)**.

By combining these functions, optimum acceleration for each machine and application can be achieved.

This results in maximum performance for each application, in accordance with the jerk limitation and precision requirements desired by the machine manufacturer.

# HMI For milling

## PA9000 milling HMI

The PA9000 Milling HMI is a user-friendly HMI which has all standard functionalities for operating a milling machine.

Product benefits:

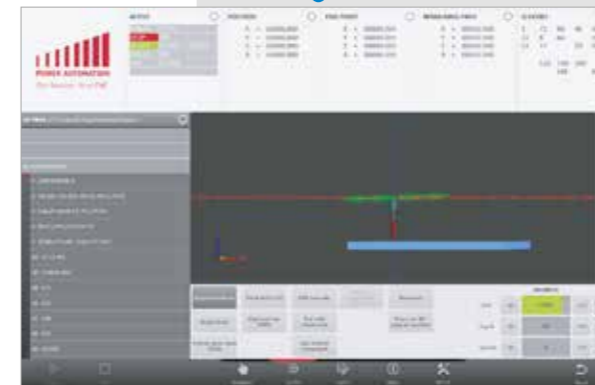
- Intuitive and easy to use
- Touch screen operation
- Scalable screen allows viewing of a large number of screens simultaneously
- Open interface for adding new parts or substituting existing components on the HMI



## Automatic mode

Options:

- Select NC program for execution
- Select single or sequential blocks for execution
- Optional halt (M01)
- Block delete (/)
- G01 override
- Test with or without movement
- Backward operation
- Manual movements in automatic mode, and automatic return to last programmed position
- Feed/spindle override control
- Start at selected NC block
- NC file view of entire NC program



## Manual mode

Options:

- Jog axis (incremental/continuous mode)
- Control of feed override (G1) and rapid override (G0)
- Set zero position (G92 offset)
- Selection of different modes to visualize axes' positions: tool coordinate position/zero position/absolute position
- Hand release mode
- Switch on/off handwheel
- Redefine homing position



## Data

Options:

- Length correction table editor (H1...H128)
- Path correction table editor (D1...D128)
- Zero offset table editor (G54...G59)
- Cycle parameter table editor



# HMI For milling

## Info

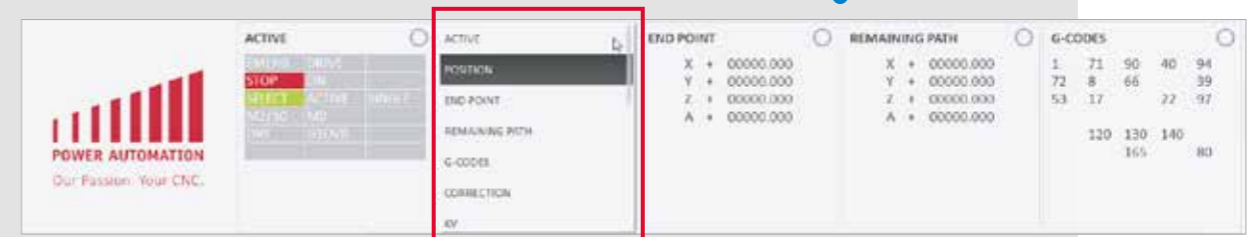
Options:

- View of actual active messages
- Interface display for CNC-PLC interface variables, PLC I/O variables



## Status bar & zoom info screen

Status bar has multiple display options, dependent on user preferences.



The following options can be chosen:

- Active signals
- Actual absolute axis position
- Axis endpoints
- Axis remaining path
- Active G-codes
- Axis corrections
- Axis KV
- Axis Lag
- Axis direction
- Axis out value
- Active compensations
- Actual feeds
- Spindle information
- Machine status
- Active BCD
- NC program information
- Axis speed

Instead of the 3D/2D graphic, a zoom of 2 status views can be shown. The status view content can be defined by the user.



## Setup

Options:

- Shutdown CNC or OS
- PLC editor
- Editor for machine parameters
- Logic analyser
- Logout/login and change password
- CNC configuration info
- Main menu settings for hiding/unhiding buttons/options on HMI
- QMI settings for resolution and sizing of HMI



## 3D visualization For milling

### 3D visualization

This new visualization renders a 3D-Scene, which shows the actual milling process performed by the CNC, including the removal of the material. So, it is possible to look at the workpiece, during the cutting process from every angle and in arbitrary scale, without the view being obstructed by dust, water or other external circumstances. PC-based architecture allows the user to switch easily to the newest CPU models and technologies. This includes the newest graphic processors, which enables rendering of the most detailed 3D-scenes in high resolutions (up to full HD) compared to our competitors. The level of detail can be set by the user.

PA offers a 3D real-time visualization of the tool, the workpiece and the machine.

### Tool

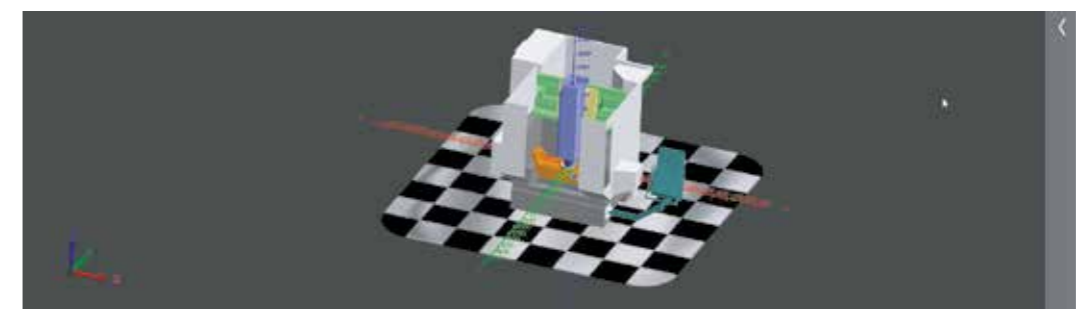
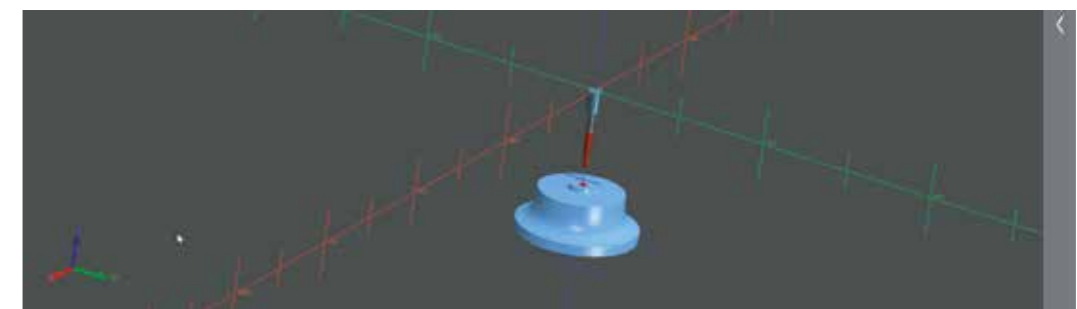
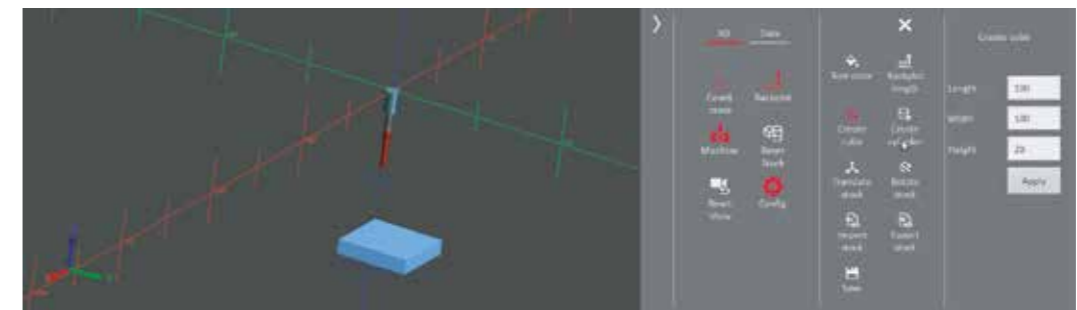
- Tool dimension and type is changed depending on the set tool in the database
- Automatic tool on tool changes are possible (tool management PLC POU from Inovance is needed)
- Different tool colours can be defined
- Cut material is shown in the defined tool colour

### Stock (material)

- Material can be defined on the HMI as a cube or a cylinder
- Material can be placed in the machine by defining X, Y, Z positions and rotations
- Complex materials can be imported by STL-file
- Newly defined or cut material can be exported in an STL-file
- Material can be saved for use again after shutting down the CNC

### Machine

- Possibility of visualizing the whole machine (needs the freeware tool machine builder and STL files from the machine/machine parts)
- Possibility of only visualizing stock and tool

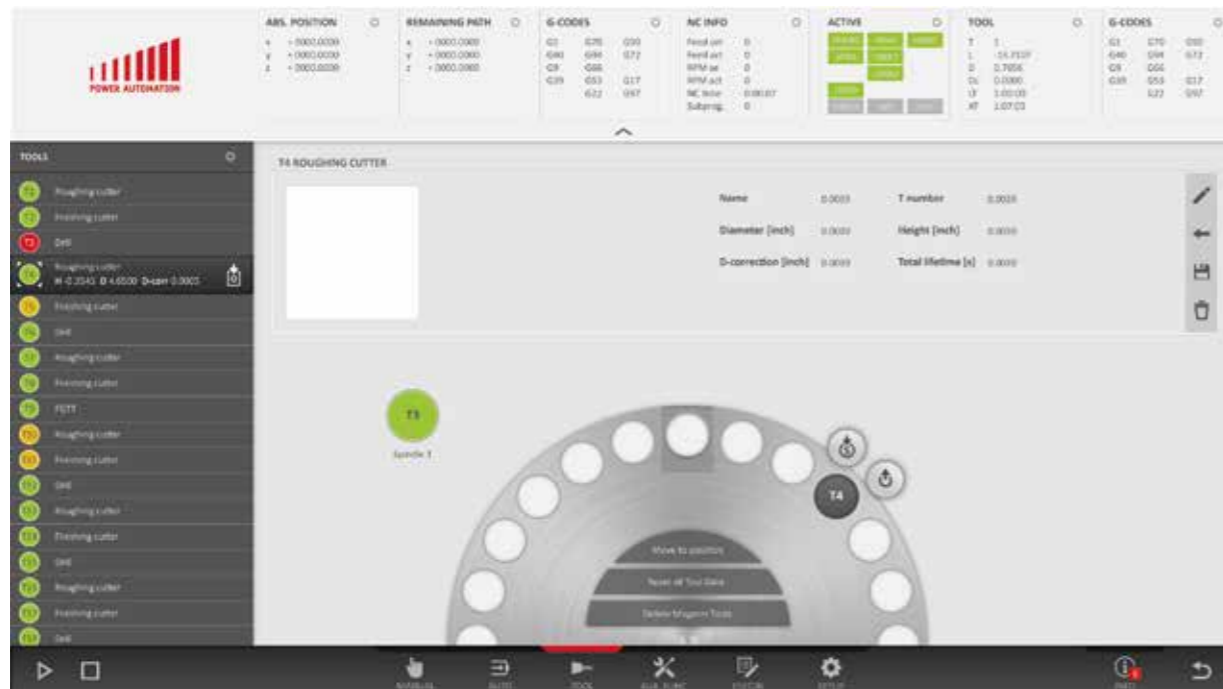




# Tool management For milling

## Tool management

The PA9000 Milling HMI uses a PostgreSQL database for tool management. The database is fully integrated in the system with accessibility from PLC, HMI, CNC and NC programs. The tool management system consists of tables about the tool, the tool type, the tool holder, the tool magazine and the tool corrections.



## Tool management tables

- Tool table: Information about tool type, tool holder and actual lifetime
- Tool model table: Information about tool type, total lifetime, lifetime warnings and information needed for visualization of the tool
- Tool holder table: Information about the dimensions of the tool holder is needed for visualization
- Tool magazine table: Information about which tool is in which place with which options

## Tool management options

- The entire tool stock of the customer can be defined
- Each tool can be combined with a tool holder
- Each tool can be defined as a Master tool or Sister tool. The Master tool is used for milling until used up or broken. When used up or broken the next sister tool is used automatically (with standard PLC POU “PA Tool management”)
- Each tool can be defined as “blocked” so that it will be ignored
- Tool usage time can be monitored according to three variables: max. tool time, which is the maximum time the tool may safely be used; and tool warning times 1 and 2, which are different thresholds that can be set by the user as a warning that the tool should be changed

## Tool corrections

- Up to 128 length corrections for 1 tool in one direction
- Up to 64 length corrections for 1 tool in two directions
- Up to 128 diameter corrections for 1 tool

# PLC For milling

In every PA9000 CNC, Inovance provides a ready to use standard PLC program. With the PA Standard PLC, you can easily implement your own functions and peripherals.

## PLC app library

Inovance also offers a PLC app library for many of the functions and peripherals that are regularly used in milling machines. The apps are programmed for use with the standard PLC, but because of the fixed defined input/output interface of every app, they can be used in any PLC.

## Examples of PLC apps

### PA tool management app

This app can be used to work with the PA tool management database. All data about active and new tools can be read and written. Tool change processes and tool time handling are integrated. Documentation assists in understanding how to create an NC-subprogram for a tool change if the existing one will not fit.

### PA MCP app

App for use of PA MCP panel

### Coolant app

App which can be used to switch on/off coolants via M-Code/HMI and hardware button

### Conveyor app

App which can be used to switch on/off conveyor via M-Code/HMI and hardware button

### MPG app (handwheel)

App for use of different MPGs

### Hardware feed override app (G0 and G1)

Freely definable hardware switch for up to 64 feed override steps

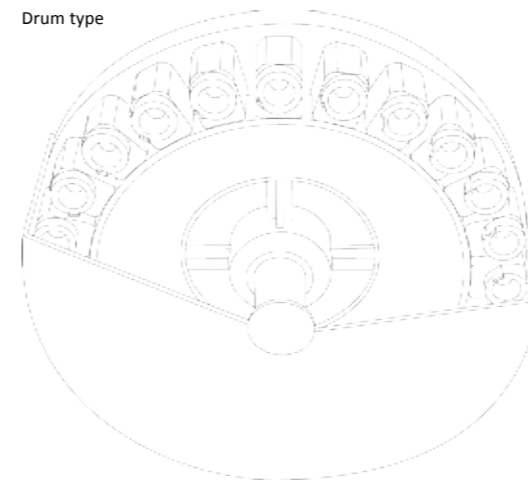
### Hardware spindle override app

Freely definable hardware switch for up to 64 spindle override steps

### Rotational tool magazine - digital control app

Rotates the magazine with digital signals place by place. Double arm logic integrated

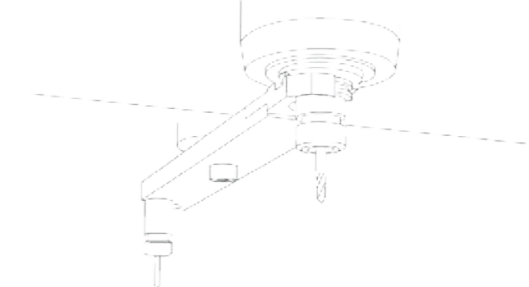
Drum type



Chain type



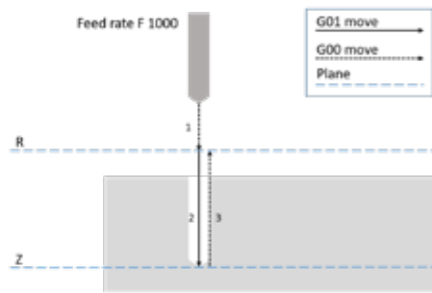
Double arm



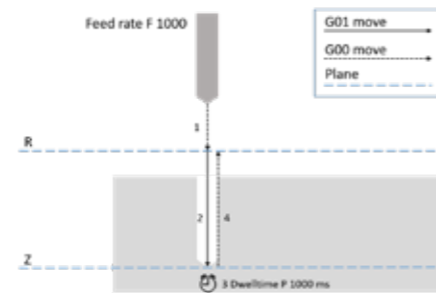
# Cycles For milling

## Drilling cycles

### G81 Drilling to final depth



### G82 Spot facing with dwell time

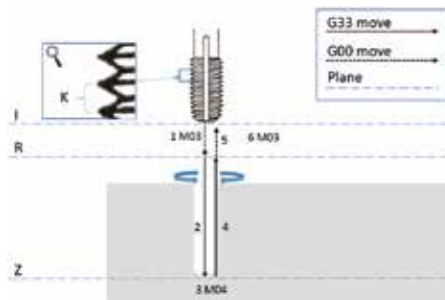


Other cycles available:

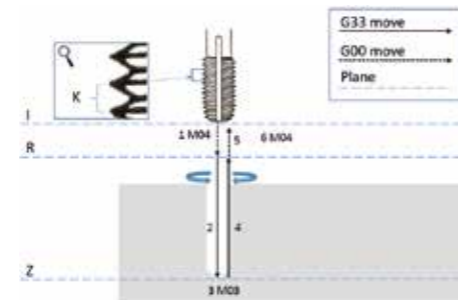
- Deep hole drilling
- Thread cutting with balanced chuck
- Reaming
- Bore out
- Reaming with measuring stop
- Bore out with spindle stop
- Bore out with intermediate stop
- Deep hole with reducing peck

## Rigid tap cycles

### G720 Rigid tapping right handed (only possible at spindle with position feedback)



### G721 Rigid tapping left handed (only possible at spindle with position feedback)

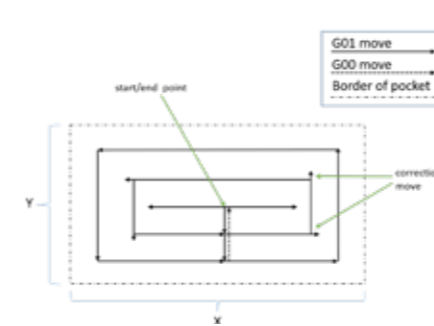


Other cycles available:

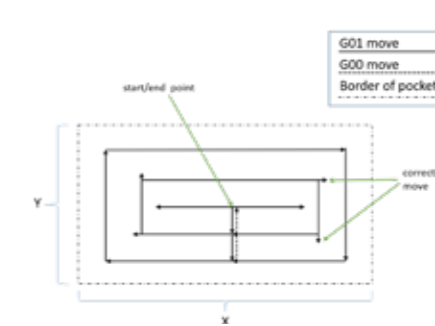
- Rigid tapping, right handed, self-reversing (needs special tool)
- Rigid tapping, right handed with variable retract feed (only possible at spindle with position feedback)
- Rigid tapping left handed with variable retract feed (only possible at spindle with position feedback)
- Rigid tapping, right handed, with variable retract feed without thread lead (needs special tool holder)
- Rigid tapping, left handed, with variable retract feed without thread lead (needs special tool holder)

## Milling cycles

### G711 Rectangular pocket counterclockwise



### G712 Rectangular pocket clockwise



Other cycles available:

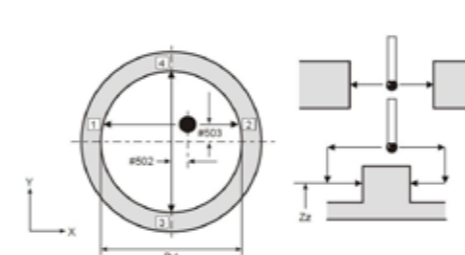
- Circular pocket, counterclockwise
- Circular pocket clockwise
- Mill boring circle counterclockwise
- Mill boring circle clockwise

Advanced cycles available:

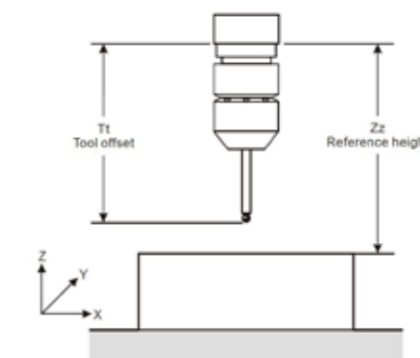
- Bolt circle
- Bolt grid
- Engraving letters

## Measuring cycles

### G850 Calibration



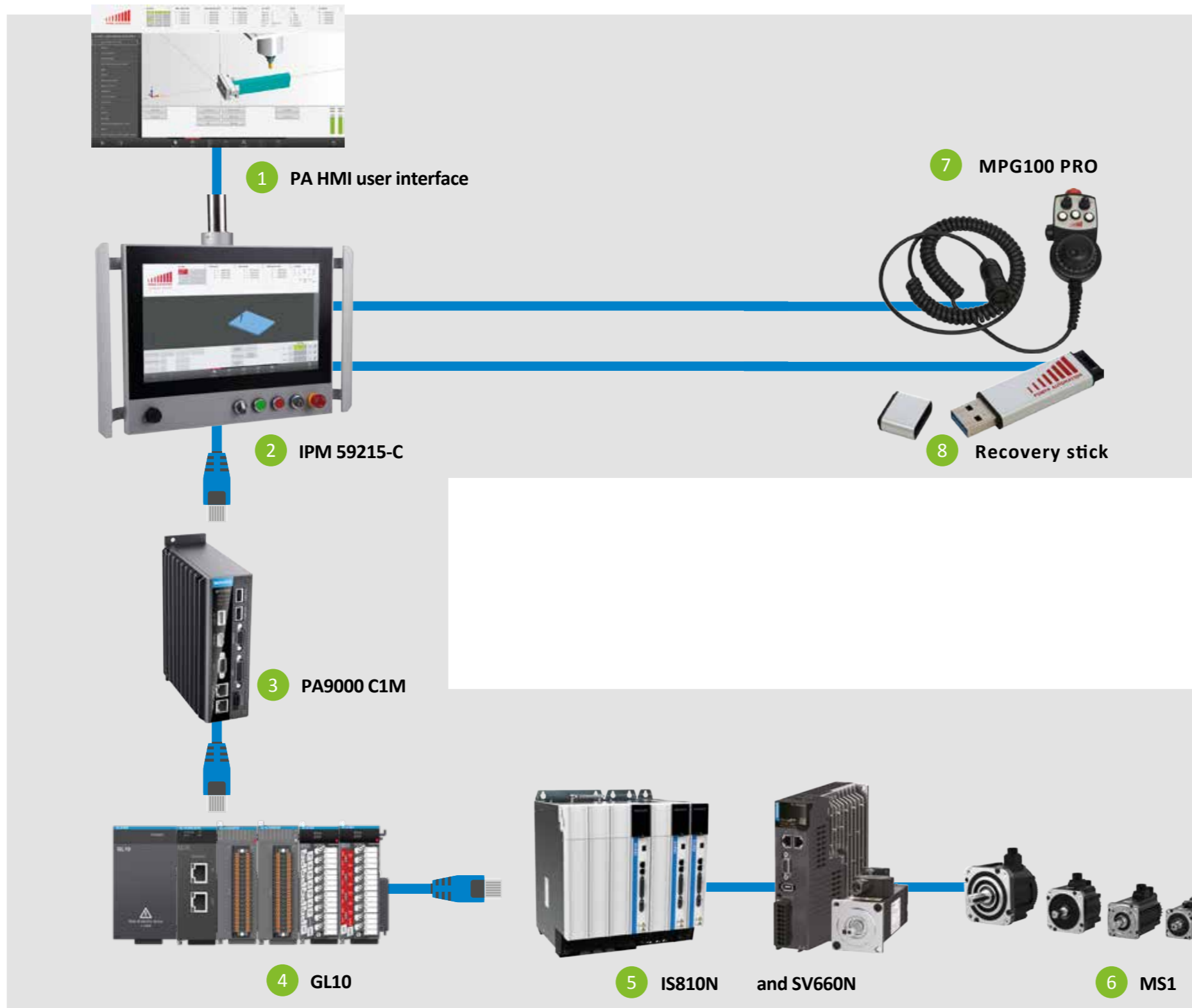
### G851 Length calibration



Other cycles available:

- Measure in one direction
- Measure two points
- Measure four points
- Corner measure
- Angle measure

# Sample Configuration



- 1 **PA HMI user interface**  
State of the art design. Easy-to-use
- 2 **IPM 59215-C**  
Operating panel with touch screen, freely definable emergency stop buttons, and USB input
- 3 **PA9000 C1M**  
Ultra compact, lightweight, EtherCAT CNC
- 4 **GL10**  
Compact EtherCAT I/O modules
- 5 **IS810**  
High performance EtherCAT servo drives 400 V series with common power supply  
Single axis versions also available
- 6 **MS1**  
Servo motors with excellent servo properties
- 7 **MPG100 PRO**  
Ergonomic handheld pendant
- 8 **Recovery stick**  
All-in-one solution for checking, testing, recovering and restoring PA9000 CNC controls

# Driven by Technology

AC Drives



AC MultiDrives



MV Drives



Single-Axis Servos



Multi-Axes Servos

EtherCAT



Robotics & Motion Controllers



PLCs & HMIs



CNC Machine Tool Solutions

EtherCAT







Electric Vehicle Inverters






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Forward, Always Progressing

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