DOCUMENTATION ISG-kernel

Functional description
Workspace monitoring

Short description:
FCT-C14

ISG Industrielle Steuerungstechnik GmbH
STEP, Gropiusplatz 10
D-70563 Stuttgart

www.isg-stuttgart.de
support@isg-stuttgart.de

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Preface

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No claims may be made for products which have already been delivered if such claims are based on the specifications, figures and descriptions contained in this documentation.

Personnel qualifications

This description is solely intended for skilled technicians who were trained in control, automation and drive systems and who are familiar with the applicable standards, the relevant documentation and the machining application.

It is absolutely vital to refer to this documentation, the instructions below and the explanations to carry out installation and commissioning work. Skilled technicians are under the obligation to use the documentation duly published for every installation and commissioning operation.

Skilled technicians must ensure that the application or use of the products described fulfil all safety requirements including all applicable laws, regulations, provisions and standards.

Further information

Links below (DE)

https://www.isg-stuttgart.de/produkte/softwareprodukte/isg-kernel/dokumente-und-downloads

or (EN)

https://www.isg-stuttgart.de/en/products/softwareproducts/isg-kernel/documents-and-downloads

contains further information on messages generated in the NC kernel, online help, PLC libraries, tools, etc. in addition to the current documentation.

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It is forbidden to make any changes to the software configuration which are not contained in the options described in this documentation.

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Icons used and their meanings

This documentation uses the following icons next to the safety instruction and the associated text. Please read the (safety) instructions carefully and comply with them at all times.

Icons in explanatory text

➢ Indicates an action.

⇨ Indicates an action statement.

⚠ DANGER

Acute danger to life!

If you fail to comply with the safety instruction next to this icon, there is immediate danger to human life and health.

⚠ CAUTION

Personal injury and damage to machines!

If you fail to comply with the safety instruction next to this icon, it may result in personal injury or damage to machines.

Attention

Restriction or error

This icon describes restrictions or warns of errors.

Notice

Tips and other notes

This icon indicates information to assist in general understanding or to provide additional information.

Example

General example

Example that clarifies the text.

Programing Example

NC programming example

Programming example (complete NC program or program sequence) of the described function or NC command.

Release Note

Specific version information

Optional or restricted function. The availability of this function depends on the configuration and the scope of the version.

Table of contents

List of figures

1 Overview

Task

Monitoring 3D bodies by defining workspace or protection areas in a cylindrical or polygonal form of a constant height.

Properties

Work space and protection space monitoring with tool centre point monitoring is possible with

- automatic mode in conjunction with:
  - Linear motion blocks
  - Circular motion blocks (regardless of orientation G17/G18/ G19)
  - Kinematic transformations
  - Polynomial contouring (monitoring interpolation points for the polynomial depending on dynamics and slope)
  - Helical motions
  - Reference point offsets with G92, G54
  - Cartesian transformations #(A)CS available as of CNC Build V2.11.2015:
- active manual mode available as of CNC Build V3.1.3068.9: in conjunction with:
  - Exclusive (G200) or inclusive mode (G201/G202)
  - Kinematic transformations

Parametrisation and programming

The parameters of workspaces/protection areas are defined [▶ 17] for a specific channel directly in the NC program by means of # commands.

Mandatory note on references to other documents

For the sake of clarity, links to other documents and parameters are abbreviated, e.g. [PROG] for the Programming Manual or P-AXIS-00001 for an axis parameter.

For technical reasons, these links only function in the Online Help (HTML5, CHM) but not in pdf files since pdfs do not support cross-linking.

2 Description

2.1 Effectiveness

Workspace or protection areas are defined, activated or deactivated by means of the #CONTROL AREA command. After a reset all workspace/protection areas are deactivated. Control normally refers to the 3 current main axes of a channel.

Release Note

As of CNC Build V2.11.2015.00 workspace and protection area control can also be used for active Cartesian transformations #(A)CS.

Release Note

As of CNC Build V2.11.2025.00 polygonal protection areas can also be defined for tracking axes. Workspace or protection areas are each programmed and are effective for a specific channel.

2.2 Standard control for axes

Software limit switches

Their simplest application is as axis-specific software limit switches for work space monitoring. The minimum and maximum limits defined for each axis limit the motion range of each axis.

The position of software limit switches can be defined by:

- Parameterisation in the axis configuration list P-AXIS-00177 and P-AXIS-00178 or
- directly in the NC program

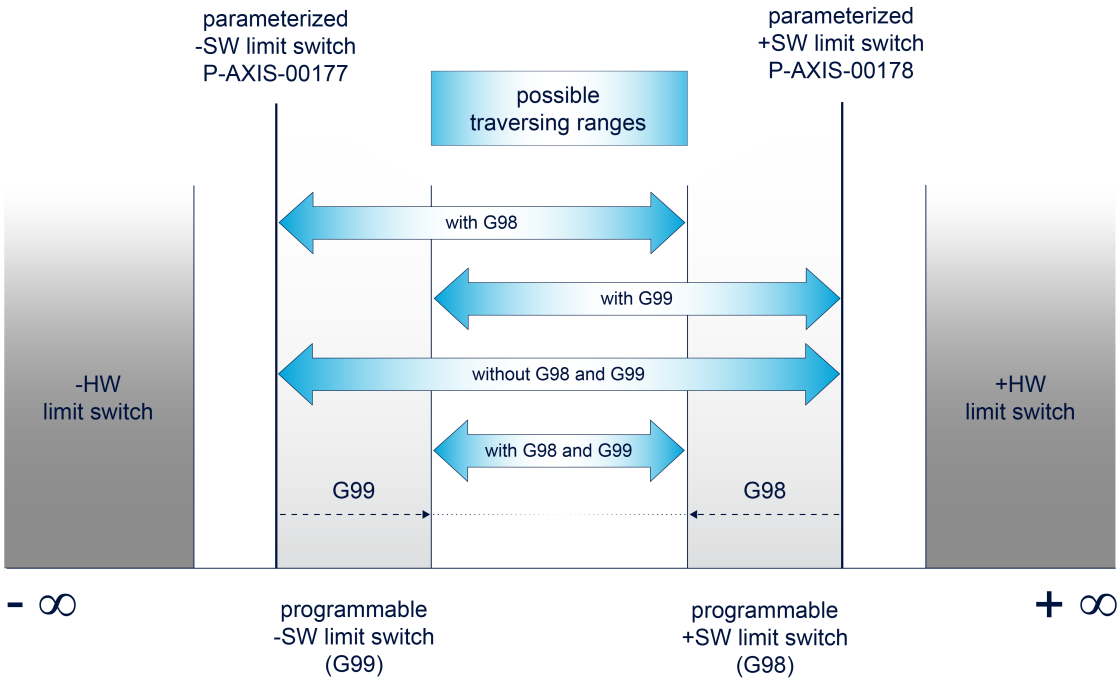


Fig. 1: Software limit switches

We recommend that you define the workspace and protection areas within the range of software limit switches.

2.3 Characteristics of workspace/protection area control

Workspace/protection areas

A workspace is defined as a zone that the TCP (Tool Centre Point) is not permitted to exit.

On the other hand, a protection area must never be touched by the TCP.

Workspace and protection areas can be nested to any extent required. When areas are nested, protection space control overrides workspace control. The number of workspace and protection areas is limited to 20.

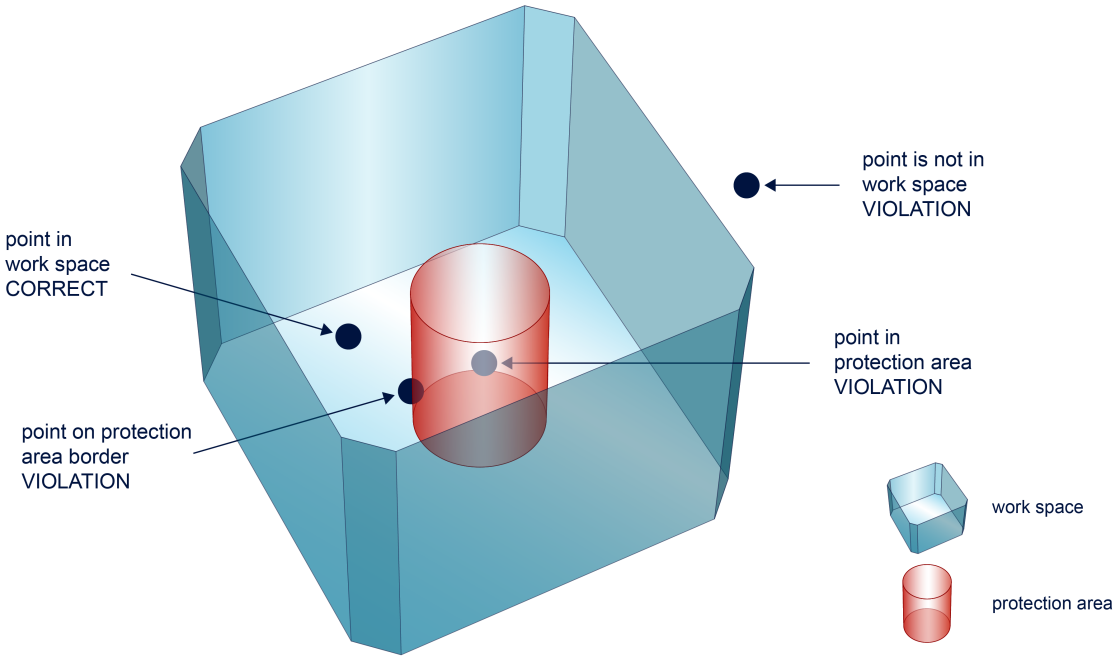


Fig. 2: Definition of workspace/protection areas

Control areas as 3D objects

A workspace/protection area is defined by an object in space. Basically 2 different geometries are available. Circles or polygons can be defined by a third constant dimension.

Cylinders are defined by a full circle in the basic plane.

Polygons can be of any complexity in the basic plane. Only the convex form (self-contained chain without overlaps) is mandatory. The number of permitted motion blocks to define a polygonal shape is limited to 20 blocks.

The X/Y/Z coordinates of the control areas are referred directly to the three main axes of the channel configuration.

Example of X/Y basic plane (G17):

X → 1st main axis

Y → 2nd main axis

Z → 3rd main axis (constant due to minimum/maximum values)

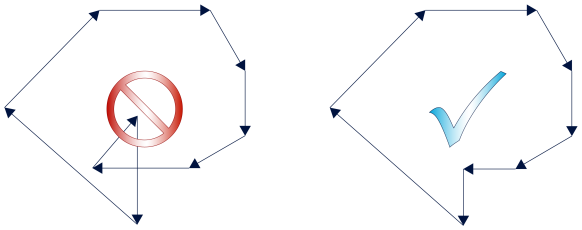


Fig. 3: Example of an incorrect and correct polygon contour

Notice

Control areas are always defined as viewed by the 3 main axes of the channel configuration (Cartesian). An active Cartesian transformation #(A)CS is not considered when control areas are defined. They are always defined in the MCS coordinate system, taking into consideration any active Cartesian offsets (e.g. G54, G92, etc.).

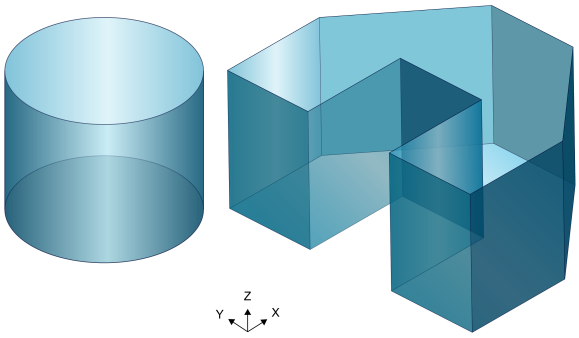


Fig. 4: Definition of 3D control areas

Schematic of 2 machining units with workspace areas that are limited by 2 cylindrical workspaces (green).

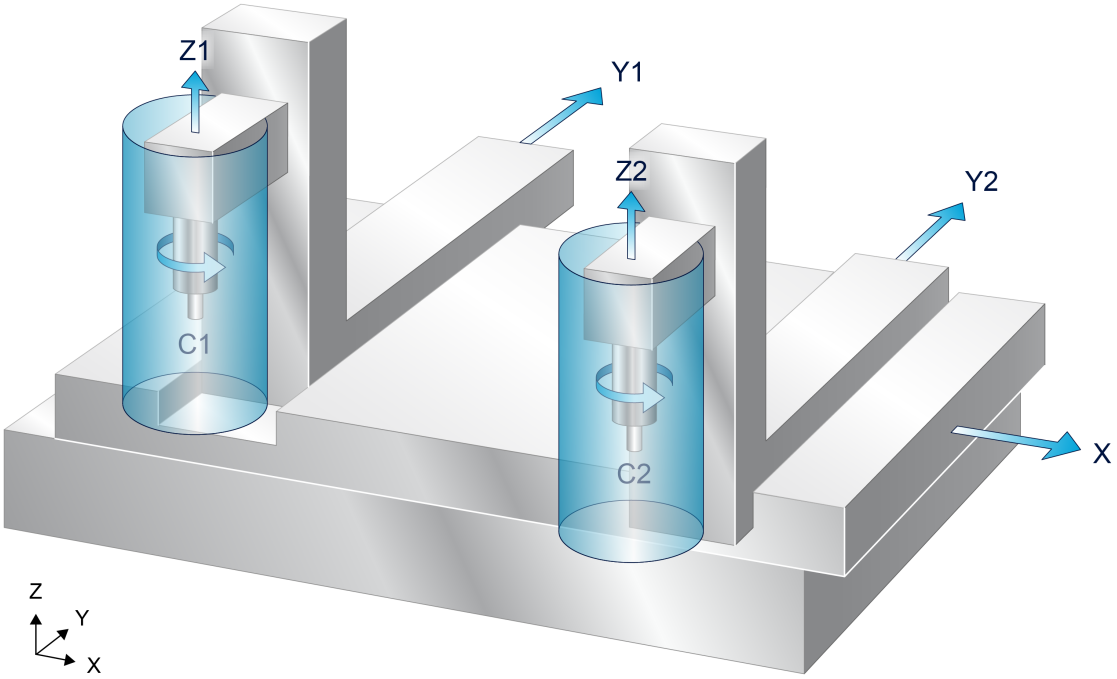


Fig. 5: Example of cylindrical workspace areas in an application

Path check

In workspace/protection area control, the path between the starting and end points is checked for any violations.

With standard linear and circular motion blocks, equations search for intersections with the defined control areas.

When polynomial contouring is activated or with helical motions, the path is first segmented and the individual points are then checked. This results in the requirement for considerably more computation resources.

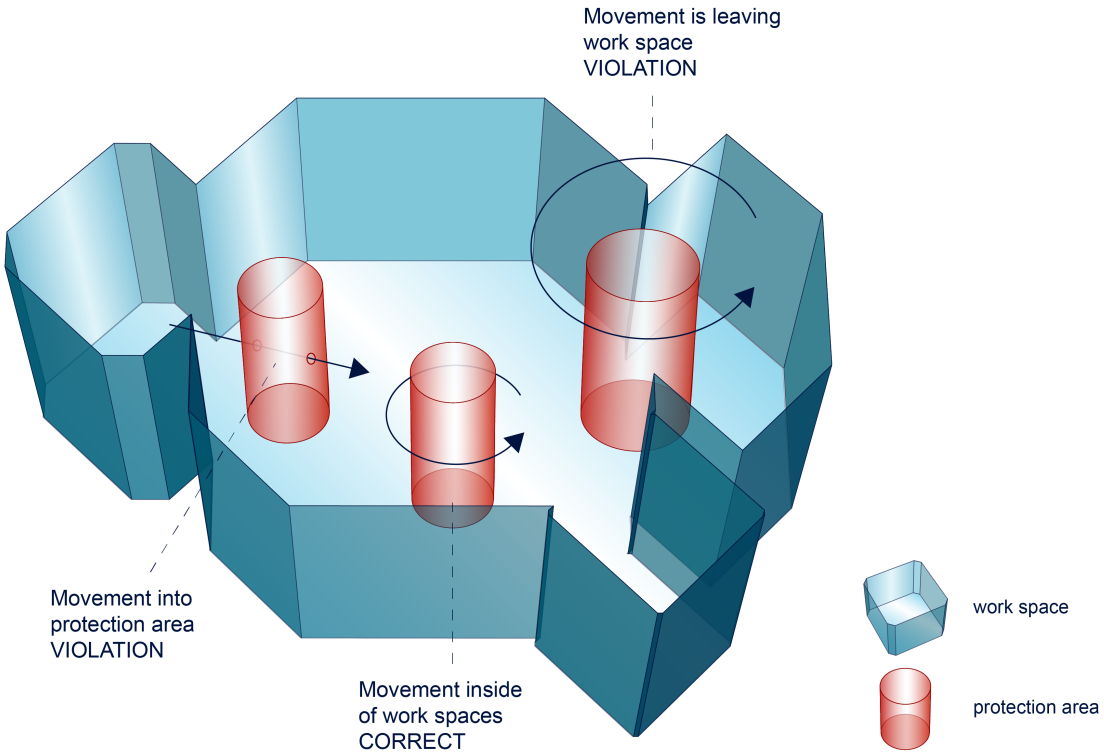


Fig. 6: Path check by area control

Control area overlaps

When there are several workspace and protection areas, they may overlap. In the figure below, a small workspace connects two other workspaces.

This permits a movement from workspace 1 to workspace 2.

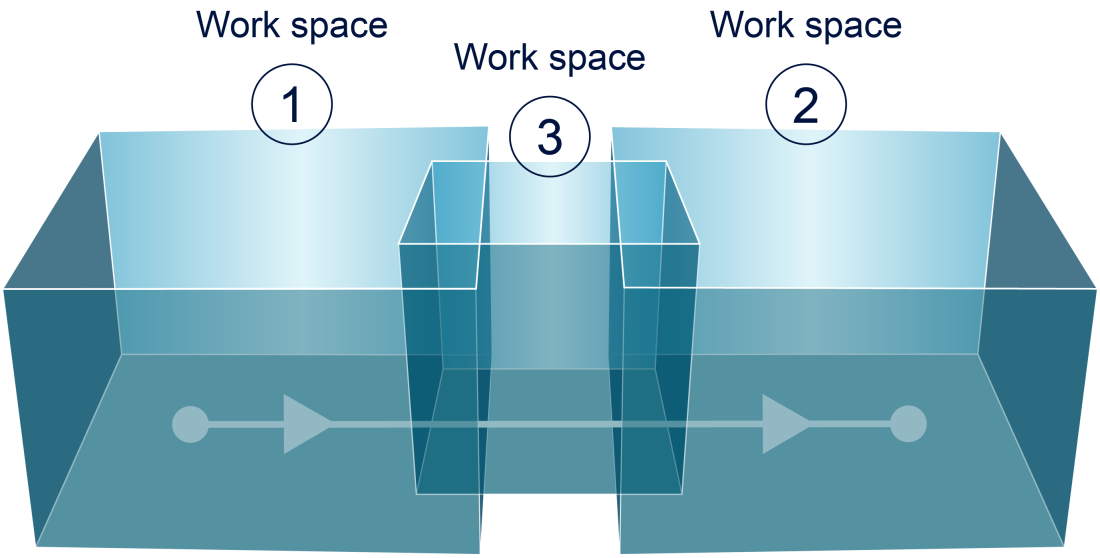


Fig. 7: Workspace overlaps

2.4 Workspace/protection area monitoring for 2-path application

When workspace or protection areas are defined for 2-path applications, the boundaries in (I)MCS coordinates are also defined by polygons or circles.

The third dimension, i.e. the Z axis, is monitored on the secondary path.

Release Note

This function is available as of CNC Build V3.1.3079.42.

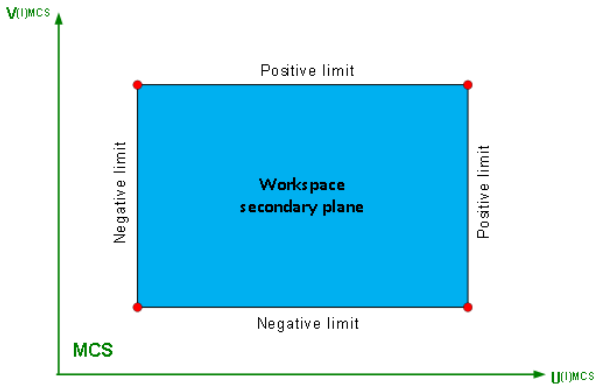


Fig. 8: Secondary level with limitation

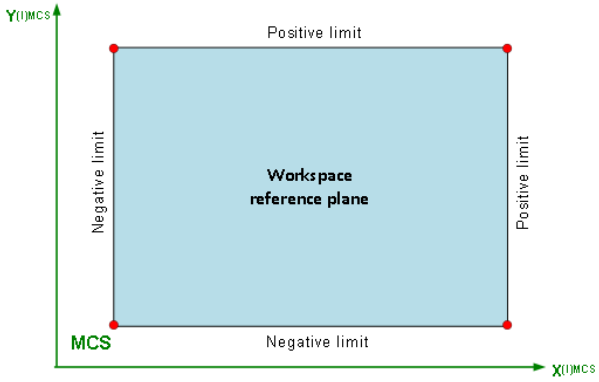


Fig. 9: Reference level with limitations

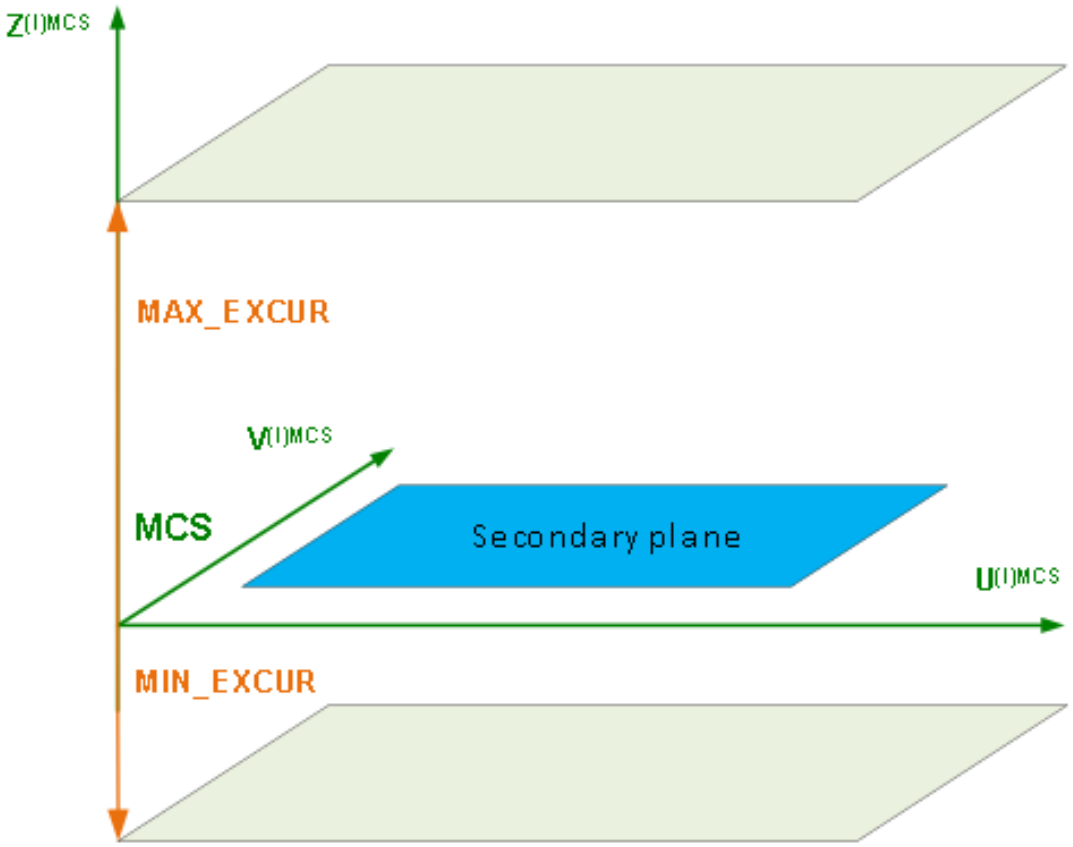


Fig. 10: Workspace limitation in U/V/W with MCS and IMCS axes

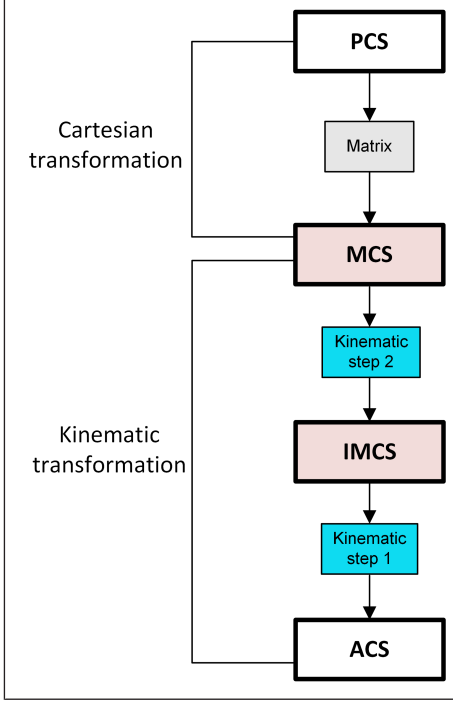
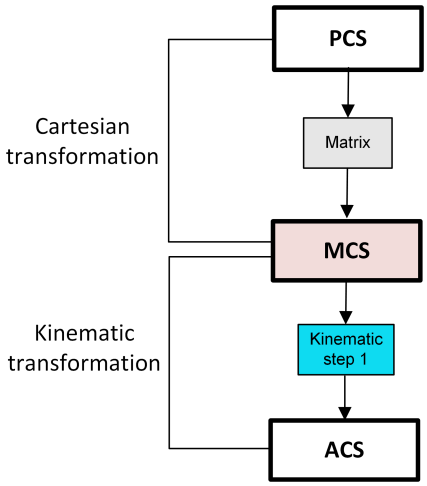
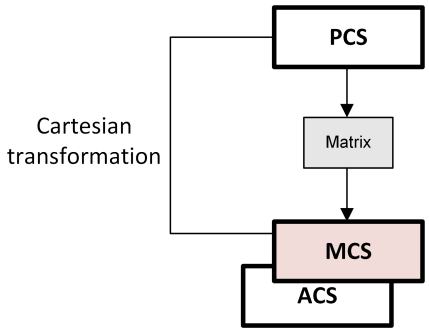
Programing Example

Defining a workspace for a 2-path application

```
N040 #CONTROL AREA START [ID=1 WORK MONITOR_LVL = "IMCS" POLY MIN_EXCUR
= -100 MAX_EXCUR = 100]
N050 : G0 X200 Y0 : G0 U150 V0
N060 : G0 X200 Y200 : G0 U150 V150
N070 : G0 X-200 Y200 : G0 U-150 V150
N080 : G0 X-200 Y-200 : G0 U-150 V-150
N090 : G0 X200 Y-200 : G0 U150 V-150
N100 : G0 X200 Y0 : G0 U150 V0
N110 #CONTROL AREA END
```

2.5 Control levels

Controls levels are represented below.

System with 2-step kinematic transformation	System with single-step kinematic transformation	System without kinematic transformation
		

3 Programming

Definition and activation

Workspace and protection areas are defined and activated directly in the NC program. Different # commands are available for this purpose. The #CONTROL AREA function initiates a workspace/ protection area command. A number of different options are then expected depending on the # command issued.

All possible states for a single control area are shown in the diagram below. In the diagram, the term "nop" stands for ‘No Operation’ and thus for a direct state transition.

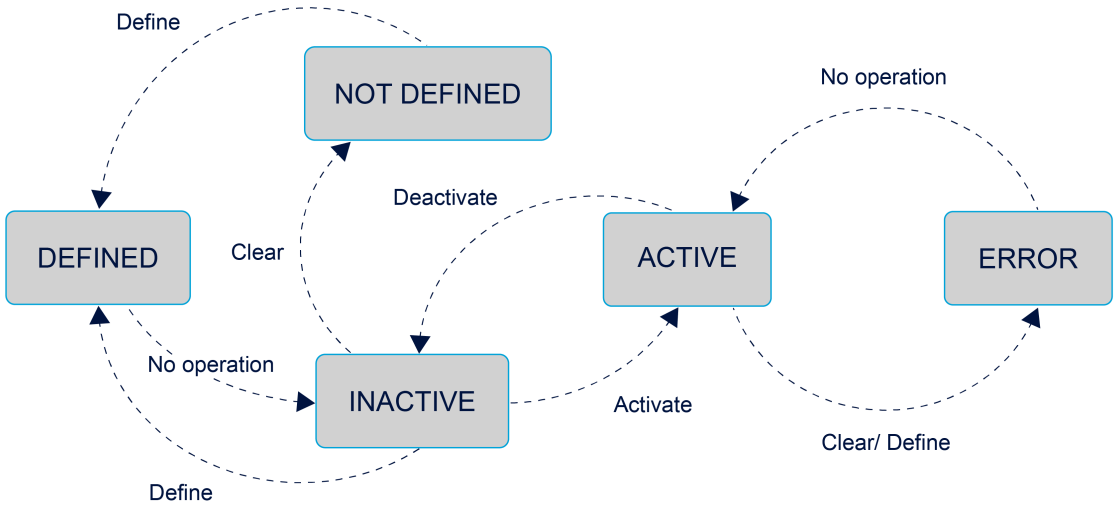


Fig. 11: State transitions caused by #CONTROL AREA commands

Notice

Program end

Active workspace and protection areas are not automatically deactivated at the end of the NC program; i.e. they continue to be monitored at the next program start. The OFF command can be used to explicitly deactivate workspace and protection areas at the end of the CNC program.

Notice

Controller reset

Stored workspace/protection areas are not deleted when the controller is reset. They are only deactivated and can be reactivated at any time by their IDs.

The clear command is used to explicitly clear workspace/protection areas.

3.1 Defining workspace and protection areas

Time of definition

No workspace/protection areas are predefined when the controller starts up. A definition in the configuration lists is not possible.

A work or protection space is defined directly in the NC program in a sequence of path motions embedded in plain text commands.

In this case, path motions must always be programmed in absolute dimensions. The contour of the control area in the plane is defined either by a closed polygon formed in any shape by linear blocks (target point and starting point of the block sequence must be identical) or by a full circle. The excursion in the third dimension and further characteristics of the control area are defined in the assigned plaintext command.

`Syntax for Start of control area definition:`

#CONTROL AREA BEGIN [ID=.. WORK | **PROT POLY** | **CIRC MIN_EXCUR**=.. **MAX_EXCUR**=..
[**EXCUR_AX**=.. |**EXCUR_AXNR**=..] [**MONITOR_LVL**=..] **]**

ID=..	Identification number of the control area (ID). The definition is global valid after program end and RESET. Up to 20 different control areas can be defined.
WORK	Control area is a workspace.
PROT	Control area is a protection space.
POLY	Contour of a control area is defined as a polygonal shape.
CIRC	Contour of a control area is defined as a full circle.

MIN_EXCUR=..	Limitation of the control area in the third dimension in negative direction in [mm, inch].
MAX_EXCUR=..	Limitation of the control area in the third dimension in positive direction in [mm, inch].
EXCUR_AX=..	Optional specification of an axis identifier for the third excursion direction of the workspace or protection area (as of CNC Build V2.11.2025.00). By default the third main axis is used.
EXCUR_AXNR=..	Optional specification of a logical axis number for the third excursion direction of the workspace or protection area (as of CNC Build V2.11.2025.00). By default the third main axis is used.
MONITOR_LVL=..	Specification of the monitoring level, see Control levels [▶ 15] (as of CNC Build V3.1.3079.42) IMCS: Intermediate coordinate system (only practical with multi-step transformations) MCS: Machine coordinate system (default)

```
Syntax for End of control area definition:
```
#CONTROL AREA END

Each control area must be closed by the command #CONTROL AREA END. Only then can further control areas be defined.

Sequence of NC command to define a workspace/protection space

Every control area definition begins with #CONTROL AREA BEGIN and must be terminated with #CONTROL AREA END. Between these two commands, the basic geometric form of the workspace or protection area is programmed by means of DIN 66025 motion commands. A valid feedrate (F word) must be active.

Depending on the configured geometric shape, G02 or G03 is expected for cylindrical control areas and G01 for a polygonal area with corresponding motion blocks.

Attention

When the control area is defined, all positions must be programmed in absolute dimensions (G90).

Attention

An active Cartesian transformation #(A)CS has no influence during the definition of the control space. Work and protection spaces are always defined as Cartesian in the MCS coordinate system.

Overwrite control areas

A control area can be overwritten by programming the same ID again. However, the condition is that the control area with this ID is not activated at the same time.

3.1.1 Polygonal control areas “POLY”

A two-dimensional polygon is defined by a string of linear NC motion commands. The string of points is checked for a convex profile, i.e. connections between 2 adjacent points may not intersect. For the 3rd dimension (3rd main axis), the minimum and maximum limits are defined in the start command.

Normally, the surface area of the workspace or protection area is defined by the first two main axes of the active machining plane.

Release Note

As of CNC Build V2.11.2025.00 polygonal protection areas can also be defined for tracking axes. The starting point of the two tracking axes must therefore be specified.

Notice

First and last points identical

When polygonal control areas are defined, note that the first and last points must be identical. This rule ensures that a closed contour is defined as a polygon.

Defining a polygonal work space

Programing Example

Polygonal workspace

```
N10 #CONTROL AREA BEGIN [ID3 WORK POLY MIN_EXCUR=-50 MAX_EXCUR=50]
N20 G01 F1000 G90 X-150 Y75 (Starting point)
N30 X-50 Y150
N40 X50 Y150
N50 X150 Y75
N60 X150 Y0
N70 X50 Y0
N80 X50 Y75
N90 X-50 Y75
N100 X-50 Y0
N120 X-150 Y0
N130 X-150 Y75 (End point identical with starting point)
N140 #CONTROL AREA END
```

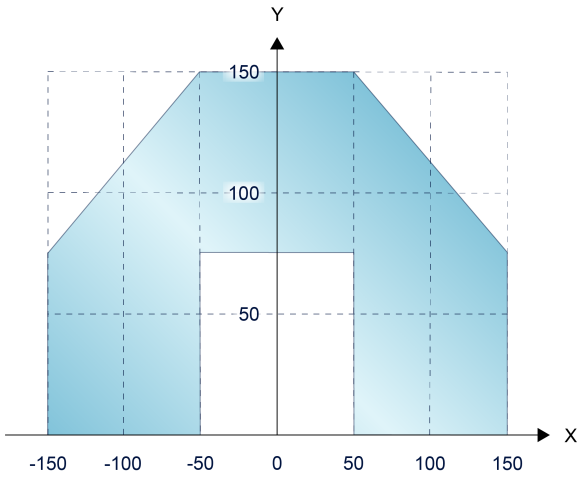


Fig. 12: 2D view of the programmed polygonal workspace

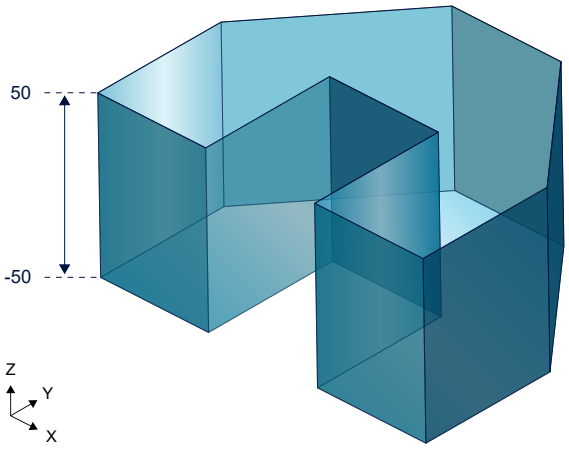


Fig. 13: 3D view of the programmed polygonal workspace

3.1.2 Cylindrical control areas “CIRC”

When cylindrical control areas are defined, two NC motion commands according to DIN 66025 are required.

The 1st motion command defines the starting point of the full circle and thus the absolute position of the control area.

A circular NC motion command (G02/G03) is expected as mandatory as the 2nd motion command. For the 3rd dimension (3rd main axis), the minimum and maximum limits are defined in the start command.

Defining a cylindrical protection space:

Programing Example

Cylindrical protection area

```
N10 #CONTROL AREA BEGIN [ID4 PROT CIRC MIN_EXCUR=-70 MAX_EXCUR=70]
N20 G01 X0 Y0 F10000    (Start point for cyl. protection space)
N30 G02 G162 I0 J75     (Definition of the full circle)
N40 #CONTROL AREA END
```

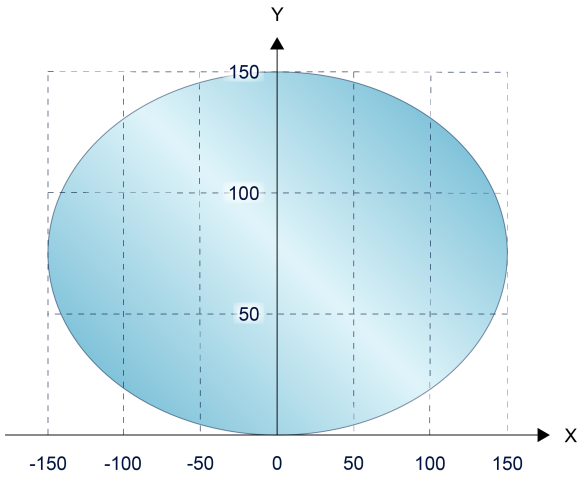


Fig. 14: 2D view of the programmed cylindrical workspace

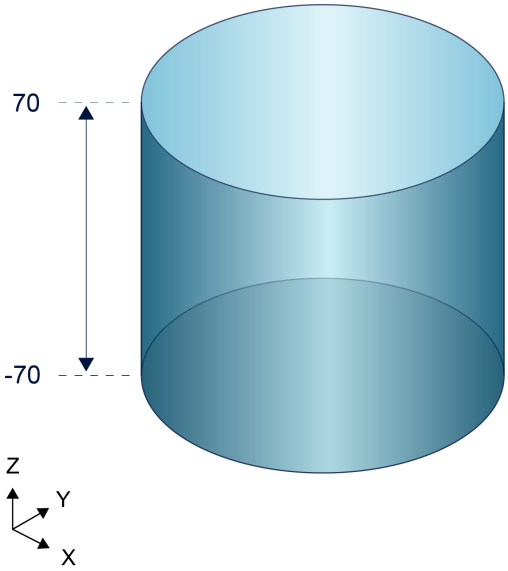


Fig. 15: 3D view of the programmed cylindrical workspace

3.2 Activating workspace and protection areas

Commands for selection

The tool TCP is checked for violations with all activated workspace and protection areas. Control areas can either be activated individually via their unique ID or they can all be activated at once.

When workspaces are activated, the TCP must already be located in the valid workspace. In the same way, when a protection area is activated, the TCP may not incur any violation at the current position.

The NC command to select a control area contains the following syntax elements:

`Syntax of Selecting a control area`

#CONTROL AREA ON [**ALL**] | **[ID**=.. **]**

ID=..	Identification number of the control area (ID).
ALL	Activate all defined control areas.

Programing Example

Activating workspace and protection areas

```
#CONTROL AREA ON [ID3] (Activate specific control area)
#CONTROL AREA ON ALL (Activate all defined control areas)
```

3.3 Deactivating workspace and protection areas

Commands for deselection

The monitoring function does not check deactivated control areas for violations. They are stored until they are cleared or until the controller is shut down and can be reactivated at any time.

The NC command to deselect a control area contains the following syntax elements:

Syntax of Deselecting a control area

#CONTROL AREA OFF [**ALL**] | **[ID=..]**

ID=..	Identification number of the control area (ID).
ALL	Deactivate all currently defined control areas.

Programing Example

Deactivating workspace and protection areas

```
#CONTROL AREA OFF [ID3] (Deactivate specific control area)
#CONTROL AREA OFF (Deactivate control area last selected)
#CONTROL AREA OFF ALL (Deactivate all active control areas)
```

3.4 Clearing workspace and protection areas

Commands for clearing

Information on cleared control areas is irrevocably lost. The memory space occupied is then released in order to define new control areas. Only deactivated control areas can be cleared.

The NC command to clear a control area contains the following syntax elements:

Syntax of Clearing a control area

#CONTROL AREA CLEAR [**ALL**] | **[ID=..]**

ID=..	Identification number of the control area (ID).
ALL	Delete all defined control areas.

Programing Example

Deleting control areas

```
#CONTROL AREA CLEAR [ID3] (Clear specific control area)
#CONTROL AREA CLEAR ALL   (Clear all defined control areas)
```

Notice

It is only permitted to clear workspace and protection area when the machine is in inactive state.

If an attempt is made to clear active workspace and protections area, the warning ID 120499 is output.

4 Monitor additional axes

Besides the main axes. X, Y, Z can adopt additional axes in the monitoring function for work spaces and protection spaces. In this case, the definition of the assigned control areas is limited to polygonal shapes. The control areas are defined using the associated axis identifiers.

Programing Example

Define a work space for the additional axes X2, Y2 and Z2

```
:
N10 #CONTROL AREA BEGIN [ID4 WORK POLY MIN_EXCUR=-50 MAX_EXCUR=50]
N20 G01 F1000 G90 X2=100 Y2=100   ;Starting point
N30 X2=-100
N40 Y2=-100
N50 X2=100
N60 X2 = 100 Y2= 100   ; End point identical with starting point
N70 #CONTROL AREA END
:
N500 #CONTROL AREA ON  ALL
:
N1000 M30
```

5 Special features in manual mode

Monitoring in manual mode is carried out in the real-time part of the CNC based on the defined and activated control areas.

Error response is identical to ACS limitation or approaching manual mode offset limits. If an IMCS / MCS limit is reached, all axes ahead of the limit without any error.

The start of the deceleration process ahead of the limit is dependent on the manual mode velocity and acceleration.

Output a warning message

The reason for motion stop is displayed to the user by the output of a warning message. To achieve this, P-MANU-00014 [▶ 32] must be set.

Exclusive manual mode (G200)

In response to an error in automatic mode, an error message is output and the program is aborted. However in manual mode, only an axis motion stop occurs as an error reaction when a person enters the protection space or leaves the workspace.

Inclusive manual mode (G201/G202)

If motions from automatic and manual mode are superimposed (parallel interpolation), work space and protective space violations may occur.

Suppress workspace monitoring

The parameter P-CHAN-00442 [▶ 31] influences or even suppresses workspace monitoring in manual mode.

Example

Suppress workspace monitoring with P-CHAN-00442

Initial situation for all cases:
The machine runs in automatic or manual mode. Before activating manual mode, activate workspace monitoring, e.g. in a subroutine.

Case 1:

P-CHAN-00442 is assigned the value 1.
Workspace monitoring is not activated in manual mode although its definition and activation were executed in the NC program. The machine can move back and forth across workspace boundaries.

Case 2:

P-CHAN-00442 is assigned the value 0.

Workspace monitoring is active in manual mode in combination with the Suppress error output from workspace monitoring in manual mode control unit [▶ 32].

When manual mode is active, workspace monitoring can be deactivated by the signal set in the Suppress error output from workspace monitoring in manual mode control unit [▶ 32]. The machine can then move back and forth across workspace boundaries.

When manual mode is activated the TCP must be within the permitted range. If this is not the case, an error is output.

Error ID 50961, if the workspace was left

Error ID 50962, if the protection area was left.

Case 3:

P-CHAN-00442 is assigned the value 2.

Workspace monitoring is activated in manual mode in combination with the Suppress error output from workspace monitoring in manual mode control unit [▶ 32].

When manual mode is activated, the TCP may be located outside the permitted range. The position of the TCP is not checked, Workspace monitoring can be deactivated by the control unit. The machine can move back within the permitted range.

6 Parameter

6.1 Overview

ID	Description
P-AXIS-00177	Position of the negative software limit switch
P-AXIS-00178	Position of the positive software limit switch
P-MANU-00014	Output a message at offset limit
P-CHAN-00268	Automatic travel range limit
P-CHAN-00442	Suppression of workspace monitoring function in manual operation

6.2 Description

Axis parameters

P-AXIS-00177	Negative software limit switch	
Description	The parameter defines the possible traverse range in the negative direction (negative software limit switch position). The programmed command positions are always checked on 'kenngr.swe_neg', the actual positions on 'kenngr.swe_neg - kenngr.swe_toleranz'.	
Parameter	kenngr.swe_neg	
Data type	SGN32	
Data range	MIN(SGN32) < swe_neg < P-AXIS-00178	
Axis types	T, R	
Dimension	T: 0.1µm	R: 0.0001 °
Default value	-100000000	
drive types.	----	
Remarks	The value of the parameter is adopted on reset, mode change and axis replacement from the axis record.	

P-AXIS-00178	Positive software limit switch	
Description	The parameter defines the possible traverse range in the positive direction (positive software limit switch position). The programmed command positions are always checked on 'kenngr.swe_pos', the actual positions on 'kenngr.swe_pos + kenngr.swe_toleranz'.	
Parameter	kenngr.swe_pos	
Data type	SGN32	
Data range	P-AXIS-00177 < swe_pos < MAX(SGN32)	
Axis types	T, R	
Dimension	T: 0.1µm	R,S: 0.0001 °
Default value	100000000	
drive types.	----	
Remarks	The value of the parameter is adopted on reset, mode change and axis replacement from the axis record.	

Channel parameters

P-CHAN-00268	Automatic motion path limiting
Description	The programmed target positions of a measurement block (G100) must be inside the software limit switches (SLS), otherwise the measurement motion is not started or executed. With specific measurement processes, the position of the PCS target positions is unknown. Movement should continue along the programmed direction until the probe responds. The parameter P-CHAN-00268 can activate the automatic limit of the measurement process. If no probe signal is detected during the measurement travel, the CNC stops the movement before the software limit switch or IMCS rectangular workspace or protection area (as of V3.1.3079.22). An error message is output with ID 50706 . This function is available with measuring methods 1, 2, 3, and 4. Measurement offsets set in the axis parameters P-AXIS-00114 or P-AXIS-00467 are only effective if the CNC does not execute any limiting of the measurement travel.
Parameter	meas_soft_limit_move_path
Data type	BOOLEAN
Data range	0: Programmed measurement motions with target position outside software limit switches are not started; a software limit switch error message is output. 1: Programmed measurement motions with target outside software limit switches are started without error message. If the measurement is not executed by the time the end of the motion path (SLS) is reached, the CNC stops the movement and error message ID 50706 is output.
Dimension	----
Default value	0
Remarks	Parameterisation example: *meas_soft_limit_move_path 1*

P-CHAN-00442	Suppression of workspace monitoring function in manual operation
Description	This parameter influences the workspace monitoring function in manual mode. As from version V3.3070.11 onwards, activating the workspace monitoring function using the NC program also simultaneously activates the workspace monitoring function in manual mode. 0: Workspace monitoring is activated as described above 1: Workspace monitoring is not activated 2: Workspace monitoring is activated; error handling is suppressed when manual mode is selected for axes located outside/within the workspace/protection area.
Parameter	suppress_workspace_monitoring_manual_mode
Data type	UNS16
Data range	0, 1, 2
Dimension	----
Default value	0
Remarks	The parameter is available as of Build V3.3070.11.

Manual mode parameter

P-MANU-00014	**Output a message at offset limit**
Description	If this parameter is set to TRUE, the CNC generates a warning if a manual movement stops at a relative offset limit (P-AXIS-00137, P-AXIS-00138) or at an absolute offset limit (P-AXIS-00492, P-AXIS-00493).
Parameter	move_limit_warning
Data type	BOOLEAN
Data range	0/1
Dimension	----
Default value	0
Remarks	This parameter is available as of CNC Build **2.11.2804.12**

6.3 PLC parameters

Violation detected in workspace monitoring	
Description	This datum reads a violation detected by the workspace monitoring system [FCT-C14 [▶ 6]].
Signal flow	CNC → PLC
ST path	gpCh[*channel_idx*]^.bahn_state.**area_mon_violation_detected_r**
Data type	BOOL
Value range	[TRUE = error detected in workspace monitoring, FALSE]
Access	PLC is reading

Suppress error output from working space monitoring in manual mode	
Description	This control unit suppresses the output of error messages from the working space monitoring system [FCT-C14 [▶ 6]] in manual mode.
Data type	MC_CONTROL_BOOL_UNIT, see description of Control unit
Access	PLC reads requested + feedback values and writes commanded value + redirection.
ST path	gpCh[*channel_idx*]^.bahn_mc_control.**suppress_area_mon_manual_mode**
Commanded, requested and return values	
ST element	**.command_w** **.request_r** **.state_r**
Data type	BOOL
Value range	[TRUE = suppress error output; FALSE]
Redirection	
ST element	**.**enable_w

7 Appendix

7.1 Suggestions, corrections and the latest documentation

Did you find any errors? Do you have any suggestions or constructive criticism? Then please contact us at documentation@isg-stuttgart.de.

The latest documentation is posted in our Online Help (DE/EN):

QR code link: https://www.isg-stuttgart.de/documentation-kernel/

The link above forwards you to:

https://www.isg-stuttgart.de/fileadmin/kernel/kernel-html/index.html

Notice

Change options for favourite links in your browser;

Technical changes to the website layout concerning folder paths or a change in the HTML framework and therefore the link structure cannot be excluded.

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ISG Industrielle Steuerungstechnik GmbH
STEP, Gropiusplatz 10
D-70563 Stuttgart

www.isg-stuttgart.de
support@isg-stuttgart.de